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Field and Greenhouse Tuberization of Six Potato Cultivars Grown From *in vitro* Plantlets

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Abstract. Nodal cuttings of six potato (*Solanum tuberosum*) cultivars were used to compare their tuberization response under field and greenhouse conditions. Cultivars used were: Desiree, Kennebec, Norgold Russet, Norland, Russet Burbank and Spunta.

Murashige and Skoog media was used for subculturing. Plantlets grown *in vitro* were transplanted into greenhouse benches filled with Metro Mix potting soil. Starter fertilizer was applied. Acclimatization was carried out by 50 % shading and frequent misting. Minitubers were harvesed 12 weeks after transplanting. Another study was undertaken under field conditions to compare tuber production of the six cultivars from the *in vitro* produced plantlets.

Significant differences occurred between cultivars grown either under field or greenhouse conditions. Cultivars response to treatments were correlated under both conditions. Significant correlation was found between average number of minitubers and average weight of field grown tubers. These studies indicated that the potential for estimating yielding ability of potato under field conditions can be obtained by a small condensed greenhouse trial for minituber production.

Introduction

There have been several literature reviews dealing with potato tuberization [1,2,3,4,5,6]. Wattemina [7] summarized the factors inducing tuberization as follows: short day, high light intensity, low night temperature, low nitrogen level, physiologically old tubers, and any combination of these factors. Tuberization of potato has been the central theme for several investigations dealing with potato growth and development.

Tuberization has been studied under both *in vivo* and *in vitro* conditions. *In vitro* produced planting stocks offer many advantages to potato growers as well as to researchers. Among these are: assurance of disease free plants; adapted to a wide

range of cultivars, usually suited to growers needs and resources and maximizes the likelihood or uniformity in plant establishment and growth. Bajaj [8] has stated that "biotechnology has literally moved the potato from the test tube to the field."

The objective of this study was to compare the performance of *in vitro* produced potato plantlets under field and greenhouse conditions with respect to tuberization responses.

Materials and Methods

Plant materials

Tubers of six potato cultivars were induced to sprout at room temperature. Cultivars used were: Desiree, Kennebec, Norgold Russet, Norland, Russet Burbank and Spuata. Sprouts of 20 to 30 mm in length were excised and sectioned into 5 mm sections, each with at least one node. Sections were surface disinfected by dipping in 70% ethanol for 20 seconds, rinses in 2% sodium hypochlorite for 2 minutes followed by rinsing in sterilized distilled water and aseptically cultured on agar media. The culture vessels were baby food jars (Ball Corporation/Gerber Products) covered with a hard plastic lid (Magenta Corporation) allowing for gas exchange.

A modified Murashige and Skoog (MS) media [9] was used for propagation (Table 1). The culture room temperature was maintained at 22 to 25°C, while photoperiod was 16 hours at 2000 lux. Auxiliary shoots and roots development occurred nearly 6 to 10 weeks following the initial sprout explant establishment. Fully developed plantlets were then used in subculturing.

Subculturing

When plantlets were 6 to 10 cm tall, they were aseptically removed from the culture jars and sectioned into nodal cuttings. About 5 nodal cuttings were placed in each culture jar. Shoots of plantlets generally attained 10-12 cm in height within two weeks.

Acclimatization

About 240 adequately rooted, two to three weeks sold plantlets of each cultivar were transplanted into "cell pack" plastic trays (American Clay Works, Denver, CO) filled with Metro Mix 350 (Metro Mix is a potting soil containing the following ingredients: Canadian sphagnum, peat moss, domestic horticultural vermiculite, processed rock ash and washed granite sand (Grace Horticultural Products, W.R. Grace Co., Cambridge, MA). Before transplanting, the soil mix was saturated with

Table 1. Composition of modified MS culture media for nodal propagation

Compound (mg l^{-1})	Single node propagation
NH_4NO_3	1650
KNO_3	1900
$CaCl_2 2H_2O$	440
$MgSO_4 7H_2O$	370
KH_2PO_4	170
H_3BO_3	6.2
$MnSO_4 4H_2O$	22.3
$ZnSO_4 7H_2O$	8.6
KI	0.83
$Na_2MoO_4 2H_2O$	0.25
$CuSO_4 5H_2O$	0.025
$CaCl_2 6H_2O$	0.025
Na_2EDTA	37.3
$FeSO_4 7H_2O$	27.8
Thiamine HCl	0.4
Myo-Inositol	100
Sucrose	3 %
Agar	0.65 %

a starter frtilizer, Miracle Gro (15-30-15) (Stern's Miracle-Gro Products, Inc., Port Washington, N.Y.) diluted at a rate of 1.3 cc l^{-1}. The plantlets were placed under shade cloth (50% shade) and watered for 30 sec every 5 min from 5 a.m. to 8 p.m. Osmocote 14-14-14, a slow release fertilizer (Sierra Chemical Co., Milpitas, CA), was applied five days later at a rate of 1.2 g $plant^{-1}$ and the watering interval was increased to 10 minutes and later to 20 and 30 minutes.

Plantlets were placed outdoors for 4 hours and exposed to the outdoor environment for increasing periods until 8 hours period was achieved after 14 days; watering intervals were also increased during this period.

Field plot

The field plot was located at the Hoticultural Research Center, Colorado State University near Fort Collins, Colorado. The study was carried out during 1986 and 1987 growing seasons. The soil was a Nunn clay, with a pH of 8.1. The site was fallow for 2 years prior to planting. The plot was fertilized with 67.2 kg ha^{-1} of nitrogen {ammonium nitrate (NH_4NO_3)} and 168 kg ha^{-1} of phosphorus (treble superphosphate {Ca $(H_2PO_4)_2$ and $CaHPO_4$)}. Randomized block design with 4 replications of 30 plants each per cultivar was used.

Transplanting was done by hand on 90 cm wide rows running east/west with spacing of 30 cm between plants. Each plantlet had at least 3 to 5 fully developed leaflets and a well developed root system. Planting depth was about 3 to 5 cm which was adequate to cover the root system of plantlets. After transplanting, about 200 cc of diluted Miracle-Gro (1.3 ml l^{-1}) were applied to every plantlet. The plot was furrow irrigated the following day.

Greenhouse minituber production

This study was carried out in the greenhouse of the Colorado Potato Certification Program, Fort Collins, Colorado.

A randomized block design with 4 replications per cultivar was used. Plantlets were transplanted at 20 × 20 cm spacing into benches filled with Metro Mix. A border row of Sangre cv. plantlets was transplanted along the outer edges of each bench. Prior to planting, 100 cc of diluted Miracle-Gro was applied to each plant location and a shade cloth was used to provide 50% shading.

Plantlets were transplanted and then watered for 30 sec every 10 min. Three days later, watering intervals were adjusted to every 30 min. Shade cloth was removed at the end of the first week. Osmocote was applied three times at the rate of 1.2 g $plant^{-1}$ at 10 days intervals. Harvesting was carried after 12 weeks of growth. Tuber number and weight were recorded.

Results and Discussion

Significant differences occurred in both number and weight of tubers per plants among cultivars grown under field and greenhouse conditions (Table 2).

Significant correlation ($P=0.05$) was found between average number of minitubers and the average tuber weight of field grown tubers (Fig. 1). This significant correlation occurred, however, when all genotypes were planted at the same planting density which may not be optimum for individual genotypes.

Table 2. Tuber yield comparisons of six potato cultivars grown under field and greenhouse conditions

Cultivars	Field		Greenhouse	
	Number (tuber plant^{-1})	Weight (g plant^{-1})	Number (tuber plant^{-1})	Weight (g plant^{-1})
Desiree	12.7	751.6	8.0	94.5
Kennebec	9.8	981.5	9.3	87.9
Norgold Russet	8.6	592.7	2.8	11.1
Norland	10.7	516.2	5.3	172.7
Russet Burbank	8.7	511.1	6.0	79.7
Spunta	10.8	1006.9	7.5	107.0
LSD	2.3	273.2	3.9	30.1

When comparing field and greenhouse conditions (Fig. 1), Spunta and Kennebec produced higher yield than Norgold Russet, Norland, or Russet Burbank. Desiree was intermediate in tuber yield.

No significant correlations were found between greenhouse and field grown plants in either tuber number or tuber weight per plant. Some cultivars (i.e. Desiree and Norland) produced higher numbers of small tubers under field conditions only. Cultivars with higher number of tubers may not necessarily produce higher tuber weight and vice versa. A significant correlation, however, was found between weight of field grown tubers and number of greenhouse grown tubers. This correlation suggested that tuber number rather than weight is important for reporting yield under greenhouse conditions. Greenhouse conditions may permit a valid expression of tuber number potential but limitations in soil space and possibly radiation may not permit maximum tuber size development. Generally, maximum yield depends on a minimum number of tubers being produced to achieve an optimum top: tuber ratio.

A vast amount of research has been done on *in vivo* tuberization with conventionally grown potatoes. Differences between cultivars have also been reported. The comparative reponses of conventional vs. micropropagation techniques under field conditions have been studied by Wattimena, *et al.* [10]. They used Norland (early

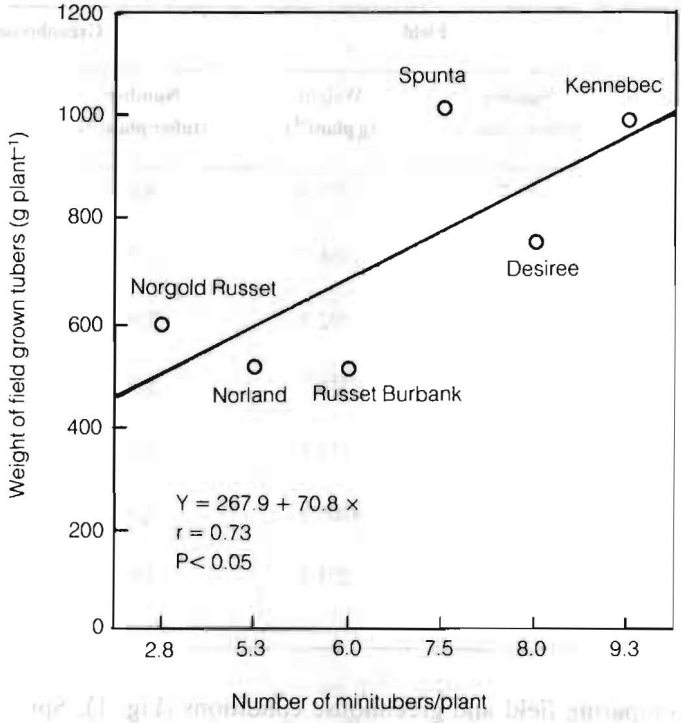

Fig. 1. Yield relationships of six potato cultivars grown under field and greenhouse conditions.

maturing) and Red Pontiac (later maturing) cultivars. The propagule sources were either seed-tuber, microtuber or microshoots (plantlets). They reported that micropropagated plants had a greater number of tubers per plant than plants grown from seed tubers. At the end of the season, no differences in total tuber weight were observed among plants produced by either method. They also reported that Norland plants grown from microshoots produced lower yield as compared with Red Pontiac plants. The results being reported herein represented similar findings as Norland was low yielding (Table 2) while Kennebec and Spunta were high yielding.

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إنتاج درنات بطاطس تحت ظروف الحقل والبيوت المحمية لستة أصناف من البطاطس مكثرة بواسطة النبيتات المنتجة في مزارع الأنسجة

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ملخص البحث. تم إكثار أجزاء من سيقان نباتات البطاطس لإنتاج نبيتات من ستة أصناف وهي ديزيراى، كينيبك، نور جولدرست، نورلاند، رست بربانك، سبونتا. وقد تم استخدام بيئة مورا شيجي وسكوج للزراعة المتكررة للأنسجة. وتم نقل النبيتات من بيئة زراعة الأنسجة إلى طاولات الزراعة في الصوبة حيث استخدمت مادة مترومكس كبيئة زراعة مع استخدام السماد البادىء أثناء الزراعة. تمت أيضًا أقلمة النبيتات بتظليلها (٥٠٪ ظل) مع الري بالضباب. وتم حصاد الدرنات الصغيرة بعد ١٢ أسبوعًا من الشتل وقد أجريت تجربة أخرى تحت ظروف الحقل لزراعة نبيتات جميع الأصناف المنتجة بواسطة زراعة الأنسجة.

تم الحصول على اختلافات معنوية في عدد ووزن الدرنات المنتجة/ نبات بين الأصناف المزروعة سواء تحت ظروف الحقل أو الصوبة. كما وجد ارتباط معنوي بين متوسط عدد الدرنات الصغيرة المنتجة في الصوبة ومتوسط وزن الدرنات المنتجة بالحقل. وتوضح هذه الدراسة أنه يمكن تقدير القدرة المحصولية للبطاطس تحت ظروف الحقل بعد إجراء تجربة مصغرة لإنتاج الدرنات الصغيرة في الصوبة.