academicJournals

Vol. 9(17), pp. 1391-1397, 24 April, 2014
DOI: 10.5897/AJAR2014. 8570
Article Number: B7DCEE344153
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Effect of stem density on growth, yield and quality of potato variety amethyst

Admire Shayanowako[1], Robert Mangani[1], Taurira Mtaita[1] and Upenyu Mazarura[2]*

[1]Africa University Box 1320, Mutare, Zimbabwe.
[2]University of Zimbabwe, Crop Science Department, P. O. Box MP 176 Mt Pleasant, Harare, Zimbabwe.

Received 31 January, 2014; Accepted 7 April, 2014

The study was carried out to determine the effect of stem density on growth, yield and quality of potato (*Solanum tuberosum* L.) variety amethyst in Zimbabwe. Three stem density treatments were used and these were initially derived from the number of sprouts or eyes per tuber: 2 stems/hill, 4 stems/hill and +6 stems/hill. Emergence, haulm growth, yield and quality characteristics of tubers were the main parameters measured. There was a significant difference in emergence among the 3 treatments (P<0.05). A mean of 30 plants/plot were recorded from the treatment with 6 stems/hill compared to 27.50 plants/plot from the treatment with 2 stems/hill at 12 day after planting. No statistical differences in tuber yield (P>0.05) among the three stem density levels was achieved. A high marketable yield was obtained at 2 stems/hill compared to 6 stems/hill. An average of 21.08 small tubers per hill that is, those considered unsellable were obtained from treatments derived from 6 stems per hill compared to 3.75 small tubers /plant from plants with 2 stems per hill. Seed producers whose main objective is to increase the multiplication rate, high stem densities per planting station have the potential of increasing plant populations resulting in many smaller tubers. For ware production, low stem densities promote greater proportion of medium to oversized tubers.

Key words: Potato, stem density, growth components, yield.

INTRODUCTION

The potato cultivar amethyst is arguably the most popular and widely grown potato variety in Zimbabwe (Manzira and Ackerman, 2011). A few comprehensive studies on stem population densities have been done on local potato cultivars. Regardless of the numerous studies on the potato worldwide, there is a gap in the area regarding interactions that contribute to the growth and subsequent yield of the crop (Masarirambi et al., 2012). In addition, no work has been reported on the response of amethyst to variation in stem. The growth and yield of potato is affected by such factors as stem density, seed tuber size, planting depth, ridge volume and nitrogen supply (Barry et al., 1990; Masarirambi et al., 2012; Nielson et al., 1989; O'Beirne and Cassidy, 2006). The stem density of a potato crop is the number of stems per unit area and differs significantly from the plant population mostly given in production recommendations.

The potato plant consists of various stems and each stem forms roots, stolons and tubers and behaves like an individual plant. The density of the potato crop consists of two components. The first component is the number of plants generally referred to as plant density and the

*Corresponding author. E-mail: umazarura@agric.uz.ac.zw; umazarura@yahoo.com

second is the number of stems per plant (Wiersema, 1987). The latter is more relevant in yield studies (Bussan et al., 2007). The number of eyes determines stem number per seed piece (Nielson et al., 1989) and similarly correlation with stem density in cultivars such as Nooksack was found in Europe. The number of eyes and stems produced per seed piece increased as cut seed piece increased (Nielson et al., 1989). Each stem from a single eye can be regarded as an independent production unit. Thus a sufficient number of strong stems should develop per seed tuber.

However, as much as higher stem density results in greater yield, it also affects the size of tubers. Growth is limited when competition among stems is high. At higher stem density, the tubers produced remained smaller than at lower stem density, while the percentage of large tubers decreased (Güllüoglu and Arıoglu, 2009). Controlled environment studies conducted to characterize differences in canopy growth and dry matter production among single and multiple stemmed potatoes showed that vegetative and dry matter yield production were unaffected by stem density (Fleisher et al., 2011). As stem density increased, fewer tubers were produced and this was due to a reduced multiplication rate which was defined as number of tubers produced per seed tuber (Fleisher et al., 2011).The primary purpose of the current study was to study the influence of stem density on the growth, yield and quality of the potato variety amethyst.

MATERIALS AND METHODS

Description of the study site

The study was done at Africa University farm, Mutare, Zimbabwe. The area is under the Agro-ecological region 2 (18°53'70, 3"S: 32°36'27.9"E) at 1131 m above sea level. Average annual rainfall ranges from 750 to1200 mm.The average maximum temperature ranges from 18°C in July to 32°C in October. Very hot weather conditions prevail between September and December. High mean maximum temperatures in excess of 30°C are recorded in October, which is the hottest month of the year.

Planting material

Amethyst is presently the most widely grown potato variety in Zimbabwe. It is a late maturing potato variety (17 to 19 weeks) and AA Class seed was procured from the Potato Seed Association of Zimbabwe. The seed was induced to sprout by dipping tubers in Gibberellic acid (32 ml of GA_3/100 L of water) for 1 min as per chemical label. The seed tubers were allowed to dry before being put in a room with subdued light until sprouting. Seed tubers were planted in furrows and ridged twice as is standard practice. The first ridging was when plants were about 20 cm in height and the second was at 35 cm.

Design of the experiment

The potato cultivar amethyst was evaluated for its response to various stem density levels in an experiment laid out in a randomized complete block design (RCBD). Treatments were as follows: 2 sprout or stems/hill, 4 sprouts or stems/hill and ≥6sprouts or stems/hill. Stem density was maintained by pruning excess growth beyond that which was stipulated by the desired number of stems per treatment. Plots were represented by 4 × 4.0 m long rows, spaced at 0.90 m between rows and 0.30 m in the row. The harvested plot was 2 × 2 m.

General management and fertiliser applications

The experimental site was deep ploughed, disked and harrowed to ensure a fine tilth. Planting stations were made as per treatment. The planting depth was 10 cm. A soil analysis of the trial site gave the following information: pH ($CaCl_2$) 5.01, and a total content of the following elements: N 45.37 (ppm), P 0.797 (ppm), Mg 4.40 (meq%), Cl 7.1 (meq%), Zn 3.53 (ppm) and Cu 0.65 (ppm). Basal Compound C (6%N, 17%P_2O_5, 14% K_2O) was applied at the commercial rate of 1500 kg/ha prior to planting. Top dressing of ammonium nitrate (AN) was applied at 300 kg/ha three weeks after emergence. This was followed by split application sulfate of potassium (K_2SO_4) at 400 kg/ha at flowering and at two weeks after flowering. Basal fertilizer was applied in each planting station while top dressing was banded. The first ridging commenced after the top dressing with AN, when all plants had an average height of 20 cm. An allowable soil moisture depletion level of 40% was maintained throughout the growing period and soil moisture monitoring was done through the use of field tensiometers. Sprinkler irrigation was used for application of water as a supplement to the summer rain.

Data collection

The number of emerged stems was recorded from 8 to 12 days after planting. Leaf counts per plot were done from 30 to 60 days after emergence (DAE). A minimum leaf length of 0.5 cm was used to indicate leaf appearance. Final leaf counts included senesced and green leaf numbers (Fleisher et al., 2011). The length of the main stem per planting station of three randomly selected plants for each plot was recorded once every 10 days from 30 to 70 days after emergence. Relative growth rate in leaf number (RGRln) was calculated from the formula (Balderrama and Chazdon, 2005):

$$RGRln = \frac{loge(ln60) - loge(ln30)}{60-30}$$

Where *ln60* is leaf number at 60 and *ln30* is leaf number at 30 DAE. Thus the parameter was calculated using data from 30 to 60 DAE. Tuber density was recorded at the time of harvesting. Four plants were selected per plot to measure the average number of tubers per plant. Tuber size distribution was also determined; samples were graded into small (25 to 37.5 mm in diameter) which made up non-marketable tubers (ware), medium (37.5 to 50 mm), large (50.00 to 56.25 mm) and oversized tubers (56.25 to 62.25 mm) which composed the marketable grades as by Masarirambi et al. (2012). Quality determinants such as number of green tubers, brown heart, tuber specific gravity and dry matter were obtained by randomly selecting 20 tubers from each treatment. In determining specific gravity, selected tubers from each treatment were first weighed in air and then re-weighed suspended in water. Specific gravity was then calculated using the following formula (Burton, 1989):

Specific gravity = Weight in air/[Weight in air - Weight in water]

Dry matter content was obtained using the formula which correlates specific gravity to dry matter by a correlation factor of 0.937% dry

Table 1. Plant emergence counts at 7, 8, 9, 10, 11 and 12 Days after planting (DAP).

Treatment	E at 7 DAP	E at 8 DAP	E at 9 DAP	E at 10 DAP	E at 11 DAP	E at 12 DAP
2 Sprouts	7.25[a]	13.00[a]	16.50[a]	22.50	26.00	27.50[a]
4 Sprouts	13.00[b]	14.50[a]	19.25[ab]	24.75	27.00	29.50[a]
+6 Sprouts	14.75[b]	19.75[b]	22.50[b]	26.50	28.50	30.00[b]
LSD	2.840	3.011	4.345	4.421	3.106	2.079
P value	*	*	*	NS	NS	NS
CV	14.1	11.0	12.9	10.4	6.6	4.1

*Denotes significance at P<0.05; NS denote non-significance at P>0.05. E = emergence. The means not sharing a common letter in a column differ significantly at P<0.05.

Table 2. Leaf number counts (LN) recorded at 30, 40, 50 and 60 days after emergence (DAE).

Treatment	LN at 30 DAE	LN at 40 DAE	LN at 50 DAE	LN at 60 DAE
2 Stems/hill	22.37[a]	74.80	116.20[a]	126.89[b]
4 Stems/hill	40.19[b]	71.40	112.70[a]	122.67[a]
+6Stems/hill	62.25[c]	73.70	100.90[b]	121.14[a]
LSD	3.730	14.48	10.08	2.924
P value	*	NS	*	*
CV(%)	12.6	10.8	8.3	3.2

*Denotes significance at P<0.05; NS denotes non-significance at P>0.05. The means not sharing a common letter in a column differ significantly at 0.05 probability.

matter =(24.182±0.035)+(211.04±3.33) specific gravity-1.09)(Burton, 1989).

Data analysis

The data collected were analyzed using Genstat Discovery 3rd edition. The data were subjected to analysis of variance and mean were separated using Fisher's least significant difference (LSD) test at P=0.05.

RESULTS

Emergence of stems

Stem density significantly (P< 0.05) influenced the number of days taken for the crop to emerge at 7, 8 and 9 Days after planting (DAP) (Table 1). Plants from seed tubers with more than four sprouts (p <0.05) emerged earlier than plants from seed tubers with 2 sprouts. There was an increase in the days to emergence as the number of sprouts per planted tuber increased. However, this was not sustained at 10, 11 and 12 DAP.

Leaf counts

Table 2 shows significant variation in leaf numbers at 30, 50 and 60 Days after emergence (DAE). At 30 DAE the leaf counts increased with increasing number of stems per hill. However at 50 and 60 DAE the reverse was observed. No differences were observed at 40 DAE. During the initial growth, leaf number appeared to be influenced by the number of stems that emerged but later it was greatest where the stems were fewer, perhaps showing the effects of reduced competition.

Relative growth rate in leaf emergence

Table 3 shows the relative growth rate (RGR) in leaf numbers (LN) from 30 to 60 DAE. There was a significant difference in the rate of leaf production at 30 to 40 DAE (P<0.05); 4 stemmed plants had relatively higher leaf production rate than 2 stemmed plants. There were no significant differences in RGR from 40 to 60 DAE among the 3 stem density treatments.

Main stem lengths

Table 4 shows the changes in stem length as affected by number of stems per station. The effect of stem density on the length of main stems showed some variations across the 3 stem density treatments. At 30 DAE the stem length increased with decreasing stem density. This trend was maintained at 40 and 60 DAE.

Table 3. Relative growth rate (Rgr) in leaf numbers (LN) from 30, 40, 50 and 60 days after emergence (DAE).

Treatment	RgrLn 30-40DAE	RgrLn 40-50 DAE	RgrLn 50- 60 DAE
2 Stems/hill	0.0335[a]	0.1239	0.01239
4 Stems/hill	0.0498[b]	0.1190	0.01190
+6Stems/hill	0.0440[ab]	0.1126	0.01126
LSD	0.01290	0.03616	0.003616
P value	*	NS	NS
CV (%)	42.6	40.8	42.6

*Denote significance at P<0.05; NS denote non-significance at P>0.05. The means not sharing a common letter in a column differ significantly at 0.05 probability.

Table 4. Stem length (cm) measured at 30, 40, 50, 60 and 70 days after emergence (DAE).

Treatment	STL at 30DAE	STL at 40DAE	STL at 50DAE	STL at 60DAE	STL at 70DAE
2 stems/hill	30.88[b]	34.93[b]	41.37	48.96[b]	63.28[a]
4 stems/hill	28.25[ab]	34.00b[ab]	40.05	47.02[a]	64.51[a]
+6stems/hill	26.94[a]	33.04[a]	40.94	46.49[a]	60.80[a]
LSD	2.746	1.340	1.766	1.425	4.20
P value	*	*	NS	*	NS
CV%	13.4	1.34	1.768	1.425	4.2

STL = stem length.*Denote significance at P<0.05; NS denote non-significance at P>0.05. The means not sharing a common letter in a column differ significantly at 0.05 probability, STL= stem length.

Table 5. Tuber yield in kg/ha, tuber density /plant and marketable yield at harvest in t/ha.

Treatment	Mean tuber yield (Kg/ha)	Tuber density (counts/plant)	S1 (non-Marketable)	S2-3-4 (Marketable)
2 stems/hill	18972	7.58[a]	3.75[a]	11.83[b]
4 stem/hill	23327	17.50[b]	16.17[b]	9.33[a]
+6 stem/hill	28885	24.75[c]	21.08[c]	11.67[b]
LSD	10863.7	4.697	2.332	2.009
P value	0.162	0.001	<0.001	0.028

*Denote significance at P<0.05; NS denote non-significance at P>0.05. The means not sharing a common letter in a column differ significantly at 0.05 probability; SI = tuber diameter of 25 to 37.5 mm; S2= tuber diameter of 37.5 to 50 mm; S3= tuber diameter of 50.00 mm to 56.25 and S4= tuber diameter of 56.25 to 62.25 mm).

Yield and tuber density counts per plant

Table 5 shows mean yield, number of tubers per plant, non-marketable and marketable yield. Although the lower stem density tended to yield less, this was not significant. Tuber density increased with increase in number of stems/hill (Table 5).

Marketable yield and non-marketable yield

Tuber size distribution which affects the volume of economic yield suitable for ware consumption was classified into marketable and non-marketable yield (Table 5) all measured in number of tubers per plant. The S1 size (tuber diameter of 25 to 37.5 mm) represented non marketable output which were tubers regarded too small for ware consumption or commercial processing while S2 (tuber diameter of 37.5 to 50 mm), S3 (tuber diameter of 50.00 to 56.25 mm) and S4 (S4= tuber diameter of 56.25 to 62.25 mm) represented the marketable yield suitable for both ware and commercial processing. Non-marketable yield increased with increase in stems/hill while marketable yield was least at 4 stems/hill and larger at 2 and >6 stems per hill.

Tuber greening, specific gravity and dry matter content

Table 6 shows the response of tuber specific gravity and the subsequent dry matter content to stem density. The

Table 6. Number of green tubers (GT/plant), Specific Gravity (Sp gravity) and per cent dry matter content of tubers (%DM content) at harvest.

Treatment	G T/plant	Sp Gravity	%DM Content
2 Stems/hill	0.25[a]	1.06930[a]	18.02[a]
4 stem/hill	1.75[b]	1.08368[b]	21.01[b]
+6 stem/hill	4.25[c]	1.07257[a]	18.70[a]
LSD	0.999	0.005195	1.079
P value	*	*	*
CV%	27.7	1.606	0.350

*Denote significance at P<0.05; NS denote non-significance at P>0.05. The means not sharing a common letter in a column differ significantly at 0.05 probability.

number of green tubers increased with increasing stem density. Specific gravity was highest at 4 stems and lower at 2 and >6 stems and this was mirrored by percentage dry content (Table 6).

DISCUSSION

Emergence counts

There are a number of factors that could explain the differences in crop emergence rate shown in Table 1. The size of seed tuber at planting, planting depth, method of planting, physiological condition of seed tuber material, edaphic and environmental factor are some of the causes of uneven crop emergence. Seed tubers with multiple sprouts can have a significant competitive edge over tubers with a fewer eyes or less sprouts as they can produce emergence of several strong seedlings per square inch (Cortbaoui, 1988). Nielson et al. (1989) established that some cultivars such as Nooksack with few spaced eyes or high percentage of blind tubers had a negative correlation of stem number to yield suggesting that uneven emergence and or missing plants help to explain the performance of stem density with respect to rate of emergence.

Leaf counts

At low stem densities production of basal lateral branches was more vigorous as the crop intended to increase its ability to intercept light and photosynthetic active radiation (PAR). Our findings agree with the findings of Fleisher et al. (2011) and Engels et al. (1993) who observed a similar trend in leaf production amongst various stem densities. As a result of increased inter-stem competition amongst high stem densities the allocation of accumulated assimilates to production of photosynthetic apparatus was reduced (Moorby, 1967).

Relative growth rate in leaves

The initial differences in RGR in LN shown in Table 3 can be attributed to the difference brought about by stem numbers soon after crop establishment. Plants derived from high stem densities had a relatively high RGR as the effects of leaf shading and competition for light interception might have been minimal during the early growth phase. Masarirambi et al. (2012) suggested that differences caused by uneven sprout numbers at emergence had an effect on the haulm growth as those plants emanating from high sprout densities had a “rich” background of nutrients stored in the parent tuber. The lack of significant difference in RGR in LN from 40 to 60 DAE may be attributed to the increase in the rate of lateral brunching among low density plants which nullified the initial differences in leaf production among the 3 densities. This phenomenon was also reported by Fleisher et al. (2011) and Masarirambi et al. (2012), in which they showed that secondary stems and lateral branching increased with a decline in stem population.

Main stem lengths

The increase in stem length with decreasing stem density as shown in Table 4 may be attributed to less inter stem competition for nutrients. Our findings confirm work by Moorby (1967) and Fleisher et al. (2011) who observed an increase in stem length at low stem density which they attributed to low inter-plant completion for both nutrients and photosynthetic active radiation.

Yield

The observations validated the findings by Hammes (1985) in which stem populations had no significant effect on tuber yield despite that more tubers were produced at high stem densities. Bussan et al. (2007) found that yield increased with an increase in stem density per hill. Our findings show that the number of tubers/plant, increased with increasing stem density as shown in Table 5. This was largely due to the fact that each stem is an independent production unit. Hence an increase in their number will consequently translate to more tubers per station. These finding are in agreement with observation by Wiersema (1987) who showed an increase in the number of tubers as stem density increased.

The non-marketable yield increased with increasing stem density. This was attributed to an increase in competition for water, nutrients and sunlight during tuber bulking and confirms work by Rex (1990) and Wiersema (1987) who reported a reduction in total marketability of tubers as stem populations increased. Marketable yield was best at the lowest and highest stem densities. We, however, expected that the proportion of marketable tubers would fall as stem density increased. Our findings which were contrary perhaps indicate that our upper cut off point for stem density was still in the optimal range for the variety we used.

Tuber greening, specific gravity and dry matter content

While other studies illustrated the significance of manipulating cultural practices such as planting depth, hilling time and interval, ridge geometry, planting method as the major factors affecting tuber greening (Bohl and Love, 2005; Mburu, 1984; Ravishankar et al., 2007; Svensson, 1962), our work showed that stem density may also be added to this myriad of factors. That the number of green tubers increased with increasing stem density was probably because the chances of tubers being exposed to the sun were greater as stems competed for space (Kouwenhoven et al., 2003; Pavek and Thornton, 2009). The specific gravity of tubers was highest at the lowest and highest stem density and highest at the intermediate stem density. Perhaps, this shows that our stem densities were within a range where trends were not firm. The same trend as with specific gravity was evident with dry matter since the dry matter was estimated from specific gravity.

Conclusions

The study showed that differences in sprout numbers per tuber had an effect on the rate of emergence. Plants established from 6 sprouts/tuber emerged earlier followed by 4 sprouts/tuber and lastly 2 sprouts/tuber. The effect of leaf number (LN) among the three subsequent densities showed a significant difference at 30 days after emergence (DAE). Plants derived from 2 stem/hill had longer main stems followed by 4 and 6 stem treatments respectively. Stem density had no effect on the total tuber yield. Tuber density increased with an increase in stem density. Marketable yield declined with an increase in stem density.

ACKNOWLEDGEMENTS

We thank the Africa university research department which helped in allocating the research plots and the Zimbabwe Seed Potato Association which provided the seed used in this study.

Conflict of Interests

The author(s) have not declared any conflict of interests.

REFERENCES

Balderrama SIV, Chazdon RL (2005). Light-dependent seedling survival and growth of four tree species in costa rican second-growth rain forests. J. Tropical. Ecol. 21(04):383–95. http://dx.doi.org/10.1017/S026646740500235X http://dx.doi.org/10.1017/S026646740500235X

Barry PT, Storey TS, Hogan R (1990). Effect of plant population and set size on the seed yield of the maincrop potato variety Cara. Irish J. Agric. Res. pp. 49–60.

Bohl WH, Love SL (2005). Effect of planting depth and hilling practices on total, US No. 1, and field greening tuber yields. Am. J. Potato Res. 82(6):441–50. http://dx.doi.org/10.1007/BF02872222 http://dx.doi.org/10.1007/BF02872222

Burton WG (1989). The Potato. Ed. 3. Longman Group Limited. http://www.cabdirect.org/abstracts/19890724888.html.

Bussan AJ, Mitchell PD, Copas ME, Drilias MJ (2007). Evaluation of the effect of density on potato yield and tuber size distribution. Crop Sci. 47(6):2462–72. http://dx.doi.org/10.2135/cropsci2007.01.0026 http://dx.doi.org/10.2135/cropsci2007.01.0026 http://dx.doi.org/10.2135/cropsci2007.01.0026

Cortbaoui R (1988). Planting Potatoes. International Potato Center. http://pdf.usaid.gov/pdf_docs/PNABA030.pdf.

Engels C, El Bedewy R, Sattelmacher B (1993). Effects of weight and planting density of tubers derived from true potato seed on growth and yield of potato crops in Egypt. 1. Sprout Growth, Field Emergence and Haulm Development. Field Crops Res. 35(3):159–70. http://dx.doi.org/10.1016/0378-4290(93)90150-L http://dx.doi.org/10.1016/0378-4290(93)90150-L

Fleisher DH, Timlin DJ, Yang Y, Reddy VR (2011). Potato stem density effects on canopy development and production. Potato Research 54 (2):137–55. http://dx.doi.org/10.1007/s11540-011-9185-2 http://dx.doi.org/10.1007/s11540-011-9185-2 http://dx.doi.org/10.1007/s11540-011-9185-2

Güllüoglu L, Arıoglu H (2009). Effects of seed size and in-row spacing on growth and yield of early potato in a Mediterranean-type environment in Turkey. Afr. J. Agric. Res. 4 (5):535–41.

Hammes PS (1985). The Effect of Stem Population on Tuber Yield in a Trial with Single-Stem Seed Pieces. Potato Res. 28(1):119–21. doi:10.1007/BF02357577. http://dx.doi.org/10.1007/BF02357577 http://dx.doi.org/10.1007/BF02357577 http://dx.doi.org/10.1007/BF02357577

Kouwenhoven JK, Perdok UD, Jonkheer EC, Sikkema PK, Wieringa A (2003). Soil ridge geometry for green control in french fry potato production on loamy clay soils in the Netherlands. Soil and Tillage Res. 74 (2):125–41. http://dx.doi.org/10.1016/S0167-1987(03)00149-1 http://dx.doi.org/10.1016/S0167-1987(03)00149-1 http://dx.doi.org/10.1016/S0167-1987(03)00149-1

Manzira C, Ackerman K (2011). Potato production manual. 1st ed. Vol. 1. The Potato Seed Association.

Masarirambi MT, Mandisodza FC, Mashingaidze AB, Bhebhe E (2012). Influence of plant population and seed tuber size on growth and yield components of potato (*Solanum tuberosum*). Int. J. Agric. Biol. 14 (4):545–49.

Mburu NJ (1984). Effect of ridging and non-ridging on tuber yield and quality of two potato varieties grown in Kenya. In X African Symposium on Horticultural Crops. 158:119–126. http://www.actahort.org/books/158/158_14.htm.

Moorby J (1967). Inter-stem and inter-tuber competition in potatoes.

Europ. Potato J. 10 (3):189–205. doi:10.1007/BF02364428. http://dx.doi.org/10.1007/BF02364428 http://dx.doi.org/10.1007/BF02364428

Nielson M, Iritani WM, Weiler LD (1989). Potato seed productivity: factors influencing eye number per seed piece and subsequent performance. Am. J. Potato Res. 66(3):151–60. http://dx.doi.org/10.1007/BF02853676, http://dx.doi.org/10.1007/BF02853676

O'Beirne D, Cassidy JC (2006). Effects of nitrogen fertiliser on yield, dry matter content and flouriness of potatoes. J. Sci. Food. Agric. 52(3):351–363. http://dx.doi.org/10.1002/jsfa.2740520308, http://dx.doi.org/10.1002/jsfa.2740520308, http://dx.doi.org/10.1002/jsfa.2740520308

Pavek MJ, Thornton RE (2009). Planting depth influences potato plant morphology and economic value. Am. J. Potato Res. 86(1):56–67. doi:10.1007/s12230-008-9062-y. http://dx.doi.org/10.1007/s12230-008-9062-y http://dx.doi.org/10.1007/s12230-008-9062-y http://dx.doi.org/10.1007/s12230-008-9062-y

Ravishankar P, Lada RR, Caldwell CD, Asiedu SK, Adams A (2007). The Effects of Light, Rehilling, and Mulching on Greenshoulder and Internal Greening in Carrots. Crop Sci. 47(3):1151–58. http://dx.doi.org/10.2135/cropsci2006.08.0517, http://dx.doi.org/10.2135/cropsci2006.08.0517

Rex BL (1990). Effect of seed piece population on the yield and processing quality of Russet Burbank potatoes. Am. J. Potato Res. 67(8):473–89. http://dx.doi.org/10.1007/BF03045110, http://dx.doi.org/10.1007/BF03045110, http://dx.doi.org/10.1007/BF03045110

Svensson B (1962). Some factors affecting stolon and tuber formation in the potato plant. Potato Res. 5(1):28–39. http://dx.doi.org/10.1007/BF02367659, http://dx.doi.org/10.1007/BF02367659

Wiersema SG (1987). Effect of stem density on potato production. technical information Bulletin. http://agris.fao.org/agrissearch/search/display.do?f=1989/QP/QP89001.xml;QP8900001.