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Effectiveness of Selection at Transplant and Minituber Crop Level in Potato (*Solanum tuberosum* L.)

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ABSRACT

The existence of genetic associations between important potato traits indicates that selection practiced for one trait may lead to changes in another. Correlations were computed between normal crops and transplant and minituber crops in order to study the selection efficiency for agronomic characters in potato transplant and minituber level. Three different transplant (field, glasshouse, seed bed) and two minituber (3g, 13g) crops were produced in glasshouse and field conditions. Selection at glasshouse transplant level was found to be moderately effective for average tuber weight, number of nodes per main stem and leaf length, and moderately to highly effective for plant height, number of stems per plant, number of leaves per plant, leaflet length, leaflet width, number of tubers per plant and tuber yield in minituber level. Selection in transplant and minituber level for some agronomic characters in potato would be effective under certain conditions.

1. Introduction

Production indices show that potato is one of the major crops in the world. It is valuable source of energy and compounds important in human diet. Potato tubers supply mainly carbohydrates, but are also relatively rich source of proteins, vitamins, dietary fibre and some minerals (Flis et al. 2012). Potato breeding worldwide has traditionally involved making crosses between pairs of parents with complementary features based on phenotype in order to generate genetic variation on which to practise phenotypic selection over a number of vegetative generations, the aim being to identify clones with as many desirable characteristics as possible for release as new cultivars (Bradshaw et al. 1998).

From a practical point of view it would be convenient if performance of particular genotypes could be predicted at the seedling stage in order to reduce the amount of plant material for selection from the beginning. For this purpose a close relationship between seedling performance and performance in subsequent field generations must exist. Again, different opinions can be found in the literature. Selection at the seedling stage does not seem to be efficient according to Tai and Young (1984) and Neele et al. (1991). However, according to Brown and Caligari (1986), Caligari et al. (1986), Maris (1988) and Gopal et al. (1992), this is possible, but with some limitations. (Ruiz de Galarreta et al. 2006; Haynes et al. 2012).

The yield components contributing to yield and agronomic characteristics may either directly or indirectly affect each other. Correlations, which can show a linear relation between two yield and agronomic components in a potato breeding programme (Güler et al. 2001; Özkaynak and Samancı 2005a). Traditional field evaluation and selection methods used for identifying superior genotypes in potato breeding programmes, are labour intensive and time consuming, requiring trials over a number of years and locations (Gopal and Minocha 1998; Haynes et al. 2012). In vitro propagated potato plants are commonly used in potato seed production programmes for production of microtubers, glasshouse production of transplants and minitubers, or field planting (Jones 1988; Struik and Lommen 1999; Özkaynak and Samancı 2005b; Afrasiab and Iqbal 2010).

The present investigation was undertaken to study the relationship between transplant and minituber de-

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rived from in vitro plantlets and normal tuber performance of various agronomic characters under glasshouse and field conditions.

2. Material and Methods

Three potato cultivars (Concorde, mid-early; Marabel, mid-late and Velox, early) were used in the present study. The experiments were conducted at the University of Mediterranean (Antalya, Turkey), in 2001-2003. Single node cuttings (0.5 cm long) from potato varieties grown in sterilized sand were propagated in MS (Murashige and Skoog 1962) medium with 3 % sucrose and 7 gl^{-1} agar in petri dishes. For explant surface sterilization, the potato single node cuttings were cut from the plant sprouts and washed with distilled water and subsequently sterilized in the laminar air flow sterile cabin with 15 % aqueous solution of commercial sodium hypo chloride (NaOCl) for 12 minutes. Surface sterilized node cuttings were washed 3 times with sterilized distilled water. The cultures were incubated at 16 hour photoperiod and 25± 2 ºC temperature regime for 3 weeks. Three week-old plantlets (4-6 cm long) were suitable for routinely transfer to ex vitro conditions. The plantlets were transplanted in a controlled growth room into a sterile mixture of peat moss and perlite (2:1 by volume) in pots. The plantlets were irrigated lightly until they were rooted (without any plant growth regulator) one week and then they were transplanted to polyethylene bags (sizes 10 x 10 x 15 cm) and grown for 10 days.

The greenhouse plantlets were grown in polyethylene bags (sizes 20 x 30 x 45 cm) in a mixture of peat moss and soil (1:1 by volume). The plantlets were developed in polyethylene bags until they were harvested. The experiments were carried out during two spring (March–June 2001 and April–July. 2002) and two autumn (October 2001–January 2002 and November 2002–February 2003) season in glasshouse conditions. Seed bed plantlets were grown in pots one week and they were transferred from pots to seed bed. The plantlets (planted at 150 plantlets m^2) were carried out during one autumn (October 2001–January 2002) and spring (April–July 2002) season in seed beds (in glasshouse) in a mixture of peat moss and soil (1:1 by volume). Seed bed transplant experiments were laid out in a completely randomised block design with three replications. The field transplants were planted within the rows 30 cm and between the rows 70 cm wide. Fertilizer was broadcasted at 6 kg/da N, 4 kg/da P_2O_5 and 8 kg/da K_2O. Disease control and irrigation were carried out according to practice. The experiments were carried out during two spring season (March–June 2001 and April–July 2002) in the experimental field at Mediterranean University Faculty of Agriculture. Transplant experiments were laid out in a completely randomised block design with three replications. 10 transplants of each cultivar transplanted in polyethylene bags in each replication in glasshouse transplants and 10 transplants of each cultivar were planted in two rows in each replication in field transplants.

Normal tuber (January-May 2001/January-May 2002) and minituber (3g and 13g average tuber weight, January-May 2002/February-June 2003) experiments were laid out in a completely randomised block design with three replications. 20 tubers of each cultivar were planted in two rows of ten tubers in each replication in normal tubers and fourteen tubers each cultivar were planted in two rows of seven tubers in each replication in minitubers, at recommended intra and inter row distances of 30 cm and 70 cm, respectively (Gopal and Minocha 1997). Normal cultural schedules were applied during plant growth and development. Foliage characters were recorded at full growth individually on all potato plants. Leaf characters were recorded on the fourth leaf from the top. Leaf and tuber characters were recorded at full maturity on all transplant, minituber and normal tuber crops according to Gopal and Minocha (1997).

Correlation coefficients for various characters were computed between the means of performance of varieties in transplant and minituber crops and the corresponding performance in the normal tuber crop. Data and correlation coefficients were analyzed by using MSTAT-C package software programme (Freed et al. 1989).

3. Results and Discussion

Correlation coefficient analysis measures the magnitude of relationship between various plant and tuber characters and determines the component character on which selection can be based for improvement in potato tuber yield. Analysis of variance showed significant genotypic differences for various characters in transplant, minituber and normal tuber crops. Most of the correlation coefficients between normal tuber crops and different transplant and minitubers generations for various characters obtained in our study low to moderate and many correlation coefficients for plant and tuber characters were positive, moderately to highly significant (Table 1). Highest positive correlation coefficients were found between normal tuber crops and spring season glasshouse transplant crops for average tuber weight (r=0.74**), number of nodes per plant (r=0.73**) and between normal tuber crops and minituber crops of 3 g and 13 g weight for number of leaflets per leaf (r=-0.74**), number of tubers per plant (r=0.74**, r=0.75** respectively) and tuber yield (r=0.86** and r=0.91** respectively).

Most of the phenotypic correlations for identical characters between generations obtained in our study varied from low to moderate (Table 1). Ruiz de Galarreta et al. (2006) found that low to moderate relations between different potato generations. Maris (1988) observed poor relationships between glasshouse seedlings and field performance for number of tuber per plant and average tuber weight, while the correlation for tuber yield was moderate (r=0.44 to 0.52). Gopal et al. (1992) found that the correlations of seedling generation with clonal generations were higher for progeny means than those for individual genotypes for characters like tuber yield and number of tuber per plant; for average tuber weight these were more or less of similar magnitudes. These results are in agreement with our findings.

For number of leaves (r=0.52**), number of stems (r=0.39*), number tubers per plant (r=0.60*) and average tuber weight (r=0.49*) moderate positive correlation coefficients were found between normal tuber crops and field transplant crops. Correlations of normal tuber crops versus seed bed transplant crops for number of stems (r=0.49*), number of leaves (r=0.49*) and average tuber weight (r=0.49*) and in normal tuber crops versus autumn season transplant crops for leaf length (r=0.61**), number of primary leaflets (r=0.42*), average tuber weight (r=0.41*) were found significantly positive and moderate magnitude.

In general, like our results a closer relationship between minituber generations between clonal generations and seedling generations was observed (Ruiz de Galarreta et al. 2006). Tai and Young (1984) proposed that a selection at the seedling generation stage would not be efficient. Neele et al. (1991) obtained that the correlations between the seedling progenies and normal potato tuber harvest performances in the subsequent years assorted between r= -0.36 and r=0.07 for tuber yield; r= -0.08 and r=0.14 for number of tubers per plant and r= -0.26 and r= -0.19 for average tuber weight (Muthoni et al. 2012). Brown and Caligari (1986) indicated that selection for yield in seedlings could be effective but could be overestimated because of the known effects of seed tuber weight (Ruiz de Galarreta et al. 2006). In our study higher correlations were found for average tuber weight and number of tubers per plant compare to Neele et al. (1991) in all transplant crops (spring season, autumn season, field transplant and seed bed season transplant).

Correlations between normal tubers and minituber crops of 3g weight were moderate to high magnitude for characters respectively such as plant height (r=0.54**), number of stems (r=0.70**), number of leaves (r=0.51**), number of primary leaflets (r=-0.74**), number of nodes (r=0.57**), leaf length (r=-0.66**), internode length (r=0.48*), primary leaflet width (r=0.58**), leaf width (r=0.48*), number of tubers (r=0.74**) and tuber yield (r=0.86**). Significant positive correlations were found between normal tubers and minituber crops of 13g weight for number of stems (r=0.70**), number of leaves (r=0.53**), number of primary leaflets (r=0.55*), internode length (r=0.44*), leaf length (r=0.44*), primary leaflet width (r=0.52**), number of tubers (r=0.75**) and tuber yield (r=0.91**).

Table 1
Correlation coefficients between transplant and minituber crops to normal tuber crops for various characters in potato.

	NT vs FT	NT vs SB	NT vs SGT	NT vs AGT	NT vs 3M	NT vs 13M
PH	—0.42*	—0.53**	—0.26	0.11	0.54**	—0.40*
SN	0.39*	0.49*	—0.50**	—0.11	0.70**	0.70**
LN	0.52**	0.49*	—0.41*	—0.34	0.51**	0.53**
LletN	—0.29	—0.22	0.14	0.42*	—0.74**	0.55**
NN	—0.38	—0.24	0.73**	0.27	0.57**	—0.45*
IL	—0.11	0.27	0.23	0.30	0.48*	0.44*
LL	—0.29	—0.28	0.46*	0.61**	—0.66**	—0.44*
LW	—0.24	—0.39*	—0.45*	0.28	0.48*	—0.58**
LletL	0.23	—0.45*	—0.49*	—0.24	0.28	0.58**
LletW	—0.30	—0.26	—0.23	—0.54**	0.58**	0.52**
TN	0.60**	—0.32	—0.29	—0.45*	0.74**	0.75**
ATW	0.49*	0.49*	0.74**	0.41*	0.18	0.16
TY	—0.21	0.35	0.36	—0.24	0.86**	0.91**

*, **: significant at P<0.05 and P<0.01, respectively. NT: normal seed tuber, FT: field transplant, SB: seed bed transplant, SGT: spring-season glasshouse transplant, AGT: autumn-season glasshouse transplant, 3M: minituber crops of 3g weight, 13M: minituber crops of 13g weight, PH: plant height (cm), SN: number of stems (per plant), LN: number of leaves (per plant), LletN: number of primary leaflets (per leaf), NN: number of nodes (on per main stem only), IL: internode length (cm), LL: leaf length (cm), LW: leaf width (cm), LletL: primary leaflet length (cm), LletW: primary leaflet width (cm), TY: tuber yield (per plant, g), TN: number of tubers (per plant), ATW: average tuber weight (g).

Gopal and Minocha (1997) were researched the correlations of normal tubers versus microtuber crops was found highly effective for plant height, moderately effective for leaf length, leaflet width, internode length and low for number of nodes, number of stems, tuber yield, number of tubers and average tuber weight. Gopal et. al. (2002) were investigated the performance of some potato genotypes for some agronomic characters in crops raise from minitubers and normal seed tubers. The performance of normal seed crop was significantly better than the minituber crop for various characters including tuber yield and yield components. Correlation coefficients were significant for several characters except number of stems and number of tubers. Highest correlations was for tuber yield (r=0.86) followed by average tuber weight (r=0.67) and number of nodes (r=0.63). They proposed that selection for tuber yield can be practised and used at the minituber crop level in potato breeding programmes. For number of tubers and tuber yield, correlations coefficients of normal tuber versus minituber were found similar to Gopal and Minocha, (1997) and Gopal et al. (2002).

In minituber crops, significantly positive correlation were found important plant traits like plant height, number of stems, number of leaves, number of primary leaflets, primary leaflet width. Increases these plants characteristics showed positive association reflects tuber yield increase. On the other hand, positive associations with plant height, number of stems, number of leaves, number of primary leaflets, primary leaflet width that vegetative fresh and vigorous plant structure with more tuber produces more yield. Thus, the characters plant height, number of stems, number of leaves, number of primary leaflets, primary leaflet width are the important tuber yield attributes to be estimated in the selection criteria for yield improvement.

In potato, the plant and tuber characters such as number of tuber per plant and average tuber weight revealed that the components showing high correlations with tuber yield. This may indicate that the direct selection for number of tubers and average tuber weight would properly be effective in increasing tuber yield in transplant crop level in potato breeding programme (Özkaynak and Samancı 2005b). In transplants, average tuber weight was to be more important than tuber in determining tuber yield, whereas in minituber crops found the contrary to be true.

Potato breeding programs constantly need new strategies to improve efficiency by increasing the frequency of selected genotypes, cultivars and reducing time and costs. Potato breeders often select for several traits at each selection stage. However, it is important to know the selection effect of one specific trait on the others (Silva et al. 2006). The existence of genetic associations between traits indicates that selection practiced for one trait may lead to changes in another. Depending on the direction, the association between traits may be of interest for breeding or not. Knowledge on the relationships between traits is therefore very important to choose a suitable selection strategy for a target trait. The strategy may be based on other very closely correlated traits are easier to measure or to identify.

In general, low to moderate correlation coefficients for plant and tuber characters may have result from the poor expression in the limited space provided by the plots and using few genotypes. Though half of the normal tuber crops versus transplant and minituber crops correlations were non-significant, the significant ones (especially yield characteristic like number of tubers, average tuber weight and tuber yield) showed that in selection transplant or minituber crop levels for various agronomic characters would be effective under certain conditions.

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