"Parent-Progeny Relationships for Physiological Attributes in Maize: Nitrogen Effects.".

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INTRODUCTION:

In maize hybrid development, gains in heterosis do not explain all the gain observed in grain yield across time [2]. Non heterosis gains (measured as grain yield improvement of parental lines) have been also an important contribution [2]. Improvement of maize inbred lines, therefore, is crucial for successful seed production but also because their improvement translate into superior hybrids. Knowledge on parent-progeny relationships (PPR) for physiological attributes (e.g. light capture, radiation use efficiency –RUE-, harvest index –HI-, kernel set per unit plant growth rate around silking –reproductive efficiency-) is very scarce and would improve the use of inbred line information as an indirect criteria indicative of hybrid performance, reducing the number of hybrid evaluations [1]. Our **objective** was to determine the described relationships for a set of twelve single-cross maize hybrids obtained from six inbred lines. Studies were performed at the crop and plant levels.

MATERIALS AND METHODS:

Field experiments were conducted at the experimental station of INTA Pergamino (33°56' S, 60°34' W), Argentina, during 2002/2003, 2003/2004 and 2004/2005**.** Hybrids were made during 2001/2002.

- **Genotypes: 6 Inbred Lines:** ZN6 ('60), LP2 ('95), LP561 ('94), LP662 ('97) and LP611 ('90) from INTA; and B100 ('93) from USA
  12 one-way Hybrids: B100 x LP2, B100 x ZN6, B100 x LP561, ZN6 x LP561, ZN6 x LP611, LP561 x LP662 and their reciprocals.
- **Plant population:** 7 plants m^{-2} **Treatments:** [initial soil N (0-40 cm) between 20 and 55 kg N ha^{-1}]:
  N_0: no N application and **N_{400}**: 400 kg N ha^{-1} (between seedling and V_9)

MEASUREMENTS: on 5 plants tagged at V_3 in each subplot:

- **Phenology**: evolution of the number of visible and senesced leaves; anthesis and silking dates.
- **Thermal time** (TT)= ΣTm – Tb; Tm: mean daily temperature and Tb: base temperature (8 °C).
- **Leaf Area Index** (LAI): leaf area plant^{-1} x plants m^{-2}.
- **Light interception evolution:** (fIPAR: fraction of incident radiation intercepted by the canopy).
- **Incident PAR intercepted by the canopy:** (IPARi)
- **Biomass production, RUE and HI**
- **Plant** (PGRcp) and **Ear** (EGR) **growth rates during the critical period**
- **Partitioning ratio** (EGR PGRcp^{-1})
- **Plant grain yield** (PGY) and its components **kernel number per plant** (KNP), **kernel number per apical ear** (KNE_1) and **kernel weight** (KW)
- **Reproductive efficiency** (KNP PGRcp^{-1} and KNE_1 EGR^{-1})
- **N uptake at maturity** (N uptake pm) and **Nitrogen use efficiency** (NUE, kg grain kg N uptake pm^{-1})

Mid-Parent Heterosis = (F1-MP)/MP x 100, F1 = reciprocal hybrids means and MP = inbred means
PPR = regression between inbred mean and the mean of their reciprocal hybrids.

RESULTS: Heterosis in environments with high and low N availability

Heterosis was higher in environments with no N limitations for traits related to light capture, PGRcp, biomass production, N uptake, PGY and its numerical components with exception of reproductive efficiency and NUE (Table 1). The environmental variability achieved through experimental years and N levels allowed to explain the variability observed in the percentage of heterosis for most attributes (Fig. 1). A positive association was found between the mentioned percentage and the environmental index (EI, calculated as the mean of 18 genotypes evaluated in each of the 6 explored environments) for LAImax (Fig. 1a), biomass pm (Fig. 1b) and many others.

Parent-Progeny relationships and heterosis

The 26 morpho-physiological attributes evaluated were classified in four different groups. The first group had low heterosis and high PPR, and included attributes usually used in breeding (time to silking, anthesis-silking interval, total leaf number) (Fig. 2a). The second group had high PPR and significant (P<0.05) heterosis at all N levels, and included traits related to light capture, biomass production, plant growth rate and HI (Fig. 2b). These attributes could be included in a breeding program because of their relationship with grain yield determination. For the third group of traits (RUE and reproductive efficiency), inbreds did not predict the performance of their hybrids accurately (Fig. 2c). These traits should be improved in hybrids but not in inbreds The forth group included traits with high PPR at high nitrogen availability but not at N_0, like kernel number and grain yield (Fig. 2d). For N_0 type environments, improvement of these attributes in inbreds should be performed on those traits related to grain yield (e.g. plant growth rate at critical periods, biomass production, light capture, HI).

Table 1: Percentage of Heterosis and regression coefficients (*b*) of the Parent-Progeny Relationships (PPR) for attributes measured under contrasting N conditions (N_{400} and N_0).

	% Heterosis		PPR	
Attribute	**N_{400}**	**N_0**	**N_{400}**	**N_0**
TT anthesis (ºCd)	-10***	-9***	0.65***	0.64***
TT silking (ºCd)	-11***	-8***	0.73***	0.84***
ASI (d)	-0.9ns	-0.2ns	0.92***	0.84***
Leaf Number	3**	3**	0.86***	1.06***
LAImax	59***	32***	1.13***	0.61**
LAIpm	114***	29ns	1.05***	0.06ns
fIPARmax	28***	30***	0.21ns	0.63***
fIPARpm	86***	40ns	0.37***	0.11ns
IPARicp (MJ m^{-2} d^{-1})	32***	31***	0.72***	1.06***
IPARipm (MJ m^{-2})	49***	35***	1.21***	1.15***
Biomass presilking (g pl^{-1})	131***	96***	-0.01ns	-0.73ns
Biomass silking+12d (g pl^{-1})	57***	33***	0.64***	0.52***
Biomass pm (g pl^{-1})	86***	43***	0.78***	0.56***
RUEcp (g MJ^{-1})	20*	-5ns	0.08ns	0.15ns
RUEpm (g MJ^{-1})	24***	4ns	0.95***	0.83**
PGRcp (g pl^{-1} d^{-1})	61***	25*	0.44***	0.58***
EGR (g d^{-1})	33*	9ns	0.59***	0.21ns
EGR PGRcp^{-1}	-17ns	-13ns	0.61***	0.72***
KNP	78***	57***	0.48***	0.22ns
KNP PGRcp^{-1} (grains d g^{-1})	12ns	24ns	0.09ns	0.11ns
KNE_1 EGR^{-1}	40***	55***	1.09**	0.31ns
KW (mg)	37***	22***	1.02***	0.46**
N uptake pm (kg ha^{-1})	75***	1ns	0.67***	0.20ns
NUE (kg grain kg N uptake^{-1})	24***	58***	0.52*	0.91***
HI	30***	33***	0.65***	0.23**
PGY (g pl^{-1})	142***	92***	0.88***	0.12ns

*, **, *** Significant at *P*<0.10, *P*<0.05 and *P*<0.01, respectively. ns= not significant

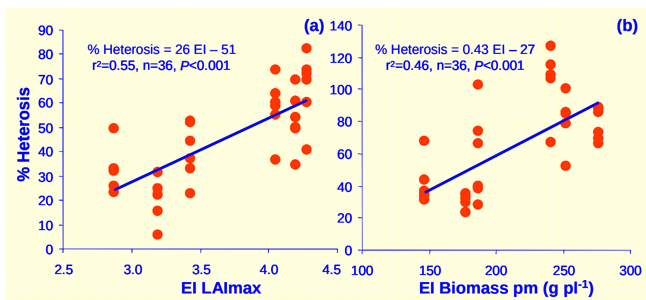

Figure 1: Relationship between % Heterosis and environmental index (EI) for (a) maximum leaf area index (LAImax) and (b) biomass production at maturity (Biomass pm).

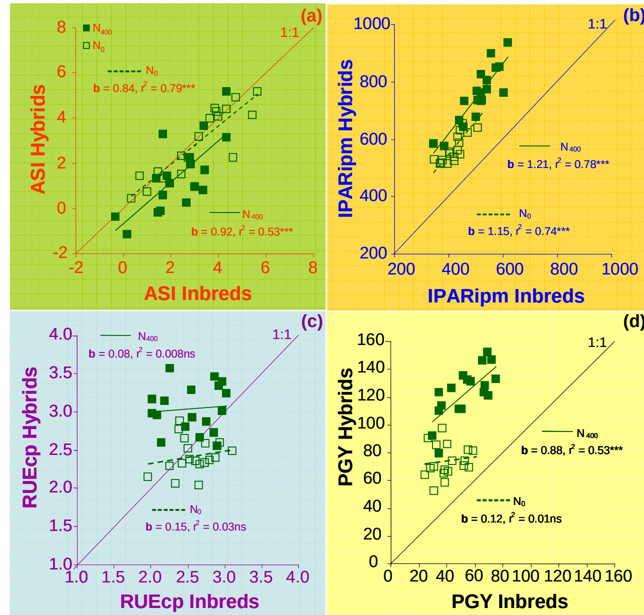

Figure 2: Parent-Progeny Relationships for (a) ASI, (b) Incident PAR intercepted by the canopy at maturity (IPARipm), (c) Radiation use efficiency during critical period (RUEcp) and (d) Plant grain yield (PGY) of 6 inbreds lines and their 12 one-way hybrids cropped at contrasting N levels (N_0 and N_{400}) during 3 experimental years.

CONCLUSIONS

✓The higher heterosis in N_{400} and its variability through evaluated environments determined a greater sensitivity under N deficiencies in hybrids than in their parental inbreds or, in other words, inbreds exhibited little response to growth under favorable environmental conditions.

✓It was demonstrated that attributes related to light capture, biomass production, plant growth rate and harvest index, which functionally explain the grain yield determination, showed to be good predictors of hybrid performance.

✓Some of these attributes (e.g., fIPARmax) could be successfully included in maize inbred lines breeding programs.

References:

1. Betrán et al. (2003) Crop Sci. 43:797-806.
2. Duvick, D.N., (1999) Heterosis: feeding people and protecting natural resources. *In* The genetics and exploitation of heterosis in crops. ASSA/CSSA/SSA, Madison, WI.

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