Scientific Papers. Series A. Agronomy, Vol. LV-2012
ISSN Online 2285-5793; ISSN-L 2285-5785

# UTILIZATION OF LARGE TESTING NETWORK TO ESTIMATE ANNUAL GENETIC GAIN FOR YIELD AND TOLERANCE OF CORN TO WATER STRESS IN A BREEDING PROGRAM FAO 480 AND FAO550

**Gabriela VALSAN, Ion CIOCAZANU, Valentin MANDACHE, Viorel DINCA**

Pioneer Hi-Bred Seeds Agro SRL, DN2, km 19.7, Ganeasa Commune, Sindrilita Village, cod 077104, Ilfov County, Romania, Phone: 021.303.53.42, Mobile: 0745 121 744, E-mail: gabriela.valsan@pioneer.com; ion.ciocazanu@pioneer.com; valentin.mandache@pioneer.com; viorel.dinca@pioneer.com

***Corresponding author e-mail***: gabriela.valsan@pioneer.com

***Abstract***

*Results obtained in a large testing network in 2011 were used to estimate the efficiency of the corn breeding effort in early stage of testing (R1 and R2), by measuring the annual genetic gain for yield and tolerance of corn to water stress in maturities groups of interest for Romania. Linear regression between yield and harvest moisture, as well as between yield averaged over water stressed locations and yield averaged over non-stressed locations were used to estimate annual efficiency of the corn breeding program for FAO maturities 480 and 550. Results showed that the process of selection was efficient in improving yield, drought tolerance in both corn maturities groups (FAO 480 and 550) and all selection stages (R1, R2), producing significant genetic gains, and confirming thus the efficiency of the breeding process on short (annual) term.*

***Key words***: corn, genetic gain, hybrids, *Zea mays* L.

## INTRODUCTION

The present study is aimed to estimate the genetic gain obtained by newly introduced Pioneer hybrids R1 (FAO480 and FAO550) and R2 (FAO480 and FAO550) in 2011. Corn with a strong economic importance was, is and will be an object for research. The great discoveries of molecular genetics were applied to corn, achieving record production per unit area. At the same time, by setting chromosomal map, mechanisms of control of certain characters and traits of corn plants were discovered and applied in breeding programs. This allowed the creation of hybrids whose genetic basis not only ensures high production capacity and quality traits absolutely necessary for superior corn utilization.

Pioneer research activity began in the period when Pioneer hybrids were submitted for the first time to official registration testing in 1975. Since then to present a continuous flow of improved Pioneer hybrids have been tested, registered, introduced and grown by numerous Romanian farmers, Pioneer becoming meanwhile the first market player in Romania. This was possible due to the genetic superiority of the newly introduced Pioneer hybrids.

Long term genetic gain has been frequently reported in plant breeding literature. Romanian breeding companies published relevant data about the size of the genetic gain achieved by their breeding programs during long periods of time. Thus, in 1982 was reported a genetic gain for grain yield of 0.232 t/ha/year in irrigation conditions and 0.141 t/ha/year in dry land condition obtained by Fundulea Institute corn breeding program with the same maturities groups as those considered in this study [12]; similar data were published in 1986 - 0.218 t/ha/year in irrigated conditions and 0.205 t/ha/year in rainfed conditions [3], while later in 1998, communicated genetic gain values from Fundulea breeding program of 0.108 t/ha/ year under irrigation and 0.058 t/ha/year in non-irrigated conditions [2].

Numerous genetic gain studies were also published in USA and all over the world;

significant genetic gains in dry land yield, have been released during the last half century [1, 4, 6, 9, 10, 11, 13]. Genetic progress in yield under dry land conditions was linear, and was responsible for at least half of total yield gain obtained in farm production. Agronomic practices improvement is the source for the other half [7]. The studies are also consistent in showing that yield gain is associated with increases in tolerance to prevailing biotic and abiotic stresses [5, 6, 8, 14]. Reports on short term genetic gain are almost absent from plant breeding literature.

## MATERIAL AND METHOD

Pioneer corn hybrids representing two maturities group, FAO480 and FAO550, two early testing stages (R1- first year of testing and R2- second year of testing) were tested in 2011 in different locations from Romania, France and Hungary. Differentiated managed irrigation regimes were applied, using small sprinkler equipment, to ensure the achievement of the two water stress levels, low water stress (full irrigation locations) and high water stress (limited irrigated and non-irrigated locations) (table 1).

Table 1. Pioneer R1 and R2 corn hybrids, representing 2011 year breeding, grouped into two maturities, number and irrigation regime of the testing locations.

| Stage | R1 | | R2 | |
|---|---|---|---|---|
| Maturity group | FAO 480 | FAO 550 | FAO 480 | FAO 550 |
| No. of hybrids tested | 90 | 83 | 83 | 86 |
| Total no.of locations | 12 | 11 | 18 | 16 |
| • Full irrigated - SH | 5 | 5 | 8 | 8 |
| • Limited irrigated - SA | 3 | 3 | 5 | 4 |
| • Non-irrigated - SA | 4 | 3 | 5 | 4 |

Experimental plot consisted of 2 rows long of 6 m, distance between rows was 75 cm; entries were randomized or nested into experiment.
The filling seed bags for all locations was centralized, the same sources of seeds were used for planting all locations. High input technology was applied to trials in all locations. Trials were mechanically over planted and manually thinned to the desired plant populations at 6 leaves stage. Yield and other important agronomic traits were collected. Results were processed and were used for a normal advancement process. Short term-one generation genetic gain of the breeding program for FAO maturities 480 and 550 was estimated visually using a special graphic representation of the linear regression between yield – q/ha - (YLD) and harvest moisture -% - (MST) (genetic gain for yield capacity), as well as between yield (q/ha) averaged over water stressed locations (WS) and yield averaged over non-stressed locations (NS) (genetic gain for adaptation to a wide range of water stress levels). Additionally, frequency distribution of advanced hybrids in 2012 was graphically compared with that for all 2011 tested hybrids.

## RESULTS AND DISCUSSIONS

- **Visually estimation of the genetic gain**

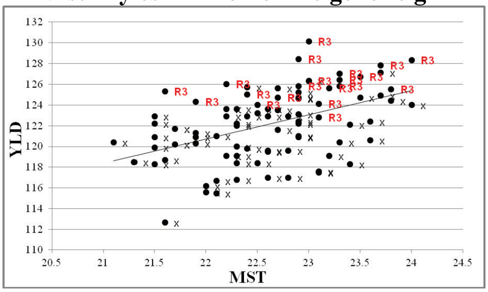


Fig. 1. Linear regression between YLD and MST, R2 hybrids, FAO480, 2011 testing.

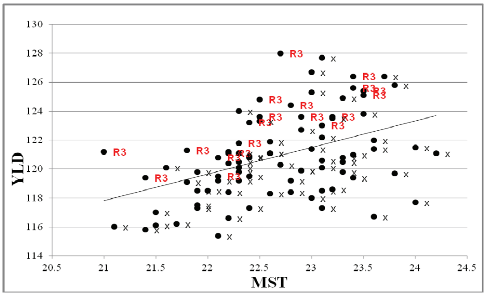


Fig. 2. Linear regression between YLD and MST, R2 hybrids, FAO550, 2011 testing.

In Fig. 1 and 2, showing the linear regression between YLD and MST of R2 hybrids submitted to 2011-2012 advancement process, the tags R3 (in red) represent the advanced R2 hybrids to R3 stage, while X represent the discarded hybrids for FAO group 480 and 550, respectively. An obvious genetic gain for yielding capacity could be observed visually since all R3 advanced hybrids are placed over the regression line in both maturity groups. In the process of advancement, other agronomic and disease traits than YLD and MST were taken into consideration, explaining the X hybrids placed also over the regression line.

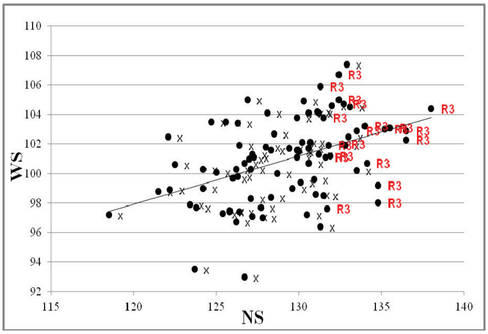


Fig. 3. Linear regression between WS and NS, R2 hybrids, FAO480, 2011 testing.

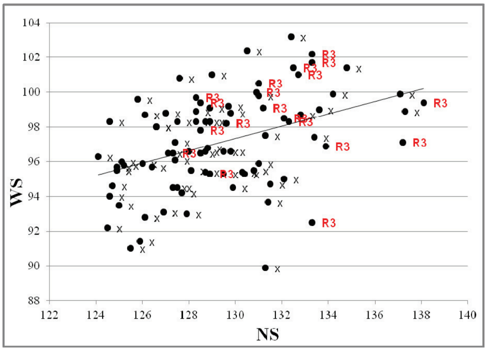


Fig. 4. Linear regression between WS and. NS, R2 hybrids, FAO550, 2011 testing

Similarly, the same graphic representation of the adaptation to a wide range of water stress levels of R2 hybrids are shown in figures 3 and 4 (linear regression between WS and NS). A good part of the newly advanced R3 hybrids (in red) are placed in the upper right quarter of the graph over regression line, showing a consistent gain for adaptation to all water stress conditions.

Position on the graphs of newly advanced R2 hybrids (in red in figure 5 and 6, showing the regession line between YLD and MST of R1, both maturity groups, tested in 2011) suggests also the efficiency of 2011 R1 to R2 advancement process, an important genetic gain for yielding capacity being visually noticeable (all R2 hybrids advanced from R1 are positioned over the regression line).

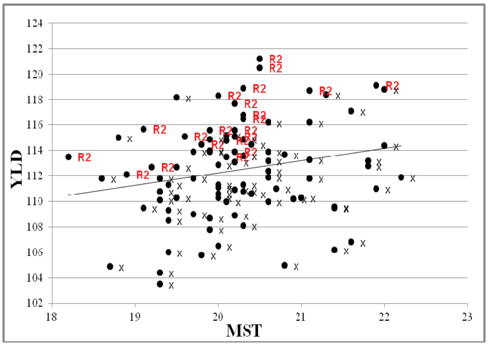


Fig. 5. Linear regression between YLD and MST, R1 hybrids, FAO480, 2011 testing.

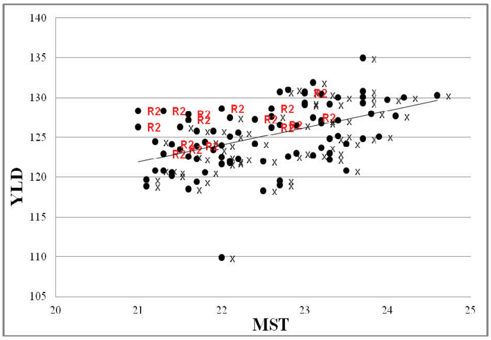


Fig. 6. Linear regression between YLD and MST, R1 hybrids, FAO550, 2011 testing.

Representation of R2 advanced from 2011 R1 (in red) in the graphs showing the adaptation potentiality to a wide range of water stress levels (regression lines between yield obtained in water stress conditions and non stress conditions in figures 7 and 8), make visually evidence of an significant genetic gain from one generation to the next one for a great part of advanced hybrids which are placed in the upper right quarter of the graphs, over the regression line, in both maturities.

- **Estimation of the genetic gain for yield by comparing frequency distributions.**

From Fig. 9 and 10, comparison of frequency distributions for YLD for R3 advanced hybrids versus all 2011 R2 tested hybrids for FAO480 and FAO550 maturities respectively, it could be observed that the mean of the population of R3 advanced hybrids moved towards higher yields with about 5 q/ha, proving a significant genetic gain for yield in both maturities groups from one generation to the next one.

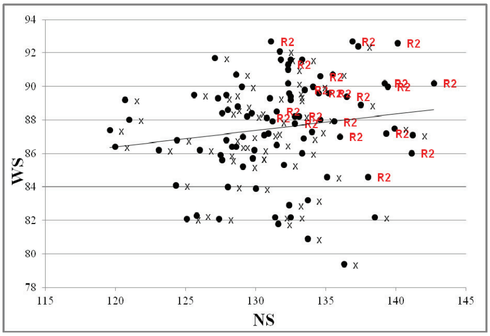


Fig. 7. Linear regression between WS and NS, R1 hybrids, FAO480, 2011 testing.

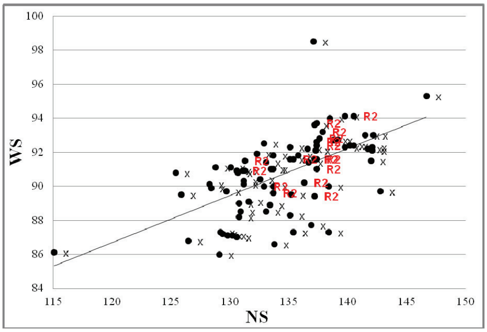


Fig. 8. Linear regression between WS and .NS, R1 hybrids, FAO550, 2011 testing.

Frequency of the promoted (advanced) hybrids in superior classes of yield increased till over 55% in 125-130 q/ha class and over 30 % in 130-135 q/ha class as compared with frequency of all tested hybrids of 20% and 1% respectively, in the case of 2011 R2 hybrids from FAO 480 group (figure 9). Considering 2011 R2 hybrids from FAO 550 group (Fig. 10) frequencies of newly advanced R3 from 2011 R2 hybrids in the superior yield class of 120-125 q/ha increased till 60% (versus around 40% for all R2 tested hybrids) and till more 22% in the highest yield class of 125-130 q/ha (versus around 10 % for all 2011 R2 tested hybrids).

Results of the frequency distributions of the yield of the newly advaced R2 hybrids versus all R1 hybrid tested in 2011 are presented in figures 11 and 12. Similarly to R2 hybrids, the mean of the promoted hybrids moved significantly to higer classes of yield with about 5 q/ha.

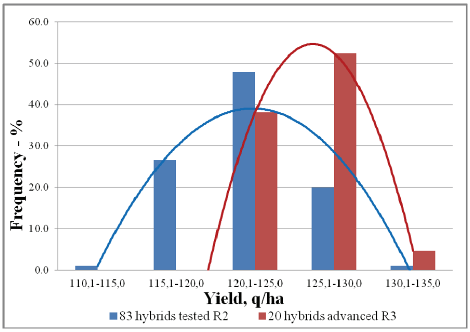


Fig. 9. Comparison of frequency distributions for YLD, of newly advanced R3 hybrids versus all R2 tested hybrids in 2011, FAO480.

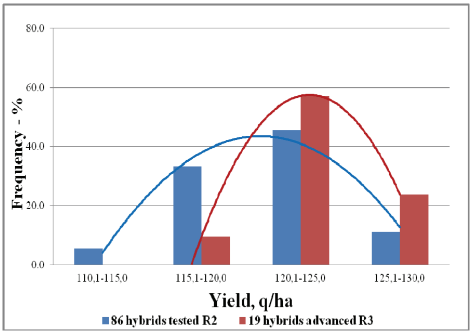


Fig. 10. Comparison of frequency distributions for YLD, of newly advanced R3 hybrids versus all R2 tested hybrids in 2011, FAO550.

This yield increasing of the mean yield of the population of newly advanced R2 hybrids can be considered as a significant genetic gain for yield on short term – from one generation to next one. As a consequence of this genetic gain, frequency distributions of the newly advanced R2 hybrids increased in the superiour yield classes. Thus, in the case of maturity group FAO480 (Fig.11), frequency of the newly advanced R2 hybrids increased to almost 60% (versus 20% for all R1 tested hybrids) in the superior yield class of 115-120 q/ha and to 10 % (versus around 2 % for all 2011 tested R1); in the case of maturity group FAO550, frequency of the newly advanced R2 hybrids increased to over 50% (versus 37% for all R1 tested hybrids) in the superior yield class of 120-125 q/ha.

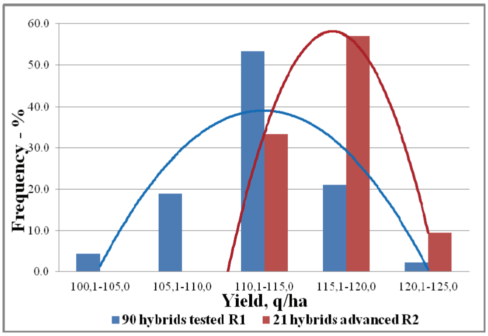


Fig. 11. Comparison of frequency distributions for YLD, of newly advanced R2 hybrids versus all R1 tested hybrids in 2011, FAO480

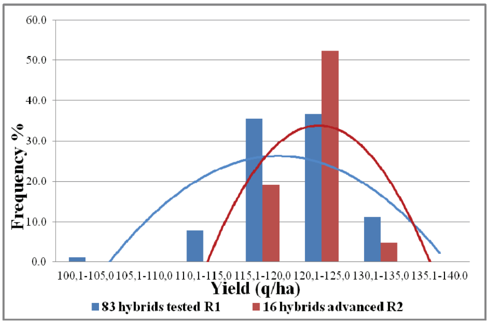


Fig. 12. Comparison of frequency distributions for YLD, of newly advanced R2 hybrids versus all R1 tested hybrids in 2011, FAO550

## CONCLUSIONS

Estimation of short term – from one generation to the next one – genetic gain is extremely important for taking corrective actions to keep the efficiency of the breeding programs at an appropriate level and thus to reach the proposed breeding objective;

Very few if almost none reports on the estimation of this type of genetic gain have been published, being more an internal process of the breeding programs.

The results presented in this study showed that at least the breeding program taken into consideration – hybrids for grain, two maturities group, FAO480 and FAO550 - has a superior efficiency in early stages of hybrid testing in improving grain yield.

A significant genetic gain from one generation to the next one of 5 q/ha (4-5% yield increasing of the mean yield of the advanced (promoted) hybrids, versus mean yield of the population of all hybrids tested and submitted to advancement (selection) process.

Extension of such kind of analysis to advanced testing stages and to other important agronomic and disease traits would be extremely useful to appreciate in a complex way the efficiency of the breeding program and to take the appropriate corrective measure in case of lack or biased genetic gain.

## REFERENCES


[1] Castelberry, R.M., Crum C.W., Krull C.F., 1983. *Genetic yield improvement of U.S. maize cultivars under varying fertility and climate environments*. Crop. Sci. 24:33-36.

[2] Ciocazanu, I., Cosmin O., Sarca, T., Bica, N., Bagiu, C., 1998. *Progrese genetice obtinute in ameliorarea porumbului la I.C.C.P.T. Fundulea in perioada 1978-1996* An. I.C.C.P.T. Fundulea LXV: 55-87.

[3] Cosmin, O., Sarca, Tr., I. Ciocazanu, V. Ulinici, D. Craiciu, Restea, T., 1986. *Evaluarea progresului genetic în ameliorarea porumbului*, An. I.C.C.P.T. Fundulea LIV : 58-72.

[4] Derieux, M., Darrigrand, M., Gallais, A., Barriere, Y., Bloc, D., Montalant, Y., 1987. *Estimation du progres genetique realise chez le mais grain en France entre 1950 et 1985.* Agronomie 7:1-11.

[5] Duvick, D.N., 1984. *Genetic contributions to yield gains of U.S. hybrid maize,* 1930 to 1980. p. 15-47. In W.R. Fehr (ed.) Genetic contributions to yield gains of five major crop plants. CSSA Spec. Publ. 7. ASA and CSSA, Madison, WI.

[6] Duvick, D.N., 1992. *Genetic contributions to advances in yield in U.S. maize*. Maydica 37:69-79.

[7] Duvick, D.N., Cassman, K.G., 1999. *Post-Green Revolution Trends in Yield Potential of Temperate Maize in the North-Central United States*. Crop Sci. 39:1622-1630.

[8] Duvick, D.N., 1997. *What is yield*? p. 332-335, In G.O. Edmeades et al. (ed.) Developing drought-and low N-tolerant maize. Proceedings of a Symposium. 25-29 March 1996. Cimmyt, Mexico, D.F.

[9] Eyherabide, G.H., Damilano, A.L., Colazo, J.C., 1994. *Genetic gain for grain yield of maize in Argentina.* Maydica 39:207-211.

[10] Ivanovic, M., Kojic L., 1990. *Grain yield of maize hybrids in different periods of breeding*. Informatsionnyi Byulleten po Kukuruza 8:93-101.

[11] Russell, W.A., 1991. *Genetic improvement of maize yields.* Adv. Agron. 46:245-298.

[12] Sarca, Tr., 1982. *Progrese genetice realizate in lucrarile de ameliorare a hibrizilor de porumb.* An. I.C.C.P.T. Fundulea, L: 69-79

[13] Tollenaar, M., 1991. *Physiological basis of genetic improvement of maize hybrids in Ontario from 1959 to 1988*. Crop Sci. 31:119-124.

[14] Tollenaar, M., Wu, J., 1999. *Yield improvement in temperate maize is attributable to greater stress tolerance*. Crop Sci. 39:1597-1604