ANADOLU, J. of AARI
12 (1) 2002, 122 - 130
MARA

STABILITY OF YIELD PERFORMANCE OF SOME PROCESSING TOMATO GENOTYPES

Eftal DÜZYAMAN ***Hüseyin VURAL***

Department of Horticulture
Faculty of Agriculture, University of Ege
35100 Bornova, İzmir/TURKEY

ABSTRACT: *The yield stability of 21 processing tomato genotypes was investigated across four environments in the main processing tomato production areas of Turkey, namely the Marmara and Aegean regions. The rank analysis method was applied to the data set of yield of the genotypes already being introduced to those areas. The genotypes NDM 055, Marzanpeel, XPH 5720, Dianapeel, Maxilandia and especially Brixy were found to be stable in terms of yield across the environments tested. Since hybrid seed imports greatly increases production costs, the non-hybrids Rio Fuego and T_2 Improved were noteworthy for their relative yields (close to the grand mean of 10867 kg/da), and remarkable stability. By considering the excellent yield of some non-stable genotypes the need for adaptation studies to specific environments was discussed.*

Keywords: *Processing tomatoes,* ***Licopersicum esculentum*** *L., adaptation studies, stability, rank analysis*

BAZI SANAYİ DOMATESİ GENOTİPLERİNİN VERİM PERFORMANSLARININ STABİLİTESİ

ÖZ: *Türkiye'de sanayi domatesi yetiştiriciliğinin yaygınlaştığı Marmara ve Ege bölgelerinde toplam dört çevrede örneklenen 21 sanayi domatesi genotipinin verim özelliklerine ilişkin stabilite değerleri incelenmiştir. Bu amaçla introdüksiyon çalışmaları tamamlanmış genotiplerin verim değerlerinden oluşan veri setine 'rank analizi' uygulanmıştır. NDM 055, Marzanpeel, XPH 5720, Dianapeel, Maxilandia ve özellikle Brixy genotiplerinin tüm çevrelerde stabil verim verdikleri belirlenmiştir. Hibrit tohum ithalatının üretim masraflarını büyük ölçüde artırdığı düşünüldüğünde, orta düzeyde verim değerlerine sahip olmalarına karşın (genel ortalama olan 10867 kg/da'a yakın) hibrit olmayan Rio Fuego ve T_2 Improved genotiplerinin bölgeler itibarı ile stabil verim değerlerine sahip olmalarının Türk salça endüstrisinin ilgisini çekeceği düşünülmüştür. Bazı stabil olmayan hibrit genotiplerin bazı çevrelerde mükemmel verim değerlerine ulaşması, spesifik çevreler için özel adaptasyon çalışmalarına ihtiyaç olduğunu göstermiştir.*

Anahtar Sözcükler: *Sanayi domatesi,* ***Licopersicum esculentum*** *L., adaptasyon çalışmaları, stabilite, rank analizi.*

INTRODUCTION

The Turkish tomato paste industries are mainly dispersed into two ecogeographically diverse regions; namely the Marmara and the Aegean regions of

Turkey. These industries have been calling for the need of an overall production improvement in this field. A collaborative program, called the *SANDOM* project (the program on the development of processing tomato production in Turkey), was started between the Faculty of Agriculture of the Aegean University and most of the Turkish tomato paste industries in 1986 and lasted for 10 years. By considering the needs of the tomato paste industries, work done so far can be summarized as improving yield performance and paste output of newly released processing tomato cultivars, seed health tests for virus infections and establishment of fertilization programs (Vural *et al*., 2000).

A total of 8 million tones of tomatoes are annually produced in Turkey out of which more than 20 % alone account for processing tomatoes. A total of 280-300 thousand tones of tomato paste is produced yearly out of which 65-70 % is exported with an overall return of 140 – 150 million USD. Turkey is one of the most important processing tomato producers and tomato paste exporters among USA, China, India and Italy in which the former SANDOM project is thought to have a significant influence (Vural *et al*., 2000).

The existence of interactions between genotype and environment is a major problem for the breeder in making a reliable estimate of the performances of the genotypes across environments (Fox *et al*., 1997). The same is true in the introduction of newly released foreign cultivars to diverse ecological regions (Özzambak *et al*., 1995; Düzyaman *et al*., 1996a,b). Stable genotypes are characterized as having more adaptability to changing environments when compared to unstable ones. Only a few studies on tomatoes dealed with the importance of genotypic stability across environments with emphasis on fruit yield and fruit quality properties in both fresh market and processing tomatoes (Stoffella *et al*., 1984; Poysa *et al*., 1986; Gull *et al*., 1989). This paper attempts to work out the stability of final yield of some processing tomato cultivars introduced to the important Turkish production areas where the paste industries are localized. Stability parameters were worked out by using the 'rank' method (Fox *et al*., 1997), introduced by Yıldırım *et al*. (1998), which advantages have been outlined in comparison with the method developed by Finlay and Wilkinson (1963).

MATERIAL AND METHODS

Four environments, representing a combination of two locations and two years were provided for the processing tomato varieties to get an overall estimate of their stability and adaptability (locations: Aegean and Marmara Region; years: 1995 and 1996). The data set on fruit yield for 21 well known processing tomato cultivars was provided from the ongoing SANDOM program (Özzambak *et al*., 1995; Düzyaman *et al*., 1996b). The materials were those already undergoing the introduction process in the experimental fields, mostly hybrids (Abaris, Brigade, Brixy, Centurion, Chunky, Dianapeel, KG-91-6, Marzanpeel, Maxilandia, Maxiroma, NDM 055, Nemapeel, Nemared, Nemasol, Novapeel, Sousolito, Spectrum and XPH 5720) and some non-hybrids (Big Rio, Rio Fuego and T_2 Improved) as checks (Table 2).

The experimental design was a Completely Randomised Block design with three replications. Each plot consisted of 50 single plants with 0.25 m within row, and 1.40 m between row spacings. Fruit harvest started when %70 of fruits ripened and was followed by two successive harvests. Total fruit yield was calculated by weighting all fruits in the whole plot at each harvest.

The resulting data set was subjected to the analysis of variance to explore the significance of the variables and genotype x environment interactions. The 'rank analysis' was then run on the SAS statistical package to estimate the stability of each genotype across environments (SAS Institute, 1988). This method represents a combination of the 'rank' of the yield of a given genotype among others in a given environment and the standard deviations of the ranks. The average of ranks and their standard deviations across environments are transferred into a two dimensional space from which the stability parameters can be determined (Figure 1) (Fox *et al*., 1997; Yıldırım *et al*., 1998). Genotypes with low rank values and a low standard deviation of rank averages (1st region in Figure 1) are considered as stable genotypes with high yields. Genotypes with high ranks and low standard deviation of ranks (2nd region) are stable genotypes as well, but with low yields. Genotypes in both 1st and 2nd regions are characterized as having general adaptability to all environments. Genotypes in the 3rd and 4th regions are non-stable, some with high yields (3rd region) and some with low yields (4th region).

RESULTS AND DISCUSSION

Results regarding the significance of genotype, environment and genotype x environment interactions can be examined from the analysis of variance presented in Table 1. All variables were significant at the 0.01 level of probability, suggesting in the case of genotype x environment interaction that there are significant differences in the responses of genotypes to environments, and hence sensitivity and instability.

Table 1. Analysis of variance of genotypes across environments.

Source of Variation	DF	Mean square	F
Block	1	164187,524	0,220 ns
Genotype	20	7961841,137	10,662 **
Environment	3	143385019,800	192,016 **
Genotype x Environment	60	4189941,670	5,611 **
Pooled error	167	746733,276	

ns: non significant, **: significance of F at 0.01 probability level.

At the basis of each environment, the average yield of genotypes ranges from 9925 kg/da (in environment II) to 13119 kg/da (in environment I) with a grand average of 10867 kg/da (Table 2). The most favourable growing conditions were created in the environment I, and the least favourable in the environment II. Genotypes having average rank values below 11.00 (the grand average of ranks) are regarded as high yield cultivars. Since it is an expression of the fluctuation of yield response of the plants to the environment, the standard deviations of ranks is also needed to explore the stability. A low standard deviation of rank would therefore mean that the yield of a single genotype does not fluctuate much across varying environments. In our case genotypes having average standard deviations of rank below 5.012 can be regarded as stable, and hence less sensitive to environmental changes.

A combination of standard deviations of ranks and rank values is presented in figure 1. high yielding cultivars with stability are those in the 1st region in the Figure 1. Those are NDM 055, Marzanpeel, Maxilandia, XPH 5720 and Dianapeel with average yields of 11473, 11410, 11388, 11355 and 11282 kg/da, respectively. Brixy turns out as to be the most promising cultivar in the experiment. It produced up to 12188 kg/da fruit yield in average across the environments, and hence high stability. Rank values of this cultivar ranged from 1 (in environment III) to 10 (in environment IV) with an grand average of 4.5. This results are in some degree in contrast to the findings of Gull *et al*. (1989) who evaluated fresh-market tomato genotypes for stability of a number of fruit trials. These researchers reported that no single tomato genotype is stable for every fruit quality trial in the tested environments.

Stable genotypes with low yields are those in the 2nd region, namely Rio Fuego, Novapeel, T_2 Improved, Maxiroma and Nemared with average yields ranging from 9367 to 10172 kg/da, and average rank values from 16.5 to 18.3. Regardless of their relatively low yields, the stability of the non-hybrid cultivars Rio Fuego and T_2 Improved is worth mentioning, since the seeds of these cultivars can be produced by low inputs by the paste industries themselves. The enormous costs of seed import of hybrid processing tomato cultivars is the main reason, besides many others like virus infected seeds, which made paste industries search for non-hybrids with acceptable yields. Rio Fuego is known for its similarity to the well adapted cultivar Rio Grande (not included in this study), one of the major non-hybrid cultivar in the main processing tomato growing areas in Turkey for several decades (Özzambak *et al*., 1995; Düzyaman *et al*., 1996a).

In contrast to the general adaptability of the genotypes in the 1st and 2nd regions, many genotypes lacked stability in yield performance, namely those in the 3rd and 4th regions. Similar stability differences and sensitivity to environmental changes in yield traits were reported by Stoffella *et al*. (1984) for fresh market tomatoes, and Poysa *et al*. (1986) for processing tomatoes. Eventhough, genotypes in the 3rd region can not be regarded as stable, their average yield is not low and when single environments are considered even extremely high. However, the fact that they can not be regarded as stable is due to the high standard deviation of the ranks each of them has. For example Abaris cultivar with up to 11931 kg/da average yield ranks 1st in the environment II and 3rd in the environment III, but 21st in the environment IV. Under favourable growing conditions this cultivar surpassed the grand averages of genotype yields in each environment up to 30 % (in environment II), 19 % (in environment III), and 10 % (in environment I). The same is true for a number of other cultivars like Centurion, Chunky, Big Rio, Brigade, Nemapeel, and Nemasol.

By keeping this in mind, it should be noted that this suggests the possibility of introducing cultivars to specific environments with expectations of high yield increases. Contradictory results to this are reported by Stoffella *et al*. (1984) who found that high yielding tomato genotypes had good phenotypic stability for yield. In our work this is valid only in the case of Brixy. For many genotypes, on the other hand, the need to investigate their adaptabilities to specific environments should be estimated. This result supports Poysa *et al*. (1986), who reported that high yielding tomato cultivars are unstable across varying environments. To assure more reliable recommendations, however, more diverse ecologies, preferably partitioned into several locations and growing seasons should be included in further analyses.

REFERENCES

Düzyaman, E., İ. Duman, H. İlbi, and H. Vural. 1996a. Üstün verim ve teknolojik özelliklere sahip sanayi domatesi çeşitlerinin belirlenmesi [Determination of processing tomato cultivars with high yield and technological properties]. Doğruluk Matbası, H. Vural (ed.), SANDOM Report 10:23-38.

Düzyaman, E., N. Budak, M. B. Yıldırım, and H. Vural. 1996b. Bazı sanayi domatesi çeşitlerinin stabilite parametreleri ve uyum yetenekleri üzerinde bir araştırma [Researches on stability parameters and adaptation capabilities of some processing tomato cultivars]. Doğruluk Matbası, H. Vural (ed.) SANDOM Report 10:51-56.

Finlay, K. W. and G. N. Wilkinson. 1963. The analysis of adaptation in a plant breeding programme. Austral. J. Agr. Res. 14: 742-754.

Fox, P. N., J. Crossa and I. Romagossa. 1997. Multi-environmental testing and genotype x environment interaction, in Statistical Methods for Plant Variety Evaluation. Chapman & Hall, London, R. A. Kempton and P. N. Fox. (eds.), 117-138.

Gull, D. D., P. J. Stoffella, S. J. Locascio, S. M. Olson, H. H. Bryan, P. H. Everett, T. K. Howe, and J. W. Scott. 1989. Stability differences among fresh-market tomato genotypes: II. Fruit quality. J. Amer. Soc. Hort. Sci., 114:950-954.

Özzambak, E., E. Düzyaman, Ö. Tuncay, and H. İlbi. 1995. Üstün verim ve teknolojik özelliklere sahip sanayi domatesi çeşitlerinin belirlenmesi II İntrodüksiyon denemesi [Determination of processing tomato cultivars with high yield and technological properties II Introduction]. Doğruluk Matbası, H. Vural (ed.), SANDOM Report 9:17-31.

Poysa, V. W., R. Garton, W. H. Courtney, J. G. Metcalf, and J. Muechmer. 1986. Genotype – environment interactions in processing tomatoes in Ontario. J. Amer. Soc. Hort. Sci., 111:293-297.

SAS Institute Inc., 1988. SAS/STAT users guide: version 6.0 edition SAS inst. Inc. Cary, N.C.

Stoffella, P. J., H. H. Bryan, T. K. Howe, J. W. Scott, S. J. Locascio, and S. M. Olson. 1984. Stability differences among fresh-market tomato genotypes: I. Fruit yields. J. Amer. Soc. Hort. Sci., 109:615-618.

Vural, H., D. Eşiyok, İ. Duman, and E. Düzyaman. 2000. Standart ve F_1 hibrit sanayi domatesi çeşitlerinin Ege ve Marmara bölgelerine uyumu ile verim ve kalite özelliklerinin değerlendirilmesi [Evaluation of standard and F_1 hybrid processing tomato cultivars for their adaptabilities, and yield and quality properties in the Ege and Marmara regions of Turkey]. III. Sebze Tarımı Sempozyumu. 378 – 382. 11 – 13 Eylül, 2000, Süleyman Demirel Üniversitesi Kültür Merkezi, Isparta.

Yıldırım, M. B., N. Budak, and C. F. Çalışkan. 1998. Genotip performanslarının rank analizi yoluyla belirlenmesi [Determination of genotype performances via rank analysis]. Journal of the University of Ege Faculty of Agriculture 34:41-48.

Table 2. Average yield performance and ranks of processing tomatoes across four environments (specified as Environment I, II, III and IV), and averages of ranks and yields and their standard deviations as grand mean of four environments.

Genotype	Environment I		Environment II		Environment III		Environment IV					
	Aver. yield	Rank	Aver. yield	Rank	Aver. yield	Rank	Aver. yield	Rank	Aver. yield	S. D. of yield	Aver. rank	S. D. of rank
Abaris	14438	6	12988	1	12112	3	8185	21	11931	2675,04	7,75	9,069
Big Rio	12913	12	10511	7	12316	2	9453	18	11298	1599,10	9,75	6,850
Brigade	12423	16	9066	16	10290	11	11605	1	10846	1476,54	11,00	7,071
Brixy	14549	3	11144	4	12553	1	10508	10	12189	1790,71	4,50	3,873
Centurion	15337	1	9476	14	11521	5	10612	8	11737	2541,94	7,00	5,477
Chunky	13105	10	10925	5	7728	19	10154	12	10478	2218,74	11,50	5,802
Dianapeel	12876	13	10034	11	11584	4	10636	7	11282	1239,31	8,75	4,031
KG-91-6	13269	9	10509	8	11013	6	9121	20	10978	1724,17	10,75	6,292
Marzanpeel	12952	11	10261	10	10835	8	11593	2	11410	1163,63	7,75	4,031
Maxilandia	14495	4 (5)	10429	9	10080	13	10547	9	11388	2080,97	8,88	3,473
Maxiroma	10362	21	7675	21	9611	16	9821	15	9367	1171,69	18,25	3,202
NDM055	14823	2	9488	13	10591	10	10991	5	11473	2321,85	7,50	4,933
Nemapeel	13581	8	11402	2	6573	21	11416	3	10743	2962,56	8,50	8,737
Nemared	11543	19	7848	20	8989	18	10462	11	9711	1624,02	17,00	4,082
Nemasol	14495	4 (5)	11357	3	10986	7	9730	16	11642	2025,41	7,63	5,822
Novapeel	12171	17	9070	15	6764	20	9873	14	9470	2231,61	16,50	2,646
Rio Fuego	12549	15	8825	18	9904	14	9411	19	10172	1644,74	16,50	2,380
Sousolito	11333	20	10593	6	9675	15	9975	13	10394	733,45	13,50	5,802
Spectrum	12800	14	8830	17	9072	17	10935	6	10409	1850,62	13,50	5,196
T2 Improved	11580	18	8310	19	10185	12	9663	17	9935	1352,06	16,50	3,109
XPH 5720	13909	7	9690	12	10600	9	11221	4	11355	1815,04	8,00	3,367
Grand Mean	13119	11	9925	11	10142	11	10282	11	10867	1821,10	11,00	5,012

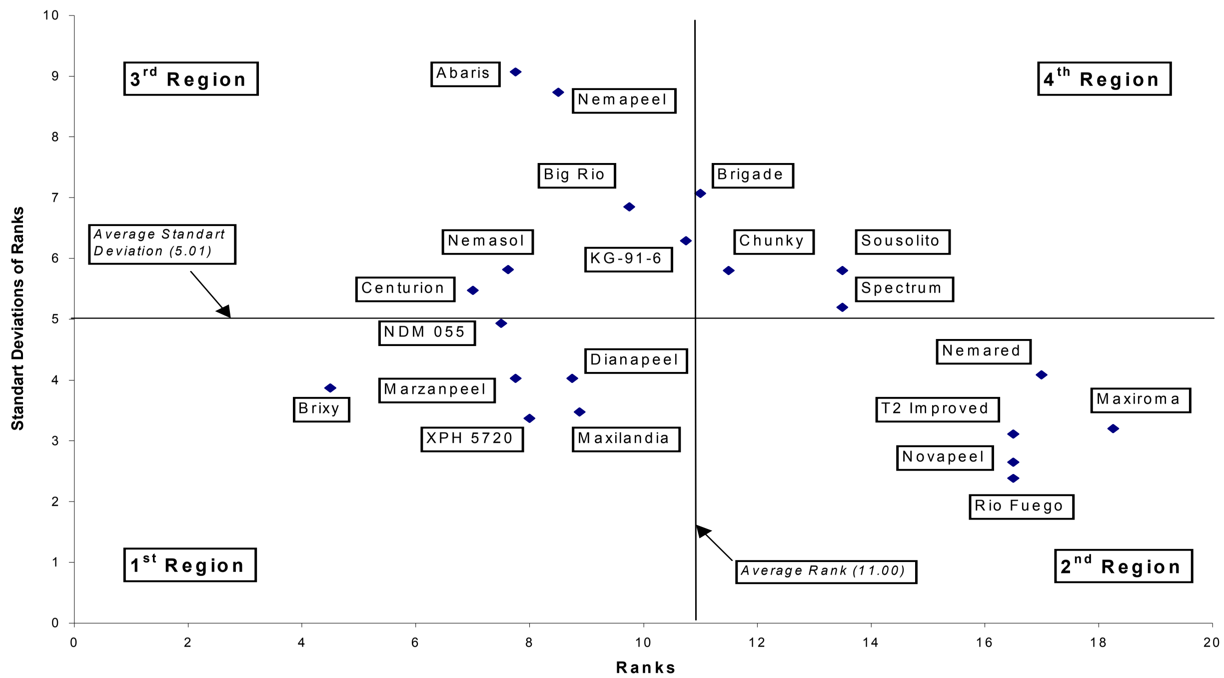

Figure 1. Dispersion of genotypes according to their average ranks and standard deviations of ranks. 1st region: stable genotypes with high yields; 2nd region: stable genotypes with low yields; 3rd region: non-stable genotypes with high yields, and 4th region: non-stable genotypes with low yields.