Australian Journal of Crop Science

AJCS

AJCS 8(8):1147-1151 (2014) ISSN:1835-2707

Producing potato crop from true potato seed (TPS): A comparative study

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Abstract

In producing a commercial potato crop from true potato seeds (TPS), ware potato crop can be grown by: direct sowing of TPS in the field for production of seed or ware tubers; raising seedlings from TPS in a greenhouse or seedbed and transplanting them later into the field for production of seed or ware tubers in the same season and; direct sowing of TPS in seedbeds at close spacing for production of seedling tubers for producing a commercial crop in the next season. Each propagation method has its advantages and disadvantages. Based on this background, a study was conducted whose objective was to compare the effectiveness of seedling tubers and seedling transplants in production of a potato crop from true potato seeds. Four potato varieties commonly grown by farmers in Kenya were crossed with five advanced clones from the International Potato Center (CIP) in a North Carolina II mating design to generate twenty cross families. The berries were harvested and seedlings were raised on sand-beds in plastic trays. Later, they were propagated as seedling tubers and seedling transplants in the field at Kenya Agricultural Research Institute (KARI), National Potato Research Centre at Tigoni between March and July 2013. At harvest, data collected included tuber numbers/plant, total weight of tubers per plant (kg) and weight of ware tubers (45 mm< in diameter) per plant (kg). The general observation was that the seedling transplants gave significantly more tubers per plant (15.68) than the seedling tubers (13.08); the reverse was the case when it came to total tuber yield (ton/ha) and percent of ware sized tuber yield. Although seedling transplants took a shorter time to produce a potato crop of commercial value, the low tuber yields (ton/ha) and percentage ware tubers renders this propagation method unsuitable for ware potato production unless there is a market for baby tubers.

Keywords: Propagation methods, Seedling transplants, Seedling tubers, True potato seeds.
Abbreviations: KARI_Kenya Agricultural Research Institute; TPS_True potato seeds; CIP_International Potato Center.

Introduction

In any breeding programme, speedy production of a cultivar is important in order to reduce the costs. In potato breeding, propagation methods that ensure rapid production of tubers of commercial value from true potato seeds (TPS) are always preferred. This has the advantage of ensuring high health status of the resultant crop. This advantage is easily lost when too many field multiplications are applied. One way of maintaining good health standards of the early generations of TPS-derived materials is the use of nurseries or otherwise well-controlled environments to produce seedlings and seedling tubers. In producing a commercial potato crop from true potato seeds, ware potato crop can be grown by 1) direct sowing of TPS in the field for production of seed or ware tubers (Martin, 1983; Almekinders et al., 1996), 2) raising seedlings from TPS in a greenhouse or seedbed and transplanting them later into the field for production of seed or ware tubers in the same season(Rowell et al., 1986) and, 3) direct sowing of TPS in the seedbeds at close spacing for production of seedling tubers for producing a commercial crop in the next season (Farook, 2005). Of the three propagation methods, use of seedling tubers is the most common (Almekinders et al., 1996; Simmonds, 1997). Seedling tubers can be produced off-season in a screenhouse thereby allowing another crop to be grown in the field at that time. In addition, use of seedling tubers avoids the problems associated with direct sowing (i.e. slow seedling growth, high vulnerability to pests and diseases, high sensitivity to stress conditions such as heat, frost and water limitations; all these result in early tuberization and hence low yields), and transplanting seedlings (i.e. transplanting shock) (Almekinders et al., 2009). The use of seedling tubers or later- generation tubers from TPS varieties is agronomically similar to the use of tubers from conventional cultivars in terms of seed rate, initial crop development, number of tubers per stem etc. (Almekinders et al., 1996). Also, the yield potential of seedling tubers and later generations of selected TPS varieties competes well with that of clonal cultivars (Wiersema, 1984; CIP, 1987; Love et al., 1994; Benz et al., 1995; CIP, 1995). The common observation is that the seedling transplants often have a longer growth duration, higher tuber set and smaller tuber size compared to plants derived from tuber seed or tuber generations of TPS (Thompson, 1980; Chujoy and Cabello, 2007). However, seedling transplants often have a lower yield than the conventional

Table1. Parents used in the crossing block to generate the 20 cross families.

Parent	Source of germplasm	Male/ Female
Cangi	KARI- Tigoni	Male
Kenya Karibu	KARI- Tigoni	Male
Tigoni	KARI- Tigoni	Male
Sherekea	KARI- Tigoni	Male
Clone 1	CIP	Female
Clone 2	CIP	Female
Clone 3	CIP	Female
Clone 5	CIP	Female
Clone 6	CIP	Female

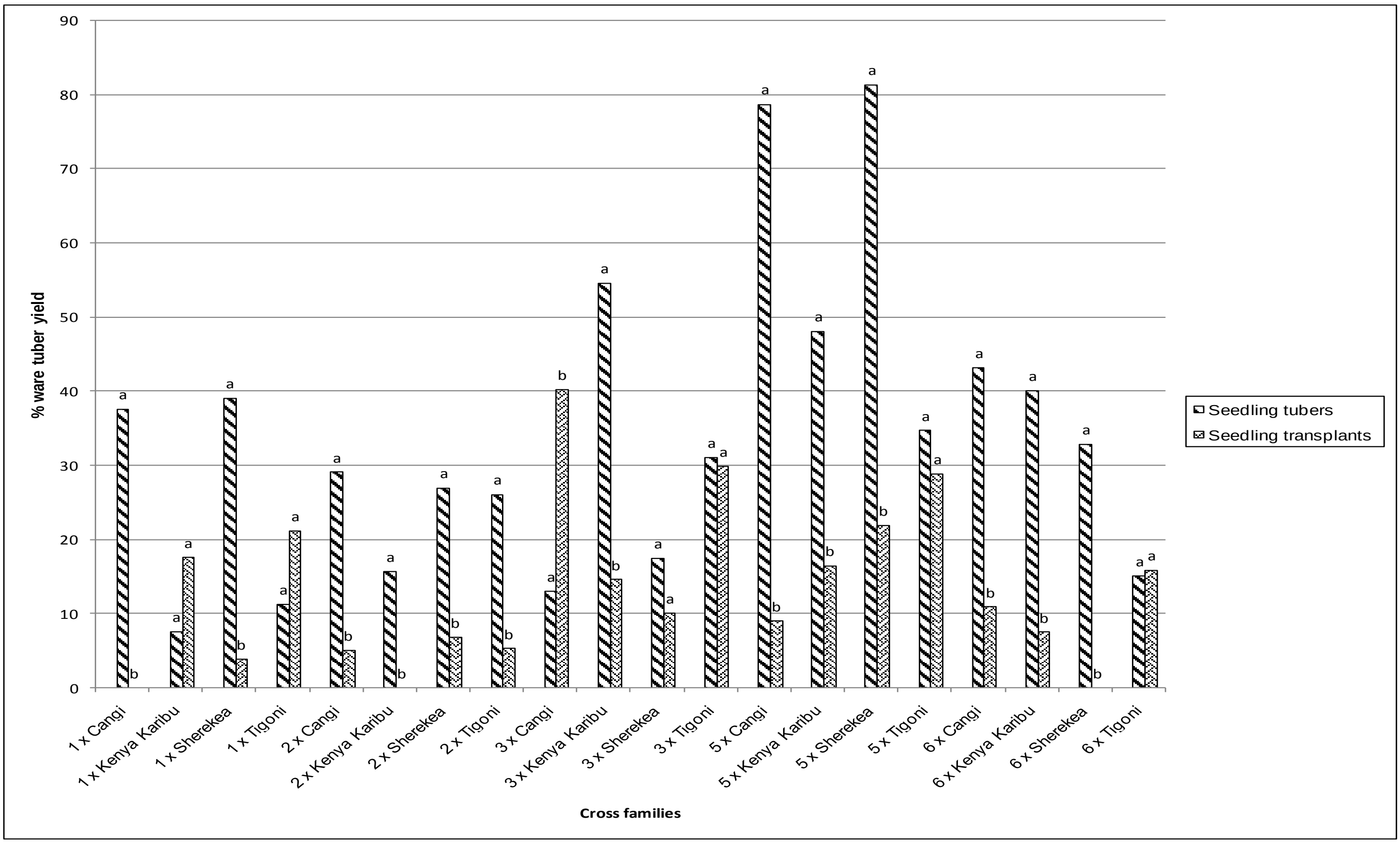

Fig 1. Percent of ware tuber yield for the various cross families and propagation methods. For each cross family, columns headed by the same letter are not significantly (P≤ 0.05) different from each other.

tuber seed crop, and seedling tubers usually outyield seedling transplants (Gisela and Peloquin, 1991; Patel et al., 1998; Chujoy and Cabello, 2007). In situations where field conditions for direct seeding are not favourable or where the growing season is too short, raising seedlings in nursery beds and transplanting them into the field is a good alternative (Almekinders et al., 1996). This shortens the growing period of the crop in the field. Production of ware potatoes from seedling transplants is advantageous in that the crop is raised from first generation plants derived from TPS and consequently, the health standard of this crop is optimal (Struik and Wersema, 1999) due to limited exposure to soil-borne pathogens. In addition, some seedling selection is possible through elimination of plants with low vigour or off-type plants during transplanting; this selection may enhance uniformity of the TPS family and improve crop performance after transplanting (Golmirzaie and Mendoza, 1986). Direct seeding or transplanting of seedlings for ware tuber production only seems to have potential in areas where the market accepts small tubers for consumption (Almekinders et al., 1966; Alemkinders e al., 2009). Against this background, a study was conducted whose objective was to compare the effectiveness of seedling tubers and seedling transplants in production of a potato crop from true potato seeds.

Results

There were significant differences in terms of tubers per plant among the different cross families, between the two propagation methods and in the interaction between cross families and propagation methods (Table 2). In addition, the seedling transplants gave significantly more tubers per plant (15.68) than the seedling tubers (13.08). There were significant differences in terms of % of ware tuber yield (based on total tuber yield in ton/ha) among the different cross families, between the two propagation methods and in the interaction between cross families and propagation methods (Table 3). In addition, the seedling tubers gave

Table 2. Tubers/plant for the various cross families and propagation methods.

Source of variation	d.f.	m.s.	v.r	F pr.
Block	4	63.61		
Cross family	19	128.11	5.65	<0.001**
Error a	76	22.67		
Propagation method	1	338.00	13.93	<0.001**
Cross family x Propagation method	19	73.69	3.04	<0.001**
Error b	80	24.27		
Total	199			

**=significant at P≤0.01

Table 3. Analysis of variance: % of ware tuber yield for the various cross families and propagation methods.

Source of variation	d.f.	m.s.	v.r	F pr.
Block	4	3087.5		
Cross family	19	1231.5	2.09	0.013*
Error a	76	590.4		
Propagation method	1	21894.1	36.18	<0.001**
Cross family x Propagation method	19	1416.1	2.34	0.005**
Error b	80	605.2		
Total	199			

*=significant at P≤0.05; **=significant at P≤0.01

Table 4. Total tuber yields (ton/ha) for the various cross families and propagation methods.

Source of variation	d.f.	m.s.	v.r	F pr.
Block	4	956.6		
Cross family	19	815.7	2.39	0.004**
Error a	76	341.8		
Propagation method	1	2531.5	7.93	0.006**
Cross family x Propagation method	19	469.9	1.47	0.119^{ns}
Error b	80	319.4		
Total	199			

*=significant at P≤0.05; **=significant at P≤0.01; ns= non-significant.

Table 5. Ranking of various cross families for total yields and ware tuber yield (%).

Cross family	Mean total yield (ton/ha)	Rank	Mean (% ware tuber yield)	Rank	Average rank	Overall rank
5 x Kenya Karibu	48.76	1	32.26	4	2.5	1
6 x Cangi	41.47	4	27.07	7	5.5	3
5 x Tigoni	36.40	6	31.82	5	5.5	3
5 x Sherekea	32.84	10	51.62	1	5.5	3
1 x Sherekea	46.00	3	21.54	10	6.5	5.5
5 x Cangi	31.51	11	43.85	2	6.5	5.5
3 x Kenya Karibu	31.24	12	34.61	3	7.5	7
1 x Tigoni	48.67	2	16.27	15	8.5	8
2 x Sherekea	32.89	8.5	16.90	13	10.75	9
2 x Tigoni	36.27	7	15.70	16	11.5	11
6 x Kenya Karibu	27.20	14	23.78	9	11.5	11
3 x Tigoni	21.87	17	30.48	6	11.5	11
1 x Kenya Karibu	39.82	5	12.62	19	12	13
6 x Tigoni	32.89	8.5	15.46	17	12.75	14
3 x Cangi	21.51	18	26.62	8	13	15
2 x Cangi	24.80	15	17.10	12	13.5	16.5
1 x Cangi	24.36	16	18.78	11	13.5	16.5
2 x Kenya Karibu	28.89	13	7.85	20	16.5	18.5
6 x Sherekea	21.16	19	16.46	14	16.5	18.5
3 x Sherekea	20.40	20	13.78	18	19	20

significantly more ware tubers (34.2%) than the seedling transplants (13.3%). The interaction between cross families and propagation methods were not significant in 1 x Kenya Karibu;1 x Tigoni; 3 x Sherekea; 3 x Tigoni; 5 x Tigoni, and 6 x Tigoni (Fig. 1). There were significant differences in terms of total tuber yield among the different cross families and between the two propagation methods. The interaction between cross families and propagation methods were not significant (Table 4). In addition, the seedling tubers gave significantly higher total tuber yields (36.0 ton/ha) than the seedling transplants (28.9 ton/ha). The five highest yielding cross families were 5 x Kenya Karibu; 1 x Tigoni; 1 x Sherekea; 6 x Cangi and 1 x Kenya Karibu in that order (Table 5). When the cross families were ranked based on total yield (ton/ha) and ware tuber yield (%), the four highest ranking cross families were 5 x Kenya Karibu; 6 x Cangi; 5 x Tigoni and 5 x Sherekea in that order (Table 5). Correlation between total tuber yields (ton/ha) and percent ware tuber yield was positive (0.0820) and non-significant (P= 0.7312).

Discussion

Although, the seedling transplants gave significantly more tubers per plant (15.68) than the seedling tubers (13.08), the reverse was the case when it came to total tuber yield (ton/ha). This could possibly mean the seedling tubers gave bigger (and hence heavier) tubers than the seedling transplants. This was confirmed by the higher % ware tuber yield obtained from the seedling tuber crop (34.2) than the seedling transplants (13.3). These results are in agreement with the common observation that seedling transplants often have longer growth duration, higher tuber set and smaller tuber size compared to plants derived from conventional tuber seed or tuber generations of TPS (Thomson, 1980; Simmonds, 1997; Chujoy and Cabello, 2007). In addition, seedling transplants often have a lower yield (tuber number per plant x average tuber weight) than the conventional tuber seed crop, and seedling tubers from TPS usually outyield seedling transplants (Gisela and Peloquin, 1991; Patel et al., 1998; Chujoy and Cabello, 2007). The general inferiority of seedling transplants in terms of total tuber yields is confirmed by lack of significant interaction between propagation methods and cross family (Table 4). Clone 5 appeared to be a good parent because three of her crosses were ranked in the first four positions in terms of total tuber yields and ware tuber yields (Table 5). Clone 5 has been observed to give big tubers and it could have a dominant effect in determining the tuber size. The lack of significant interaction between cross families and propagation methods in 1 x Kenya Karibu;1 x Tigoni; 3 x Sherekea; 3 x Tigoni; 5 x Tigoni, and 6 x Tigoni in terms of ware tuber yield could be due the fact that Tigoni generally does not yield big tubers. In addition, this parent could have a dominant effect in determining the tuber size.

Materials and Methods

Plant materials and field layout

Four potato varieties commonly grown by farmers in Kenya were crossed with five advanced clones from CIP in a North Carolina II mating design to generate the experimental materials (Table 1). After crossing, the resultant 20 F_1 cross families were harvested from the mother plants when the berries were mature. The berries were stored in khaki paper bags for three weeks to soften before processing. The ripened berries were processed by cutting them with a knife and empting the seeds into a basin containing clean water. The seeds were washed and then spread on filter papers and placed on a table to air-dry overnight in the laboratory. The following day, half of the seeds from each cross family were soaked in 1500 ppm GA_3 solution for 24 hours to break dormancy. Thereafter, they were rinsed and immediately sown in plastic trays containing sterilized sand. (The other half of the seeds were dried over silica gel and then hermetically sealed in aluminium foil; they were then stored at room temperature for four months). Four weeks later, the seedlings from the trays were transplanted into plastic polythene pots containing a mixture of sterilized forest soil and farmyard manure. The seedlings were transplanted one seedling per pot. The pots were then placed in a screenhouse. (These were the pot seedlings). Watering was done using a can and the plants were sprayed against pests and disease as need arose. When they were mature, the crop was harvested and all the seedling tubers from each cross family were bulked together. They were then sprouted by treating them with GA_3 at 5 ppm. and then planted in the field in the following rainy season to give the seedling tuber crop. The other half of the seeds which had previously been stored were treated with 1500 ppm GA_3 solution for 24 hours to break dormancy. They were then sown in trays. Four weeks later, the seedlings were transplanted directly from the plastic trays into the field to give the seedling transplant crop. The seedling tubers and seedling transplants were planted in the field at the same time during the same season (i.e. March-July 2013).

In the field, the experiment was laid out in split plot design in which the cross families (20 of them) were the main plot and the propagation methods (seedling tubers and seedling transplants) were the subplots. There were five replications. Each subplot consisted of one 10-meter row containing 33 plants. Plant spacing was 75 cm x 30 cm between and within row, respectively. During planting, DAP (18% N: 46% P_2O_5) was applied at the recommended rate of 500 kg/ha. Weeding, earthing-up and spraying against pests and late blight were carried out as per recommendations for potato production in Kenya (KARI, 2008).

Data collection and analysis

Once the crop was mature in the field, ten plants were randomly sampled from each subplot. From each plant, data collected included tuber numbers/plant, total weight of tubers per plant (kg) and weight of ware tubers (45 mm< in diameter) per plant (kg). Figures from each of the 10 plants were averaged to give the subplot value. These were then used to calculate total tuber yield (ton/ha) and yield of the ware tubers by weight (% of tubers 45 mm< in diameter) of the total tuber yield (ton/ha). Data was analysed using Genstat statistical package, 14th edition (Payne et al., 2011) and means separated using Fisher's Protected LSD Test at 5% (Steel and Torrie, 1980).

Conclusions

Seedling transplants gave significantly more tubers per plant (15.68) than the seedling tubers (13.08) while seedling tubers gave higher tuber yields (ton/ha) and a higher percentage of ware tubers than the seedling transplants. Although seedling transplants take a shorter time to produce a potato crop of commercial value, the low tuber yields (ton/ha) and percentage ware tubers renders this propagation method unsuitable.

Acknowledgements

The authors are grateful to the Alliance for a Green Revolution in Africa (AGRA) for funding this research and Kenya Agricultural Research Institute (KARI), National Potato Research Centre management for facilitating the fieldwork.

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