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Effect of spacing and variety on potato seed tuber production in eastern Uganda

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Abstract

In the highlands of eastern Uganda, potato (*Solanum tuberosum*) productivity per unit area is constrained by limited availability of quality seed. This study evaluated the effect of plant spacing and variety on potato seed tuber production at three locations in eastern Uganda. Two varieties and four different spacings were used. Results for all locations and seasons showed that close plant spacing (20 x 20 cm) produced significantly (P = 0.05) highest potato seed tubers, total tubers and tuber yield per unit area while seed tubers were least at widest crop spacing of 70 x 30 cm. However, high plant density resulted in significantly (P = 0.05) reduced average tuber weight. Variety x spacing interactions were not significant for most variables, indicating that spacing was the most critical factor for determining tuber size number.

Key words: Quality seed, seed-size tubers, *Solanum tuberosum*

Introduction

Although the present trends in Uganda and elsewhere in Africa (except Egypt and South Africa) show an increase in potato output, this is attributable to expansion in area cultivated rather than increased productivity per unit area (Okigbo, 1997). In the highlands of eastern Uganda, potato (*Solanum tuberosum*) is an important food and the main cash crop (Adipala *et al.*, 2000). However, it is becoming increasingly difficult to expand productivity in the region because of limited availability of quality seed (Alacho *et al.*, 2000), suitable arable land due to high population density and bacterial wilt (*Ralstonia solanacearum)* disease infestation. Because of land limitation, few potato growers adhere to recommended crop rotation which is a key component in bacterial wilt management (Tusiime and Adipala, 2000; Adipala *et al.*, 2001, 2002). Instead, farmers rely on purchased seed and/or recycled seed, which is expensive not only in terms of high costs but is a potential source of bacterial wilt disease spread through latently infected ware tubers used as seed tubers (Nyangeri *et al.*, 1984; Adipala *et al.*, 2002), thus limiting available land for seed potato production. Furthermore, due to limited availability of quality seed in the region, about 99% of the farmers grow unimproved potato seed, hence the low yields of <7 t ha^{-1} (Adipala *et al.*, 2000). This compares poorly with the production potential of 25 t ha^{-1} for Uganda (Hakiza *et al.*, 1997). Therefore, development of good quality potato seed production system is fundamental to increased potato production, especially since seed quality and its availability plays a very critical role in plant growth and development.

In an effort to enhance potato seed availability to farmers, the International Potato Centre (CIP) has advocated for and encouraged informal potato seed production system (Adipala *et al.*, 2001). With this system, success has been reported in Cameroon (Demo *et al.*; 2000), Ethiopia (Tesfaye Getachew and Awole Mela, 2000), southwestern Uganda (Alacho *et al.*, 2000; Tindimubona *et al.*, 2000) and Kenya (Kinyua *et al.*, 2001). However, in Uganda, due to limited finances, a farmer-based seed production scheme has so far only been promoted in southwestern Uganda and is currently lacking in eastern

Uganda, an important potato growing region. Consequently, these factors have impacted negatively on the transfer of potato production technologies and rates of adoption among farmers. Farmers who have appreciated use of disease-free seed have had to get it from Kalengyere (about 800 km away), making seed the most expensive input in potato production due to its bulkiness hence high transport costs. There is therefore, need to develop "a simple disease-free seed system'' to support improved potato productivity in eastern Uganda.

For the resource-poor, small-scale farmers, the use of seed plot techniques is an option to increase availability of seed tubers. The seed-plot technique is an intensive method of producing quality seed by planting at high densities on small bacterial wilt-free plots (Kinyua *et al.*, 2001). Based on findings from earlier studies, wider spacing results in increased tuber weights while closer spacing increases the number of seed-size tubers (Nelson, 1976; Berga Lemaga and Gebrmedhin, 1994). Furthermore, potato grown at high plant density are reported to reduce bacterial wilt incidence through utilisation of small but uninfested portions of land to produce clean seed for ware potato production (Kinyua *et al.*, 2001).The unused land during the season could either be left fallow or planted in rotation to crops that are non-hosts to *Ralstonia solanacearum* hence reducing soil borne inoculum (Berga Lemaga *et al.*, 1999). However, each potato variety has different growth characteristics, and this may vary with location. Therefore there is need to establish optimum spacing for each variety and for each agroecology. Thus, this study investigated the effect of spacing and variety on potato seed tuber production in eastern Uganda.

Materials and methods

The study was conducted in three major potato growing areas in eastern Uganda, namely: Kapchorwa, Wanale-Mbale and Buginyanya ARDC-Sironko. The experiment was conducted during the first (April to August) and second (September to December) seasons of 2002. These seasons are subsequently referred to as 2002A and 2002B seasons, respectively. Two potato cultivars, Victoria and Nakpot3 were each grown at spacings 20 x 20 cm, 40 x 20 cm, 70 x 10 cm and 70 x 30 cm giving plant populations of 125,000 and 142,857 plants per hectare, respectively. Trials were set up using a split plot in a randomised complete block design and replicated three times per site, with the varieties as the main plots and population densities in the sub-plots. Each sub-plot measured 2 m x 4 m, with one-metre alleys between plots. Standard agronomic practices including regular weeding based on weed intensity, earthing-up and basal application of compound fertiliser at a rate of 80 kg ha^{-1} (N.P.K 17:17:17) were carried out. However, for seed plots (20 cm x 20 cm), weeding was minimal and done by hand pulling. Depending on weather conditions, prophylactic sprays were administered to the crop using Dithane M45 (Mancozeb 80% WP) to control late blight. Dithane M45 was obtained from ROHM and HAASITALIA, Sri Via della Filanda, 20060 Gessate (MI), Italy.

Data collection and analysis

Assessment of bacterial wilt disease started at the onset of wilt symptoms. Plants that showed complete or partial wilting were considered wilted, counted and staked to avoid double counting or missing out those that die early during the growth period. The total number of infected plants in the plot was recorded and expressed as a percentage of the total number of plants in the plot. A sample of harvested tubers were further analysed for latent infection by enzyme-linked immunosorbent assay on nitrocellulose membranes, NCM-ELISA (Priou *et al.*, 1999). At harvest, the number of potato tubers per plot were counted and graded into large (>55 mm), seed size (25-55 mm) and under-size (<25 mm) tubers and subsequently expressed as number of tubers m^{-2}. Weights of these grade categories were recorded and subsequently, yield per hectare determined. Data on bacterial wilt incidence, yield and yield components were then subjected to analysis of variance (ANOVA) using Genstat 5 Release 3.2 package and treatment means separated using Standard Error of the Difference (SED) between means

at a probability level of 0.05 (5%). Data for each season and location were analysed separately but where no significant differences were observed between the varieties, seasons and the three locations, data were pooled.

Results

Large tubers (>55 mm)

The ANOVA results indicated that number of over-size tubers produced was not significantly affected by varieties, variety x spacing and all the 3-way interactions. However, there were significant ($P<0.001$) differences between the two seasons, three locations, and spacing, hence, the data for the three locations were not pooled (Table 1).

During 2002A at Buginyanya (Table 1) plant spacing of 70 x 10 cm and 70 x 30 cm produced more tubers than close spacing (20 x 20 cm). However, during 2002B, spacing did not have a significant effect on number of large tubers produced. A similar trend was observed at Kapchorwa. At Wanale, plant spacings of 70 x 10 cm and 70 x 30 cm produced the highest number of large tubers (16 tubers m^{-2}) and the least was produced at 40 x 20 cm spacing in 2002A. In 2002B, 70 x 30 cm spacing had the highest number of large tubers (8 tubers m^{-2}) and the spacing of 20 x 20 cm produced the least number of tubers (5 tubers m^{-2}).

Seed size tubers (25-55 mm)

Spacing x season x location interactions significantly ($P = 0.005$) affected the number of seed size tubers produced (Table 2). At Buginyanya, plant spacing of 20 x 20 cm resulted in highest seed-size tuber production of 61 and 68 tubers m^{-2} while the lowest (19 and 15 tubers m^{-2}) was from the 70 x 30 cm spacing during the first and second seasons of 2002, respectively. At Kapchorwa, the spacing of 20 x 20 cm also produced significantly ($P<0.001$) more seed-size tuber yields (107 and 74 tubers m^{-2}) compared to plants spaced at 70 x 10 cm (65 and 41 tubers m^{-2}), 40 x 20 cm (52 and 36 tubers m^{-2}) and 70 x 30 cm (9 and 11 tubers m^{-2}) during the first and second seasons of 2002, respectively. The trend was similar at Wanale where seed plots spaced at 20 x 20 cm produced most seed tubers (Table 2).

Table 1. Effect of spacing on large tuber production (tubers m^{-2}) of two potato varieties grown at three locations in eastern Uganda during the first (2002A) and second (2002B) seasons.

Spacing	Buginyanya		Kapchorwa		Wanale-Mbale		Overall mean
	2002A[1]	2002B	2002A	2002B	2002A	2002B	
20 x 20 cm	4.5	2.1	13.0	4.1	13.3	4.6	6.9
40 x 20 cm	13.3	2.1	10.4	3.6	10.4	5.9	7.6
70 x 10 cm	18.5	4.8	16.4	3.2	16.4	4.9	10.7
70 x 30 cm	12.6	3.0	16.8	3.2	15.9	8.3	10.0
SED (0.05)	4.1	Ns[2]	1.2	Ns	1.0	0.0	
CV (%)	59.5		14.3		12.9	16.7	

[1]2002A and 2002B refer to first rain (March - June 2002) and second rain (September - December 2002) seasons, respectively.

[2]Ns = not significant at 5%.

Under-size tubers

Under-size tuber category was observed during the second season of 2002 but was negligible in 2002A. In 2002B season at Buginyanya, there were significantly more under-size tubers at higher plant density (20 x 20 cm), comprising 14% of the total tuber production; the wide spacing of 70 x 30 cm produced the least number of under-sized tubers, i.e., 5.5% of the total tuber production (data not presented). The trend was similar at Kapchorwa and Wanale.

Number of total tubers

There was non-significant (P>0.05) variety x spacing and variety x spacing x location interaction effects on total number of tubers (Table 3). However, spacing and spacing x season x location interaction effects were significant (P = 0.005). Thus, results of number of total tubers m^{-2} are presented for only spacing x season x location interaction (Table 4). At Buginyanya, plant spacing of 20 x 20

Table 2. Effect of spacing x location x season interaction on number of seed-size potato (25-55 mm) tubers m^{-2} of two potato varieties grown at three locations in eastern Uganda during the first (2002A) and second (2002B) seasons.

Spacing	Buginyanya		Kapchorwa		Wanale-Mbale		Overall mean
	2002A[1]	2002B	2002A	2002B	2002A	2002B	
20 x 20 cm	60.5	67.7	106.7	74.4	82.1	73.9	77.6
40 x 20 cm	37.4	37.9	51.5	41.2	26.9	38.9	39.0
70 x 10 cm	51.0	41.7	64.5	36.4	22.4	39.9	42.6
70 x 30 cm	18.8	15.4	8.9	11.1	9.7	13.8	13.0
Mean	41.9	40.7	57.9	40.8	35.3	41.8	43.0
SED (S x L x S)							6.83
CV (%)							28.0

[1] 2002A and 2002B refer to first rain (March - June 2002) and second rain (September - December 2002) seasons, respectively.
[2]Pooled data for two potato varieties.

Table 3. Effect of variety x spacing x location interaction on number of under-size (<25 mm) tubers m^{-2} of two potato varieties grown at three locations in eastern Uganda during the second season of 2002.

Variety	Spacing	Buginyanya	Kapchorwa	Wanale	Mean
Victoria	20 x 20 cm	10.0	16.9	6.7	11.2
	40 x 20 cm	4.2	4.1	2.1	3.4
	70 x 10 cm	5.7	4.8	2.9	4.4
	70 x 30 cm	1.0	1.4	1.2	1.1
	Mean	5.2	4.8	3.2	5.0
Nakpot 3	20 x 20 cm	13.0	11.9	20.0	15.3
	40 x 20 cm	5.2	2.2	13.8	7.1
	70 x 10 cm	5.2	2.3	5.8	4.4
	70 x 30 cm	1.0	1.0	4.2	1.9
	Mean	6.2	4.3	10.9	7.2
	SED (V x S x L)[1]				1.9
	CV (%)				35.8

[1] V x S x L = variety x spacing x location.

cm compared to 70 x 30 cm generally resulted in higher total tuber production of 65 and 82 tubers m^{-2}; the lowest total number of tubers (33 and 19 tubers m^{-2}) was at 70 x 30 cm spacing, during the first and second seasons of 2002, respectively. Similarly, at Kapchorwa, seed plot spacing of 20 x 20 cm resulted in significantly ($P<0.05$) higher total tuber yield (109 and 93 tubers m^{-2}) compared to plants spaced at 70 x 10 cm (71 and 43 tubers m^{-2}), 40 x 20 cm (56 and 48 tubers m^{-2}) and lowest at 70 x 30 cm (21 and 15 tubers m^{-2}) during the first and second seasons of 2002, respectively. At Wanale, seed plots spaced at 20 x 20 cm also produced more tubers than the other spacings (95 tubers m^{-2}) during both seasons. Across locations and seasons, potatoes planted at 20 x 20 cm spacing produced the highest number of tubers (90 tubers m^{-2}) while the spacing of 70 x 30 cm resulted in the least number of tubers.

Total tuber yields (t ha^{-1})

There was significant variety x spacing x location x season interaction effects on total tuber yields (Table 5). Thus, further discussion of yield results is based on the significant 4-way interaction. At Buginyanya, close spacing of 20 x 20 cm resulted in significantly ($P = 0.025$) highest tuber yields of 26.0 t ha^{-1} for both Victoria and 26.3 t ha^{-1} for Nakpot 3. Planting Nakpot 3 at 20 x 20 cm resulted in significantly ($P = 0.014$) higher yield (22.9 t ha^{-1}) compared to only 13.2 t ha^{-1} obtained at 70 x 30 cm and 17.1 t ha^{-1} at 70 x 10 cm spacing. A similar trend was observed in 2002B. In Kapchorwa, plant spacing of 20 x 20 cm resulted in significantly ($P = 0.024$) higher tuber yields (57.5 t ha^{-1}) compared to only 22.4 t ha^{-1} obtained at 70 x 30 cm spacing for variety Victoria; 49.6 and 14.5 t ha^{-1} for Nakpot 3, in 2002A, respectively. A similar trend was observed for tuber yields in 2002B with highest yield of 40.4 and 39.8 t ha^{-1} at 20 x 20 cm spacing and lowest (11.0 and 9.1 t ha^{-1}) at 70 x 30 cm spacing, for Victoria and Nakpot 3, respectively (Table 5). At Wanale, a spacing of 20 x 20 cm also resulted in significantly ($P<0.001$) higher tuber yields (44.4 and 62.8 t ha^{-1} for Victoria; 38.5 and 25.9 t ha^{-1} for Nakpot 3) during 2002A and 2002B, respectively, compared to only 16.2 and 19.3 t ha^{-1} for Victoria; 13.7 and 11.2 t ha^{-1} for Nakpot 3 at 70 x 30 cm spacing. Victoria spaced at 40 x 20 cm also yielded 30.0 t ha^{-1} in the first and 35.5 t ha^{-1} in the second seasons, while Nakpot 3 grown at the same spacing produced 16.7 and 19.6 t ha^{-1}; which was significantly higher than for those spaced at 70 x 30 cm.

Bacterial wilt incidence and latent infection of tubers

Generally, irrespective of plant spacing, the highest bacterial wilt incidence was recorded at Wanale with mean incidences of 11.8% for Victoria and 12.6% for Nakpot 3, compared to only 3.9% and 6.7%

Table 4. Effect of spacing x location x season interaction on total tuber number per m^2 of potato grown at three locations in eastern Uganda during the first (2002A) and second (2002B) seasons.

Spacing	Buginyanya		Kapchorwa		Wanale-Mbale		Overall mean
	2002A	2002B	2002A	2002B	2002A	2002B	
20 x 20 cm	65.0	81.8	109.2	92.9	95.4	95.4	90.0
40 x 20 cm	50.2	41.2	55.8	48.1	37.2	53.0	47.7
70 x 10 cm	69.6	52.0	70.7	43.2	38.1	49.1	53.8
70 x 30 cm	32.7	18.8	21.1	15.4	27.2	20.6	22.6
Mean	54.4	48.4	64.2	49.9	49.5	54.6	53.5
SED (S x L x S)[1]							7.11
CV (%)							23.3

[1]S x L x S = Spacing x location x season.
[1]Pooled data for two potato varieties (variety effects were not significant).

for the respective cultivars at Kapchorwa (Table 6). However, differences among various spacings were not significant except for Victoria at Wanale. Bacterial wilt was not observed at Buginyanya. At Wanale, highest wilt incidence occurred in Victoria spaced at 70 x 10 cm (14.6%) followed by 70 x 30 cm spacing (11.3%) for Nakpot 3 and 70 x 10 cm and 40 x 20 cm for Victoria. Likewise, at Kapchorwa, plants spaced at 70 x 30 cm recorded highest bacterial wilt incidence of 12.5% for Nakpot 3 and 6.3% for Victoria. There was low bacterial wilt incidence in 2002A with mean incidences of only 2.8% and 1.4% at Wanale and Kapchorwa, respectively. In this season, crop spacing of 70 x 10 cm registered highest incidence of bacterial wilt (7.5%) at Wanale and 5.0% at Kapchorwa (data not presented).

All potato tubers obtained from different plant spacing at Wanale reacted positively to NCM-ELISA test, except Victoria obtained from a spacing of 40 x 20 cm (Table 6). In Kapchorwa, only tubers from plants spaced at 20 x 20 cm for both varieties reacted positively with ELISA test. Contrastingly, all potato samples from Buginyanya were non-reactive with NCM-ELISA irrespective of plant spacing (data not presented).

Discussion

The number of seed size tubers, total tubers per unit area and fresh tuber yield were highest under close plant spacing (20 x 20 cm, 40 x 20 cm) compared to wider spacings (70 x 10 and 70 x 30 cm) probably due to the higher number of plants planted and harvested per unit area under close spacing. Thus, the lower yields from the wide spaced crop (70 x 30 cm) was probably due to fewer numbers of plants per unit area. In a related studies, Beukema and Van der Zaag (1990) and Berga Lemaga and Caeser (1990) observed that increasing plant density (close spacing) increased yields and attributed this to increased number of stems per unit area. Generally, however, for both varieties, highest yields were obtained at high plant density and variety x spacing interaction effects were not significant indicating that spacing was the overriding factor in determining tuber numbers and hence yield. Although close spacing resulted in significantly highest number of seed-size tubers, total tubers and yield per unit area,

Table 5. Influence of variety, spacing, season and location on tuber yield (t ha^{-1}) of two potato varieties grown at three locations in eastern Uganda during the first (2002A) and second (2002B) seasons.

Variety	Spacing	Buginyanya		Kapchorwa		Wanale-Mbale		Overall mean
		2002A	2002B	2002A	2002B	2002A	2002B	
Victoria	20 x 20 cm	26.0	27.1	57.5	40.4	44.4	62.8	43.1
	40 x 20 cm	19.3	17.6	34.0	18.2	30.0	35.5	25.8
	70 x 10 cm	23.3	25.5	37.5	21.0	18.6	34.1	27.8
	70 x 30 cm	18.9	8.6	22.4	11.0	16.2	19.3	16.1
	Mean	21.9	19.7	37.9	22.7	27.3	37.9	28.2
	SED	3.0	3.2	8.0	6.1	2.0	4.7	
	CV (%)	15.7	19.7	25.8	33.0	9.0	15.2	
Nakpot 3	20 x 20 cm	26.3	31.7	49.6	39.8	38.5	25.9	35.3
	40 x 20 cm	22.9	13.1	27.3	32.5	16.7	19.6	22.0
	70 x 10 cm	17.1	16.4	44.3	27.5	17.0	21.4	25.6
	70 x 30 cm	13.2	6.9	14.5	9.1	13.7	11.2	11.5
	Mean	19.9	17.0	33.9	27.2	21.5	19.5	23.6
	SED	2.8	4.8	9.8	0.9	3.8	2.2	
	CV (%)	17.4	34.2	35.5	4.0	21.6	12.4	

[1] 2002A and 2002B refer to first rain (March - June 2002) and second rain (September - December 2002) seasons, respectively.

the same spacing also produced the highest proportion of under-size tubers, which is undesirable. The implication is that agronomic practices should be altered according to plant density.

Close plant spacing and hence high plant density in excess of that required for ware yields still produced tubers in the large size (>55 mm) category. This suggests that potato tubers respond differently to competition. As such, some tubers may be preferentially positioned in relation to assimilate supply such that they remain largely unaffected by competition while other tubers are highly affected and with increased competition may lead to reduced size. Gray (1973) and Oparka (1987) also reported similar results.

Mean tuber weight generally increased with wider spacing probably due to more competition for assimilates for tuber bulking and other plant growth factors at high plant density. Also, at close spacing, low average tuber weights could have been as a result of the plants' reaction to high level of shading. The study by Ebwongu *et al.* (2001) revealed that potato plants in an attempt to place their leaves in light, partition more assimilates for stem growth and became taller due to phototropism, at the expense of tuber bulking. Similarly, Burton (1989) reported that shading reduced total radiation intercepted and consequently the net assimilates directed to tubers, resulting in light tubers. Hence close spacing is only appropriate for seed and not ware tuber production.

Higher bacterial wilt incidence was recorded on potato from farmers' fields at Wanale-Mbale and at Kapchorwa but no wilt was observed at Buginyanya, yet planting materials were from the same source and were clean. These results imply that soils in Wanale were more infested by *Ralstonia solanacearum* than at Kapchorwa. The NCM-ELISA test confirms these results. Secondly, absence of bacterial wilt at Buginyanya was probablly due to the fact that the crop was established on plots previously under fallow for over three years while at Kapchorwa, farmers had previously practiced crop rotation by planting their plots with maize and wheat. These factors are known to reduce bacterial wilt inoculum in the soil (Berga Lemaga *et al.*, 1999). At Wanale, on the other hand, due to small land holdings, plots were under continuous cultivation with vegetables such as tomatoes and eggplants, which are hosts to *R. solanacearum*.

Table 6. Effect of spacing and variety on bacterial wilt incidence and latent infection of potato tubers during 2002B[1] in eastern Uganda.

Variety	Spacing (cm)	Wanale		Kapchorwa	
		[2]BW%	Latent infection	BW%	Latent infection
Victoria	20 x 20	9.2	++	2.0	+++[3]
	40 x 20	12.2	-	3.3	-
	70 x 10	14.6	+++	4.2	-
	70 x 30	11.3	+++	6.3	-
	Mean	11.8		3.9	
	SED	0.77		Ns	
	CV (%)	6.5		-	
Nakpot 3	20 x 20	12.5	+++	4.6	+++
	40 x 20	8.3	+++	4.3	-
	70 x 10	13.4	+++	5.1	-
	70 x 30	16.3	+++	12.5	-
	Mean	12.6		6.7	
	SED	Ns		Ns	
	CV (%)	26.7		-	

[1]2002B refer to second rain (September - December of 2002) season.

[2]BW = bacterial wilt disease.

[3]-, +, ++, +++ = non-reactive, reactive, very reactive and highly reactive, respectively, with NCM-ELISA.

Generally, however, in fields where *Ralstonia solanacearum* inoculum existed, all plots irrespective of plant spacing, exhibited some potato plants with wilt symptoms. This shows that manipulation of plant spacing alone can not singly control the pathogen. However, the advantage with close spacing (seed plot) especially at 20 x 20 cm is that more number of seed-size tubers is produced per unit area as exemplified by the results of this study. The implication therefore is that even potato farmers with small land holdings (as is the case with hilly and densely populated potato growing areas of eastern Uganda) could set aside small but clean plots for seed tuber production and also practice crop rotation using non-hosts to *R. solanacearum* in the cropping sequence to reduce bacterial wilt inoculum in the soil. Since manipulation of plant spacing alone could not control the pathogen, an Integrated Disease Management (IDM) approach is viewed as the best approach for bacterial wilt control. It also implies that greater care should be placed in selecting plots for seed-potato production. Furthermore, studies on other IDM protocols such as soil solarisation and using plastic sheets which may be possible under small seed plots could be part of a strategy for bacterial wilt management.

Conclusion

The results of the study generally showed lack of significant varietal effects, and in most cases, variety x environment interaction were not significant. Thus, the two varieties can be used in all the study areas for seed and for ware production. What is crucial is to determine whether production is for ware or for seed. For seed production, spacing of 20 x 20 and 40 x 20 cm appear appropriate, while for ware, the spacing of 70 x 10 cm could be used. Seed plot spacing at 20 x 20 cm compared to wide plant spacing (70 x 30) produced significantly highest proportion of seed size tubers and total number of tubers per unit area. Therefore, to enhance potato seed production in eastern Uganda, high plant density should be used. However, there is still a problem of bacterial wilt latent infection. Therefore, farmers should be assisted by researchers, extension workers and other partners in potato production to identify bacterial wilt-free areas in their plots for seed-potato production.

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