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NOTE

TPS-DERIVED SEED TUBERS FOR POTATO PRODUCTION IN FEREYDAN REGION OF IRAN

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ABSTRACT

In Iran, as in other developing countries, seed tuber is a major constraint to potato production. Thus, it is logical to consider the use of true potato seed (TPS) in Iran, as in some countries such as China. This study involved two experiements. In Experiment I, TPS-derived tubers from 12 progenies were compared to those of four cultivars. The cultivars were superior, regarding yield, number of tubers and tuber weight. However, compared to progenies, they had less uniform tubers, mainly due to more within-plant variation. Experiment II involved 5 progenies, 2 methods of elimination (eliminating small tubers or poor plants) and 2 intensities of elimination (eliminating the first 10% or 20% of small tubers, or poor plants). Eliminating the first 20% of small tubers resulted in significant 7% increase in yield per plant and improved tuber uniformity by 2%.

Key words: TPS, True potato seed.

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غده بذری حاصل از بذر واقعی برای تولید سیب زمینـــــی در منطقــه فریدن ایران

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چکیده

در ایران ، مانند دیگر کشورهای در حال توسعه، بذر عامل محدود کننده اصلی در تولید سیب زمینی است. بنابراین ضروری است در ایران نیز، مانند برخی کشـورها از قبیـل چیـن، تولیـد بـذر واقعـی سـیب زمینی مورد توجه قرارگیرد. این پژوهش شامل دو آزمایش بود. در آزمـایش اول، غـده بـذری حـاصل از ۱۲ نتاج بذر واقعی سیب زمینی با چهار رقم سیب زمینی مقایسه شد. ارقام، از نظر عملکرد، تعداد غـده و وزن غده، نسبت به نتاج برتری داشتند. ولی یکنواختی غده های آن ها، به علـت تغییرات درون بوتـه ای بیشتر، از نتاج کمتر بود. آزمایش دوم شامل ۵ نتاج، ۲ نحوه حذف(غده های ریز یا بوته های کم عملکرد) و ۲ شدت حذف (حذف ۱۰ درصد یا ۲۰ درصد)، بود. حذف ۲۰ درصد غده های ریـز تـر بـاعث ۷ درصـد افزایش در عملکرد و ۲ درصد بهبود در یکنواختی غده ها گردید.

INTRODUCTION

Potato production in the developing countries of Asia has trippled during the last 30 years (7). However, one of the main constraints to its production is the high cost of seed tubers. Healthy seed tuber is vital to potato production in Iran. Healthy seed tuber, has been produced, in a limited scale, through the cooperation of Isfahan University and the Ministry of Agriculture, using the standard tissue culture technique. This technique, however, due to its rather elaborate nature, has not been used extensively in Iran. Similar problems have been reported from other developing countries (12). As a supplementary method, use of TPS can be considered (1, 12). In the last two decades, TPS technology has been adopted in a number of developing countries with different agro-ecological and socio-economic conditions, with China, India and Vietnam being the leading countries (7). In some cases such as Egypt and India, TPS provides better or cheaper planting material than a seed tuber program (1). In Iran, although being the fourth largest potato producer in Asia (7), research on TPS is recent. In fact the first published work was in 1988, on the use of local material for preparing soil mix to grow seedlings from TPS (10). Further work regarding different TPS planting methods was carried out in Fereydan and Isfahan (8). However, at present, producing potatoes through transplanting TPS seedlings is not being practiced by the farmers, since it requires greenhouse facilities and knowledge of growing and handling the transplants. TPS-derived seed tuber seems to be a more practical alternative (1). According to Simmonds (12), direct seeding and transplanting have been abandoned in favour of the use of 'tuberlets' or somewhat larger mini tubers. In fact, utilization of tubers from TPS has been promising in Italy (4). Superior yields and heavier tubers resulting from seed-tubers as compared to transplants (13), and comparable yield and tuber weight to that of cultivars have been reported (1, 13). Moreover, yield improvements may be brought about by rouging out weak seedlings, which are mainly the result of selling. In fact, Atlin and Wiersema (3) questioned the necessity of producing hybrid seeds to obtain a high yielding TPS. They believe open pollinated progenies can be produced from mixed plantings of suitable clones and the resulting mixture of hybrid and inbred progenies can be improved by roguing out weak seedlings in the nursery seed bed. Of course, elimination of inbred seedlings or their resulting tubers can be achieved more efficiently through the use of marker genes, such as the one used by Arndt and Peloquin (2). Direct seeding at the spacing of 10 cm × 10 cm in the nursery bed (producing 1242 tubers per m^2) was recommended by Wiersema (15). Uniformity is still a problem with production of tubers from TPS and has limited its uptake in Europe (5). A difference of 2% in coefficient of variability (CV) of tuber size, has been shown to alter the saleable yield by 3.5% (15).

In this study, two experiments were carried out to: a) compare the performance of some TPS-derived seed tubers to those of cultivars grown in Fereydan, the major potato producing region of Isfahan province and b) investigate the possibility of increasing their yield and tuber uniformity, through the elimination of poor plants and small tubers in a seed program.

MATERIALS AND METHODS

Experiment I

Seeds from each of the 12 TPS progenies (Table 1), obtained from International Potato Center (CIP) were grown in 60 Fin pots in the greenhouse in April 1993 and the seedlings were transplanted to a field in Fereydan in June. At harvest, five bags were prepared for each progeny, each containing one tuber from each plant, to be used as five replications in the following experiment. In May 1994, the tubers from the 12 progenies along with those of four cultivars commonly grown in the area were planted in a field in Fereydan in a randomized complete block design with 5 replications. Each plot consisted of a row of 60 tubers. At the end of the growing season, each plant (hill) was harvested separately. First, tubers less than 35 g were discarded. Then the weight, length, width (breadth) and thickness of the others were measured. The progenies and cultivars were compared regarding: weight and number of tubers per plant (hill), average tuber weight and the corresponding within plot coefficients of variability. They were also compared with respect to total, within and between plant uniformity, using overall variability index (OV), suggested by Sepahi (10). The method, in short, is based on the amount of variation regarding length, width, and thickness of the tubers. A given tuber can be represented by a point in a 3-dimensional space, with its coordinates representing the length, width and the thickness of the tuber. If a TPS progeny is highly uniform, regarding the three dimensions, the resulting points will cluster close to one another in space; otherwise, the points will be scattered throughout a larger space. Thus the sum of squares of the deviations of the points from the center of the cluster, is used as a measure of variability.

Experiment II

Based on yield, uniformity and marketing quality, obtained from Experiment I, five progenies (Table 2) were selected and the following procedure was followed for each of them. True seeds were planted in beds in the greenhouse in Nov. 1994, producing 50 plants. At harvest, two bags were labelled T and P, each containing one tuber from each of the 50 plants.

In the spring 1995, the tubers from each bag were planted in separate rows in the field. At harvest, four bags were labelled T, each containing one tuber from each plant from the T row and four bags labelled P, each containing one tuber from each plant from the P row. In short, the aim of the above procedure was to obtain 8 bags each containing one tuber from each of the original plants from TPS. The tubers from the 8 bags were planted in separate rows in the field in June 1996. At harvest, the tubers from each of the rows, labelled T, were ranked, based on tuber size. The smallest 10% (class 1), the second 10% (class 2) and the remaining 80% (class 3) were bulked in three separate bags. For the rows labelled P, the plants were ranked based on their yield. Thus the tubers from the poorest 10% plants, the second 10% and remaining 80% were bulked in three separate bags.

In May 1997, the tubers were planted in the field in a split split plot design with four replications. The main plots represented the progenies, each consisting of two sub plots, corresponding to the two methods of elimination (T and P). Each subplot consisted of a single row divided into three segments, to which tubers from the three corresponding classes were planted at random. Tubers from each segment were harvested separately. To reduce the number of measurements, they were visually ranked according to size. Then, every other one was picked, and its weight, length, width and thickness were measured.

The analysis of a split split plot design was used, with the progenies and the methods of elimination (T or P) assigned to the main and subplots, respectively. The sub sub plots, however, were assigned to the two intensities of (tuber or plant) elimination:

- The first 10% eliminated, thus using the measurements on the tubers from the 2nd and 3rd classes (bulked),
- The first 20% eliminated, using the measurements on the tubers from the 3 rd class.

The characteristics considered were: yield per plant (hill) and average tuber weight, its coefficient of variability, and uniformity index, all expressed as the percent of the no elimination (i.e. all three classes considered).

RESULTS AND DISCUSSION

Experiment I

Mean comparisons for the nine characteristics are presented in Table 1. At the bottom of the table, single-degree-freedom comparisons between the cultivar means and the progeny means are presented. These comparisons indicate the superiority of the cultivars regarding yield and number of tubers per plant; tuber weight and uniformity in yield and number of tubers per plant. However, regarding the characteristics related to tuber uniformity, i.e. the last four columns of the table, the progenies were superior, mostly due to their higher within plant uniformity. Uniformity of tubers produced from TPS, comparable to that of cultivars have been reported by previous workers [e.g., review by Carputo *et al.* (4)]. However, their being more uniform than the cultivars is not normally expected. The higher variability of the tubers from the cultivars, in this study, could be due to the fact that cultivars, on the average, produced 2.1 tubers per plant more than the progenies. A positive correlation between tuber number and CV of tuber size has been reported in some experiments [e.g., review by Wurr *et al.* (16)}. The correlation coefficient of 0.69 ($P<0.01$) between number of tubers and total MS (columns 3

Table 1. Mean comparisons† for yield and number of tubers per plant (hill), average tuber weight; and their corresponding coefficients of variability, along with tuber uniformity determined in terms of total, between and within plant mean squares (MS), for the four potato cultivars and twelve progenies. The single-degree freedom comparisons between the cultivars and progenies are presented at the bottom of the table.

				CV for			Uniformity		
Cultivar or progeny	Yield plant^{-1} (g)	No of tubers plant^{-1}	Avg. tuber weight (g)	Yield plant^{-1}	No of tubers plant^{-1}	Avg. tuber weight	Total MS	Between plant MS	Within plant MS
Moren	995a	7.4a	135a	43cde	40cd	71a	8.5a	8.3ab	8.3a
Marfona	937a	7.4a	126ab	33e	38cd	65abc	5.9a	9.0ab	5.5a
Famosa	806a	6.8ab	116bc	41de	41bcd	60abc	5.7a	10.8a	5.0ab
Draga	768a	6.0abc	125ab	41de	33d	69ab	5.6a	7.7ab	5.3a
980001	511b	4.8cd	110bc	65bcd	56bcd	65abc	5.4a	7.2ab	5.0ab
985003	469b	4.8cd	100cd	62bcd	59abcd	60abc	4.8ab	10.2ab	3.6abc
978004	464b	5.2bcd	87d	70abc	62abcd	63abc	4.3ab	8.4ab	3.5abc
981002	446b	4.4cd	98cd	65bcd	60abcd	60abc	4.0ab	6.3ab	3.4abc
984001	434b	5.6bc	76d	84ab	76ab	55abc	3.3ab	8.1ab	2.4 b
985002	432b	4.4cd	94cd	70abc	60abcd	64abc	4.5ab	8.7ab	3.4abc
985001	417b	5.4bcd	79d	63bcd	55bcd	58abc	3.8ab	8.1ab	3.0abc
986001	409b	4.2cd	97cd	74ab	64abcd	67abc	4.2ab	7.4ab	3.3abc
980003	408b	5.8abc	73d	78ab	69abc	54abc	3.4ab	8.6ab	2.5 b
985004	397b	4.8cd	80d	82ab	73abc	62abc	3.7ab	8.3ab	2.7bc
978001	353b	4.2cd	83d	77ab	64abcd	53bc	2.9b	5.2b	2.3 b
987001	258b	3.4d	76d	98a	91a	53bc	3.8ab	7.0ab	3.0abc
Cultivar mean	876	6.9	125	39	38	66	6.4	9.0	6.1
Progeny mean	416	4.8	88	74	66	60	4.0	7.8	3.2
F value	132.11**	70.7**	121. 57**	80. 87**	40. 55**	10. 20**	49.34**	2.41	79.94**

†. In each column, means with the same letters are not significantly different at the 5% level, using the Student-Newman-Keul's test.

and 8 of Table 1) shows a decrease in uniformity with an increase in the number of tubers.

Field observations showed that tubers from the cultivars and progenies were quite uniform in shape; and variability was mostly in size. Thus, the correlation coefficient of 0.77($P<0.01$) between the figures in the 7th and 8th columns of Table 1, attests to the validity of the uniformity index suggested by Sepahi (10).

The fact that, between plant variation of progenies was more than within plant variation, led to the possibility of further increasing tuber uniformity through eliminating poor genotypes at the early stage of seed increase. This was the incentive for conducting Experiment II.

Experiment II

Mean comparisons between the levels of the three factors for four characteristics are presented in Table 2. All progenies responded, more or less, positively to elimination, regarding yield per plant, CV for tuber weight and the uniformity index. However they did not respond as well, regarding tuber weight. In fact, in the case of progeny 978004, there was a slight decrease in tuber weight (attributable to chance), causing lack of effect shown for the corresponding methods and intensities of elimination. Both tuber and plant elimination, specially elimination of the first 20% of small tubers, caused a significant increase (about 7%) in yield, and improved tuber uniformity (i.e., CV for tuber weight and the uniformity index) by about 2%. Positive correlation between yield and the size of seed tuber has been reported by some workers (6), with the highest yield obtained from seed tubers of about 62 g.

Tuber elimination was more effective than plant elimination. This could probably be due to one or both of the following:

1. Variation in the size of seed tubers within a progeny, affect the yield more than the variation in genotypes. This would be expected, if the genotypes
2. comprising the TPS progenies, produced by CIP, are fairly uniform in performance.

3. Plant elimination removes only the inferior genotypes; whereas tuber elimination, besides removing small tubers, could indirectly reduce the frequency of inferior genotypes (assuming that inferior genotypes produce relatively more small tubers).

Table 2. Mean comparisons† for yield per plant (hill), tuber weight, CV for tuber weight and the uniformity index for the five progenies, two methods of elimination and two intensities of (tuber or plant) elimination, all expressed as percent of no elimination.

Factor	Yield plant^{-1} (g)	Avg. weight tuber^{-1} (g)	CV for tuber weight	Uniformity index
Progeny				
980001	103 cd	100 ab	99 ab	99 ab
985003	105 bc	100 ab	98 ab	99 ab
978004	108 b	99 b	97 ab	98 ab
984001	102 d	104 a	96 b	95 b
980003	110 a	101 ab	100 a	100 a
No Elimination	100 d	100 ab	100 a	100 a
Elimination method				
Tuber	106 a	101	98 b	98 b
Plant	104 b	100	98 b	99 a
No elimination	100 c	100	100 a	100 a
Elimination intensity				
10 %	104 b	100	98 b	98 b
20 %	107 a	100	98 b	98 b
No elimination	100 c	100	100 a	100 a

†. In each column, means with the same letters are not significantly different at the 5% level, using the Student-Newman-Keul's test.

CONCLUSIONS

The yield of the progenies in Experiment I was not promising. However, this was an exploratory small sample of progenies and a great number of them should be tested to find some with yields comparable to those of the cultivars for the Fereydan region. Nevertheless, results from Experiment II indicated the possibility of improving yield and uniformity of such progenies.

Thus a three generation (over two years) procedure can be suggested for the production of TPS-derived seed tubers for Iran:

1. Seeding TPS in greenhouse beds in winter and thinning out to about 10 × 10 cm, through roguing out of weak seedlings,
2. Seed tuber increase in the field involving, roguing out infected plants, harvesting individual hills and eliminating off-type tubers or those from low yielding plants,
3. Another tuber increase in the field involving, roguing out infected plants, field inspection for certification and elimination of small tubers at harvest.

Thus, from one m^2 of greenhouse bed planted to TPS, seed tubers to plant one ha, can be obtained in two years. The task, however, should be carried out by experiment stations or approved growers, since it requires greenhouse facilities, experience in working with TPS and the precautions to avoid infection, especially with bacterial wilt. Viruses will pose a lesser problem in the production of TPS-derived seed tubers. This is because of only two years of exposure in the field, compared to about six years for producing seed tubers of cultivars (as through a 'limited generation program' in the US).

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