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Associations of genetic parameters with F1 grain yield of maize (*Zea mays* L.) and grain yield prediction of diallel crosses

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Abstract: **This study was initiated with the objective of investigating association of genetic parameters with grain yield and grain yield prediction based on genetic parameters used for the study. Four genetic parameters viz., specific combining ability (SCA), mid-parent heterosis (MPH), better parent heterosis (BPH) and Standard heterosis with grain yield (GY) were used for the study. Genetic analysis for SCA effect and estimation of, MPH, BPH and SH were done as a result of significant variation observed among 45 F1 half diallel cross hybrids for grain yield. The estimated genetic parameters association was used for grain yield prediction or regression analysis. Ten elite inbred lines were selected based on over per se performances. The crosses were done in a 10 x 10 half-diallel mating design to produce 45 F_1 single crosses hybrids during 2016. The experiment was conducted at Bako national maize research in 2017 main season by using alpha lattice design. SCA, MPH, BPH and SH were used for multiple linear correlation and regression analysis for grain yield. The specific combining ability, mid parent, better parent and standard heterosis were showed highly significantly ($p < 0.01$) and positive associated with grain yield at value of $r = 0.78, 0.60, 0.65$ and 1.00 respectively. Those significantly and positively associated genetic parameters with grain yield had 61%, 36%, 42%, 100% grain yield predictive values for SCA, for MPH, BPH and SH respectively.**

Keywords: **Heterosis, Diallel, Multiple regressions, Specific combining ability, Grain yield.**

1. INTRODUCTION

Maize (Zea mays (L.) 2n = 20] is the third most important cereal crop worldwide after rice and wheat in terms of area planted and consumption (Kornher, 2018). However, currently maize becomes the second most produced crop in the world. Specifically, in sub-Saharan Africa, global statistics show that more and more land is being used for (small-scale) maize production to meet future food demands (Santpoort, 2020). Maize grows in most parts of the world over a wide range of environmental conditions, with altitudinal ranges of 0 to 3000 meters above sea level (m.a.s.l) (Dowswell *et al*., 1996). It is one of the most important food crops world-wide, serving as staple food, livestock feed, and industrial raw material (Troyer, 2006).

In Ethiopia, the demand of maize is increasing from time to time due to the high food demand associated with the increased human population (Abate *et al*., 2015). FAO (2019) stated that maize yields have doubled from around 1.6t/ha in 1990 to more than 3.7 t/ha in recent years, the highest level after South Africa. Despite the recent progress in productivity, yield levels in Ethiopia are still very low relative to what it could be (GYGA, 2019). This could be highly driven by the existing and emerging biotic and abiotic stresses which might include fall army worm, turcicum leaf blight, lack of high yielding and stress tolerance varieties or prominent parental materials, lack promoting the existing varieties, climate change, soil degradation and loss of arable lands.

Thus, the development and release of a greater number of higher potential stress tolerant maize varieties is very important to assist in cope up with these challenges. Development of commercial maize hybrids usually requires good knowledge of genetic parameters association that may help as a grain yield prediction tools in maize breeding program. Information on parameters association and grain yield prediction in maize breeding program is a crucial and indispensable in maximizing the effectiveness of hybrid development. Therefore, this study was initiated to support the maize hybrids breeding program of the mid-altitude maize breeding through the estimate associations of genetic parameters of mid-altitude maize with grain yield and grain yield prediction.

2. MATERIALS AND METHOD

Experimental Location: The experiment was conducted at Bako national maize research center during 2017 main cropping season. Bako is located in East Wollega zone of the Oromia National Regional State, Western Ethiopia. Th center lies between $9^0$6' North latitude and 37^0 09' East longitudes in the sub-humid agro-ecology, at altitude of 1650 meters above sea level. It is 250 km far from Addis Ababa, the capital city of the country. The mean annual rain fall in the last half century is 1238 mm. The rainy season covers April to October and maximum rain is received in the months of July and August. The mean minimum, mean maximum and average air temperature is 12.8, 29.0, and 20.9 ^{0}C, respectively; and relative humidity of 51.04%. The soil is reddish brown in color and clay and loam in texture (Wakene, 2001). According to USDA (2015) soil classification, the soil is Alfisols developed from basalt parent materials, and is deeply weathered and slightly acidic in reaction (Wakene, 2001).

Experimental Materials: Ten inbred lines namely, L1, L2, L3, L4, L5, L6 and L7 from BNMRC (Bako National Maize Research Center), L8 and L9 from CIMMYT and L10 from IITA were used in this study. The inbred lines were cross pollinated in a half diallel fashion to develop 45 single cross hybrids. A total of 48 hybrids, 45 single cross hybrids and three commercial standard checks (BH546, BH547 and SPRH1) were evaluated during 2017 main cropping season for grain yield and related agronomic traits.

Experimental Design: Each 48 hybrid was sown in 5.1-meter-long rows with inter- and intra-row spacing of 0.75 m and 0.30 m respectively. The experiment was laid out in alpha lattice (0, 1) with two replications at both testing locations. Ten parental lines were also sown in adjacent to hybrids trial at Bako in randomized complete block design with similar inter- and intra-row spacing and replicates of hybrids.

Trial Management: Each plot was hand planted with two seeds per hill, which were later thinned to one plant per hill to get a total plant population of 44, 444 per hectare. Planting was done on the onset of the main rainy season when the soil retains sufficient moisture to promote optimum germination and seedling development. Weeds were controlled by applying pre-emergence herbicide at planting and followed by 2-3 hand weeding at different stages of plant growth. Di-ammonium phosphate and urea fertilizers were applied as per the package of the locations (150 kg ha^{-1} and 200kg ha^{-1} respectively). Di-ammonium phosphate fertilizer was applied once at planting time, while urea was applied in split, half at planting and the remaining half at knee height. Other agronomic practices were carried out as per the recommendation for the area.

Collected Data

Grain weight per plot (t/ha**)**: Ears were removed from all plants in each plot leaving other crop residues (husk, leaf, stem and tassel) intact. The total field weight from all the ears of each experimental unit was recorded and converted to $tonha^{-1}$using the following formula.

$$\text{Grain yield } (\text{tonha}^{-1}) = \frac{\text{FW(kg)} \; x \; (100 - \text{MC}(\%))}{(100 - 12.5)} x \frac{10}{\text{A (sq. m)}} \; x \; 0.8$$

Where, FW = Field Weight, MC = Moisture Content, 12.5 = Adjusted moisture percentage, A = Plot area, 0.8 = Shelling Percentage

Data Analysis:

Analysis of variance was analyzed using statistical analysis software SAS 9.3 version (SAS, 2010).

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Estimation of specific combining ability: SCA was conducted using Griffing's (1956) method IV (F_1's) model I (fixed model) to obtain the estimates of SCA effects using the Proc GLM model of the SAS program (SAS, 2014) using Diallel-SAS procedure (Zhang *et al.*, 2005).

Estimation of heterosis: Mid parent heterosis (MPH), better parent heterosis (BPH) and standard heterosis were calculated for the characters that showed significant differences between genotypes (crosses and parents) following the method suggested by Falconer and Mackay (1996).

$$\text{MPH (\%)} = \frac{F_1 - MP}{MP} \text{x100}, \quad \text{BPH (\%)} = \frac{F_1 - BP}{BP} \text{ x 100}, \quad \text{SH (\%)} = \frac{F1 - SC}{SC} x100$$

Where, F_1 = Mean value of the crosses, MP = Mean value of the two parents or (P1 + p2)/2, BP = Mean value of the better parent, SC = Mean value standard check, P1 = Mean value of parent1, P2 = Mean value of parent 2

Multiple linear regression analysis: Multiple linear correlation and regression analysis used grain yield as dependent variable and four independent variables (specific combining ability, mid parent heterosis, better parent heterosis and standard heterosis) were considered as independent variables following formula suggested by Gomez and Gomez (1984). The relationship of the dependent variable Y to the K independent variables x_1, x_2, x_k can be expressed as:

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_{k+} + \epsilon$$

Where Y = dependent variable, x = independent variable, k = number of independent variables, α = intercept, β1, β2, β_k = regression coefficients β_1 measures a change in Y for unit change in x_1, if x_2 is held constant. Similarly,β2, β3… β_k measures the rate of change in Y for a unit change in x2, x3, x_k where x_3, x_4, …x_k is held constant, ϵ = the model's error term (also known as the residuals).

3. RESULT AND DISCUSSION

The four genetic parameters namely specific combining ability, mid parent heterosis, better parent heterosis and standard heterosis values for grain yield were used to estimate the association of these parameters with grain yield. The association analysis result for grain yield with each genetic parameter viz., SCA, MPH, BPH and SH is presented in **Table1**. All independent variables (genetic parameters) used for simple linear correlation and regression for grain yield prediction used for the study were highly significant ($P < 0.01$) and positively associated (r = 0.78 for grain yield with specific combining ability, r = 0.60 for grain yield with both mid parent value and mid parent heterosis, r = 0.65 for grain yield with better parent heterosis and r = 1.00 for grain yield with standard heterosis). Those positively associated genetic parameters with grain yield had 61%, 36%, 42%, 100% predictive values for SCA, MPH, BPH and SH respectively (**Table 1**).

Specific combining ability (SCA) was revealed highly significant ($p < 0.01$) and positive strongly correlated (r = 0.78) with grain yield indicating that as SCA value increase, grain yield would also be increased. The study was in line with

Simple linear correlations were used to investigate the relationship between heterosis and F1 hybrid performance on grain yield. Mid parent heterosis, better parent heterosis and standard heterosis manifested highly significant ($P < 0.01$) correlation with grain yield. However, the mid parent heterosis and better parent heterosis had moderate association (r = 0.60), while standard heterosis showed relatively strong or perfect correlation with grain yield. This might suggest that the standard heterosis could be used to predict performance of F1 hybrids better than the other heterosis. Makumbi (2006) found moderate and significant correlation between mid-parent heterosis and grain yield at well-watered environment. Similarly, Balestre *et al.*, (2008) and Devi and Singh (2011) described that MPH and BPH were found as major determinant of per se performance of hybrids. However, Bhusal and Lal (2017) reported weak and significant association of mid-parent and better parent heterosis with grain yield (r = 0.28 for MPH with grain yield, and r = 0.38 for BPH with grain yield). The scholars also found that the F1's grain yield showed significant positive relationship with varying degree to mid parent heterosis, better parent heterosis and specific combining ability of hybrids across environments and suggested different environments influence the association.

Multiple liner regression of grain yield on SCA, MPH, BPH and SH for F1's hybrids were significant with R^2 values of 0.61, 0.36, 0.42, 1.00. Similarly, Bhusal and Lal (2017) found significant linear regressions of grain yield on SCA, MPH and BPH with R^2 values of 0.57, 0.53 and 0.78 respectively.

Table 1: Pearson correlations and linear regression for grain yield prediction with foour genetic parameters

Parameters	N	r	r^2	Predictive value (%)	Slope	Intercept	95% CI for ρ	P-Value
GY Vs SCA	45	0.78**	0.61	61	1.00	8.62	(0.63, 0.87)	0.000
GY Vs MPH	45	0.60**	0.36	36	0.01	7.66	(0.37, 0.76)	0.000
GY Vs BPH	45	0.65**	0.42	42	0.02	7.96	(0.44, 0.79)	0.000
GY Vs SH	45	1.00**	1.00	100	0.10	9.93	(1.00, 1.00)	0.000

** = Significant at $P < 0.01$ probability level, GY = Grain Yield; Vs = Versus; N = Number of observations; SCA = Specific Combining Ability; MPH = Mid Parent heterosis; BPH = Better Parent Heterosis; SH = Standard Heterosis; r = correlation coefficient; r^2 = Coefficient of determination

4. CONCLUSION

In summary, the present study reveals the relationship between genetic parameters and hybrid performance (F1) in grain yield and grain yield prediction. Highly significant positive association of grain yield with SCA (0.78**) , MPH (0.60**), BPH (0.65**), and SH (1.00**) were found. These genetic parameters had 61%, 36%, 42%, 100% grain yield predictive values for SCA, for MPH, BPH and SH respectively.

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Competing interests

The authors declare that they have no competing interests.

REFERENCES

[1] Abate, T., Shiferaw, B., Menkir, A., Wegary, D., Kebede, Y., Tesfaye, K., Kassie, M., Bogale, G., Tadesse, B. and Keno, T., 2015. Factors that transformed maize productivity in Ethiopia. *Food security*, *7*(5), pp.965-981.

[2] Balestre, M., Von Pinho, R.G., Souza, J.C. and Lima, J.L., 2008. Comparison of maize similarity and dissimilarity genetic coefficients based on microsatellite markers. *Genet. Mol. Res*, *7*(3), pp.695-705.

[3] Bhusal, T.N. and Lal, G.M., 2017. Relationship among heterosis, combining ability and SSR based genetic distance in single cross hybrids of maize (Zea mays L). *Vegetos*, *30*(2), pp.17-26.

[4] Devi, P. and Singh, N.K., 2011. Heterosis, molecular diversity, combining ability and their interrelationships in short duration maize (Zea mays L.) across the environments. *Euphytica*, *178*(1), pp.71-81.

[5] Dowswell, C.R., Paliwal, R.L. and Cantrell, R.L., 1996. Maize in the third world. Westview Press, Boulder, CO. *Maize in the third world. Westview Press, Boulder, CO*.

[6] Falconer DS, Trudy FC, Mackay (1996). Introduction to Quantitative Genetics. 4th ed., Malaysia, Longman Group Limited.

[7] FAOSTAT, F., 2019. Food and Agriculture Organisation of the United Nations. FAOSTAT.

[8] Global yield gab atlas (GYGA). 2019. GlobalYieldGapAtlas.http://yieldgap.org/.

[9] Gomez, K. A., Gomez, K. A., & Gomez, A. A., 1984. Statistical procedures for agricultural research. Second edition. International Rice Research Institute, John Wiley & Sons.

[10] Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian journal of biological sciences, 9(4), 463-493.

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[11] Kornher, L., 2018. Maize markets in Eastern and Southern Africa (ESA) in the context of climate change Background paper for The State of Agricultural Commodity Markets (SOCO) 2018. Retrieved from www.fao.org/publications

[12] Makumbi, D., 2006. *Phenotypic and genotypic characterization of white maize inbreds, hybrids and synthetics under stress and non-stress environments* (Doctoral dissertation, Texas A&M University).

[13] Santpoort, R., 2020. The drivers of maize area expansion in Sub-Saharan Africa. How policies to boost maize production overlook the interests of smallholder farmers. *Land*, *9*(3), p.68.

[14] SAS Institute Inc., 2010. SAS Guide for personal computers version 9.3 Edition. SAS Institute Carry NC, USA.

[15] Troyer, A.F., 2006. Adaptedness and heterosis in corn and mule hybrids. *Crop science*, *46*(2), pp.528-543.

[16] USDA-FAS (2015). United States Department of Agriculture, Foreign Agricultural Service. World Agricultural Production Circular Series WAP04 -15, April 2015.

[17] Wakene NC, 2001. Assessment of important physico-chemical properties of Dystric Udaf (Dysrtic Nitosols) under different management systems in Bako area, Western Ethiopia. An M.Sc. Thesis presented to School of Graduate Studies of Alemaya University. 93 p.

[18] Wakene, N. (2001). Assassment of important physio-chemical properties of dystricudalf (dystric Nitosols) under different management systems in Bako area, Western Ethiopia. M.Sc. Thesis. Of Graduate Studies, Alemaya University, Ethiopia.

[19] Zhang, Y., Kang, M. S., & Lamkey, K. R. (2005). Diallel-Sas05. Agronomy Journal, 97(4), 1097.

APPENDICES - A

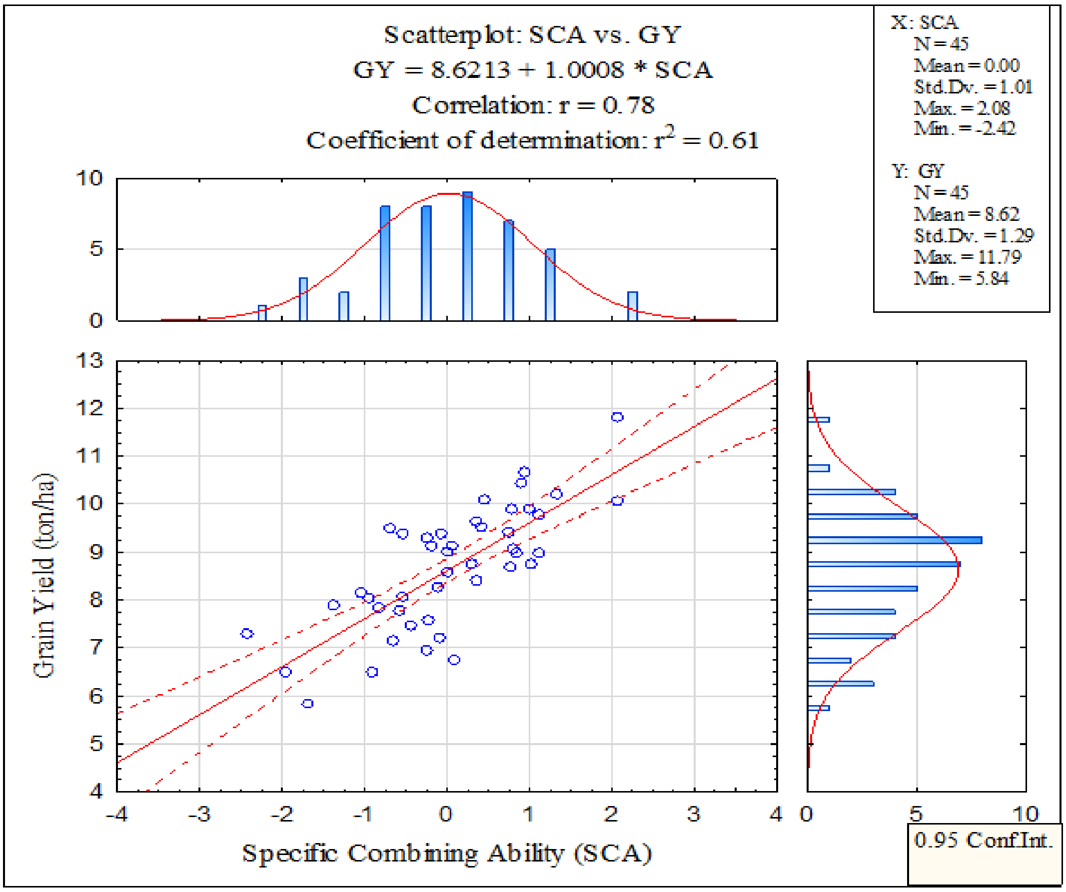

Figure 1: Simple linear correlation and regression for prediction of grain yield against specific combining ability

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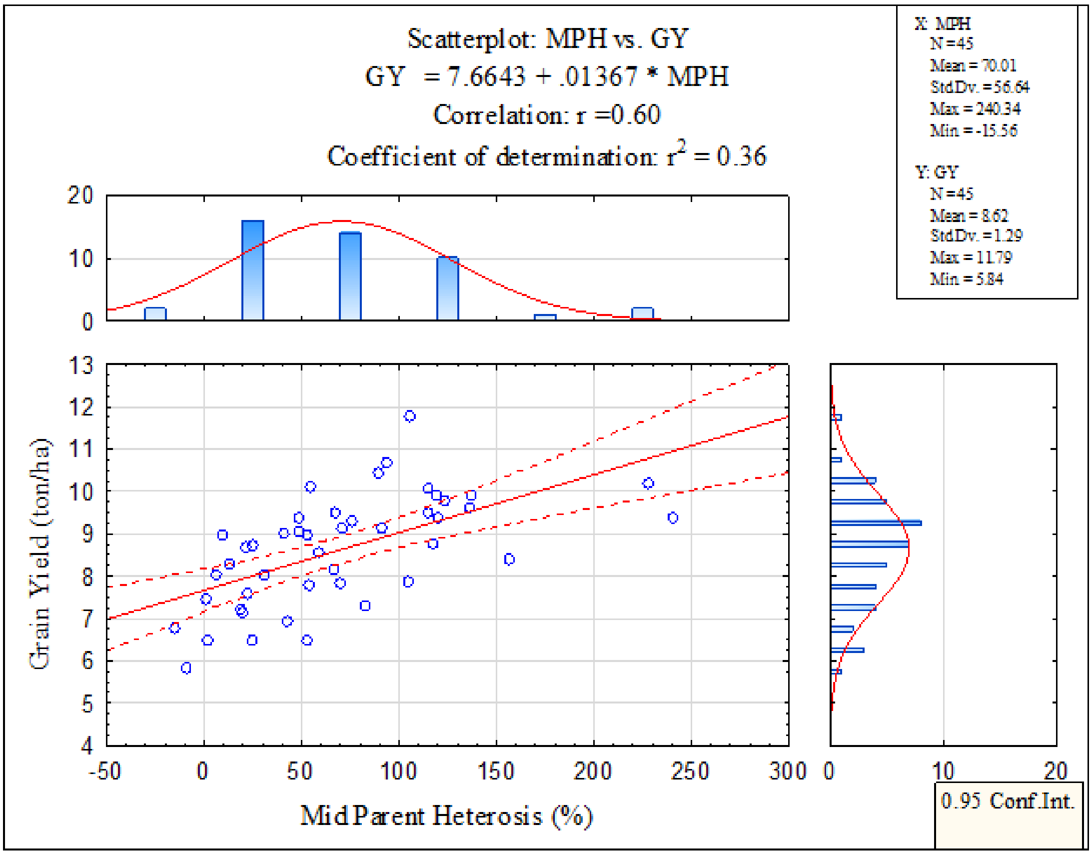

Figure 2: Simple linear correlation and regression for prediction of grain yield against mid parent heterosis

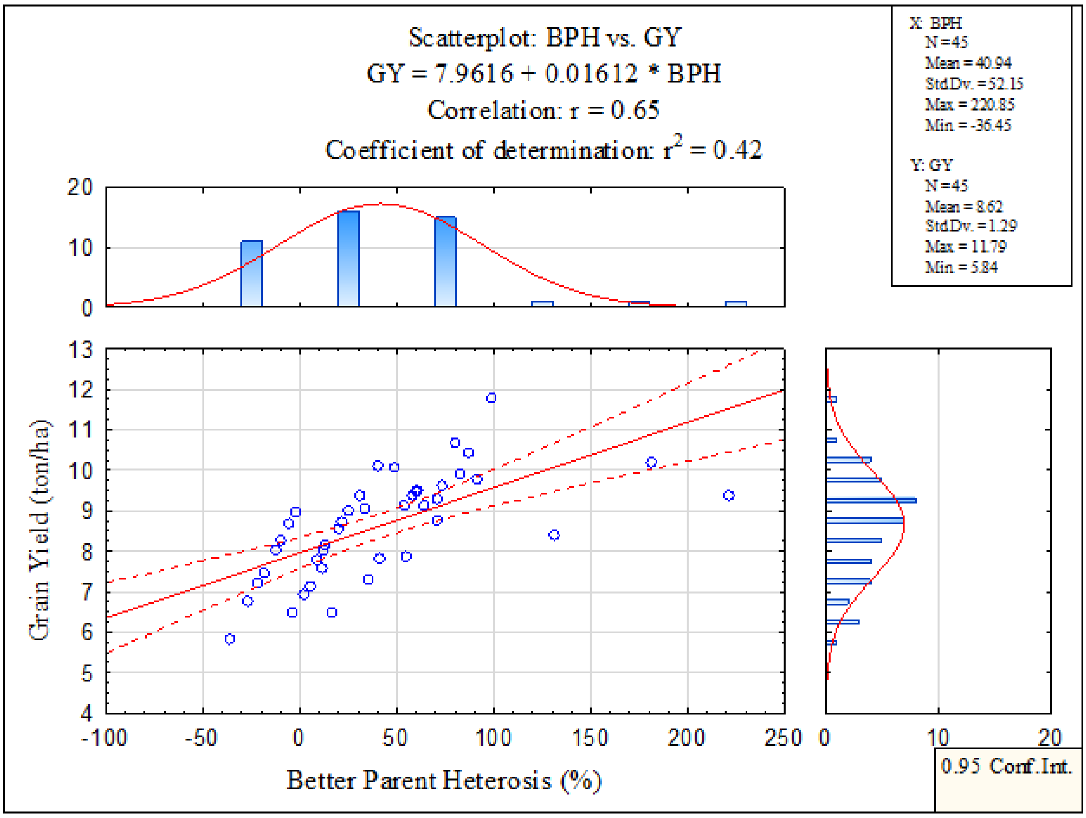

Figure 3: Simple linear correlation and regression for prediction of grain yield against better parent heterosis

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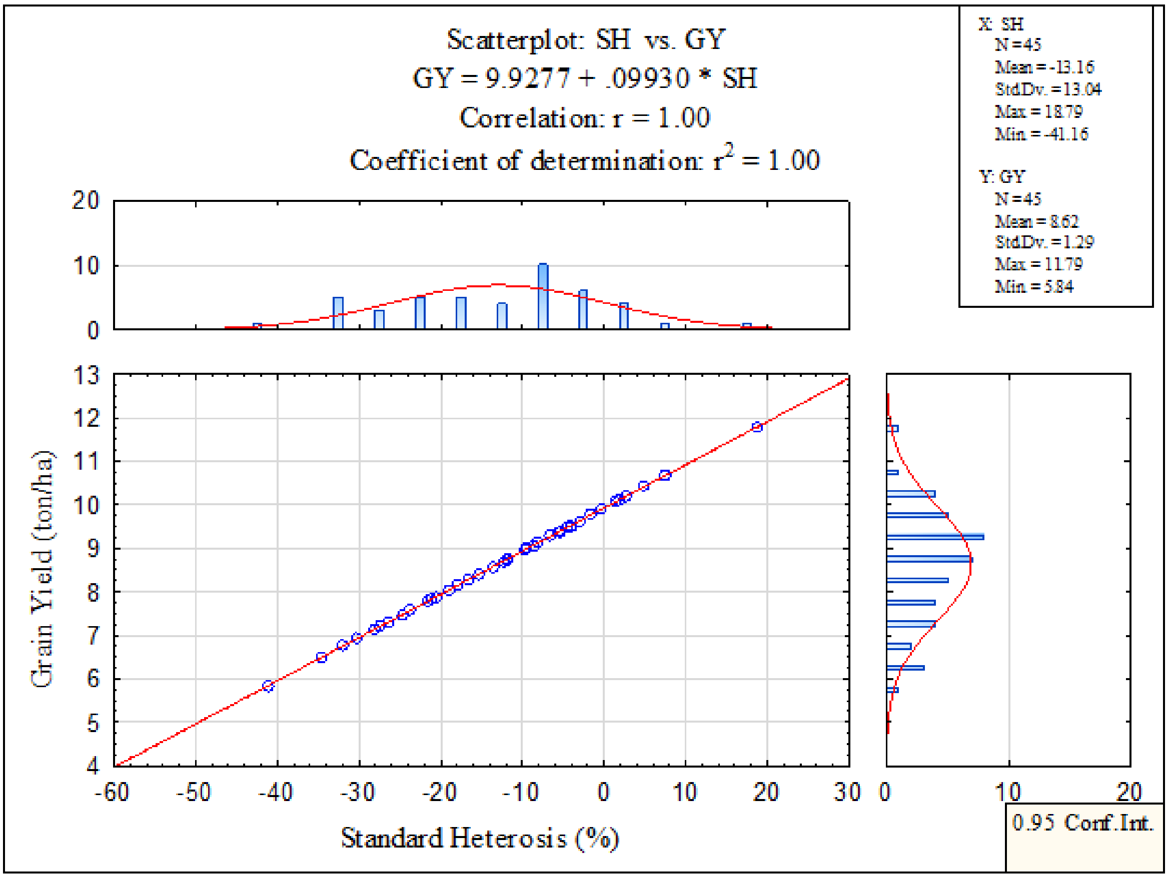

Figure 4: Simple linear correlation and regression for prediction of grain yield against standard heterosis