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Correlations between Yield and Yield - Attributing Traits and their Influence on Soybean

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ABSTRACT: In the 2022 Kharif season, comprehensive research was undertaken at the Dryland Agriculture Research Centre, College of Agriculture, Indore, Madhya Pradesh, employing a randomized block design with dual replications. The primary focus was to discern the relationship between 13 unique traits and soybean productivity. Through the assessment of 63 advanced genotypes, compared alongside three benchmark varieties, it was ascertained that grain yield (kg/ha) held a markedly significant positive phenotypic association with attributes such as the number of primary branches per plant, plant height, pod count and weight per plant, individual plant grain yield, and biological yield(kg/ha). Additionally, a pronounced positive genotypic correlation with the grain yield was observed for factors including the duration to pod initiation, days to 50% podding, and the harvest index, among others. The study faced several challenges, including the complexities of managing a large number of genotypes and ensuring the accuracy of phenotypic measurements under variable environmental conditions. Additionally, the genetic diversity of the genotypes added layers of complexity to the analysis of phenotypic and genotypic correlations. Furthermore, the study's results contribute to the understanding of the genetic architecture of soybean, paving the way for the development of high-yielding, resilient varieties. In essence, this research holds promise for bolstering food security by optimizing soybean production through informed breeding strategies.

Keywords: Genotypic Correlation Coefficient, Phenotypic Correlation Coefficient, Soybean, Heat map.

INTRODUCTION

Soybean, *Glycine max* (L.) Merr., stands as one of the world's paramount leguminous crops, esteemed for its rich protein and essential oil content (Hartman *et al*., 2011). It is classified as an oilseed crop because of its high vegetable oil content. This self-fertilizing annual legume possesses a chromosome count of 2n = 2x = 40 (Bairagi *et al.,* 2023). These attributes position it as a pivotal element in global food security and agricultural economics (Goldsmith, 2008). With the continuous upsurge in global populations, the demand for protein-centric foods like soybean is forecasted to intensify, underscoring the relevance of research aimed at bolstering soybean yields.

An avenue showing significant promise in the journey to amplify soybean production centers on discerning the relationships between yield and its attributing characters. These characters, including facets like pod number, seed number per pod, and plant height, are theorized to play substantial roles in determining final yield outcomes. While these traits individually contribute to yield, their collective interplay and cumulative impact on yield necessitates further scrutiny. Past research endeavors have provided insights into the relationships between some yield-attributing traits and soybean yield, yet a holistic examination encompassing a diverse range of these traits is comparatively limited. Moreover, the interplay of these traits under varied environmental conditions and their combined influence on yield remains a captivating research frontier (Rotundo and Westgate 2009).

This study is geared towards illuminating the correlations between soybean yield and its attributing characters. The pivotal role of correlations in understanding the intricate associations between diverse plant traits, especially with respect to seed yield, cannot be overstated. In breeding initiatives, comprehending the relationships between traits is highly beneficial as it allows the breeder to easily determine which characteristics should serve as indicators for selection (Prathima *et al.,* 2022). A refined grasp of these correlations can pave the way for innovative breeding strategies, agronomic interventions, and crop management paradigms that aim for maximized soybean production (Hyten *et al*., 2010).

MATERIAL AND METHODS

In the 2022 kharif season, the Dryland Agriculture Research Center, College of Agriculture, Indore, Madhya Pradesh, conducted a comprehensive study on 63 unique soybean genotypes. These were compared with three regional standards: JS 20 98, JS 20 116, and JS 20 34. Using a randomized block design, each genotype was replicated twice and organized in paired rows with specific spacing: 10 cm between plants and 45 cm between rows. Data was collected from five randomly selected plants per plot, examining both visible and deeper metrics, such as primary branch count, plant height, number of pods, seed yield, and weight of pods. The study also tracked key soybean growth milestones and quantified yield in kg/ha. Additionally, the harvest index was analyzed to gauge yield efficiency relative to biomass. Correlation was calculated for all the traits under the study and their association with seed yield (kg/ha).

Statistical Analysis. To determine the phenotypic and genotypic correlation coefficients between traits, we employed the following formulas using specific variance and covariance components:

- Phenotypic correlation, $(rp) = PCoV_{xy}/\sqrt{PV_x.PV_y}$

- Genotypic correlation, $(rg) = GCoV_{xy}/\sqrt{GV_x.GV_y}$

Overall correlation,

$$r_{xy} = \frac{CoV\ (x.y)}{\sqrt{V(x) \times V(y)}}$$

Where:

- r_{xy} is the correlation coefficient between traits x and y.
- CoV represents the co-variance between traits x and y.
- V(x) and V(y) denote the variance of traits x and y, respectively.
- r_p and r_g symbolize the phenotypic and genotypic correlations, respectively.

To ascertain the significance of the correlation coefficients, we compared the estimated values with those tabulated by Fisher and Yates (1963). This comparison was done at two probability levels: 5% and 1%.

RESULTS AND DISCUSSION

Correlations reveal the linear relationship between two traits and helps pinpoint key traits that impact dependent features, like seed yield. It aids in establishing selection criteria to concurrently enhance multiple traits and boost economic production. Plant breeders typically favor a positive correlation, as it aids in enhancing both linked traits simultaneously.

In the current study, the genotypic correlation surpassed the phenotypic correlation, highlighting the significance of genetic factors in connecting these traits.

The relationship between grain yield (expressed in kg/ha) and various yield-contributing attributes is systematically delineated in Table 1, complemented by the illustrative heat maps provided in Fig. 1 and 2.

There was a notably significant and positive genotypic correlation between grain yield (kg/ha) and several attributes. Specifically, the highest correlation was observed with biological yield (kg/ha), followed closely by attributes such as the weight of pods per plant, the number of pods per plant, plant height, the count of primary branches per plant, the time to achieve 50% podding, the harvest index, and the days taken for pod initiation. Importantly, no negative associations were detected in both the genotypic and phenotypic correlations, emphasizing the positive nature of the relationships.

Moreover, our findings resonate with previously published works. For instance, Banerjee *et al*. (2022) reported a similar correlation between seed yield and variables like the number of primary branches per plant, number of pods, biological yield, and harvest index. Corresponding results were found by Mahbub *et al*. (2015) focusing on plant height, Berhanu *et al*. (2019) on primary branches and plant height, Chandel *et al.* (2017) on biological yield and harvest index, Goonde and Ayana (2021); Kumar *et al*. (2018); Baraskar *et al*. (2015) on biological yield, and several other studies that investigated various combinations of these attributes. Conversely, Kuswantoro *et al*. (2018); Baraskar *et al.* (2015), in their study on the number of primary branches per plant, presented findings that were in contrast to the prevailing trend.

CONCLUSIONS

This study illuminates the dominant role of genotypic correlations over their phenotypic counterparts in determining trait relationships in soybeans. We've detailed the nexus between grain yield and its contributory attributes, with biological yield standing out as the paramount factor. Attributes like pod weight, count, plant stature, branch count, and pod initiation further substantiate the yield. Our findings, consistent with most prior research, emphasize the importance and reliability of these associations in plant breeding. However, divergent viewpoints from studies like Kuswantoro *et al*. (2018); Baraskar *et al*. (2015) underscore the intricate nature of plant genetics. Ultimately, this research champions the significance of genotypic correlations, empowering breeders to optimize crop yields and drive agricultural advancement.

Table 1: Correlation between Genotypic and Phenotypic Traits Affecting Yield in Soybean Varieties.

		Days to pod initiation	Days to 50% podding	Days to physio-logical maturity	No. of primary branches per plant	Plant height	No. of pods per plant	Pod weight per plant	Grain yield per plant	Hundred seed weight	Biological yield (kg/ha)	Harves t index	Grain yield (kg/ha)
Days to 50% Flowering	G	0.94**	0.93 **	0.72 **	0.21	0.49**	0.65 **	0.24 *	-0.016	-0.52 **	0.47 **	-0.54**	0.18
	P	0.92 **	0.89 **	0.69 **	0.06	0.25 **	0.48 **	0.14	-0.064	-0.42 **	0.19 *	-0.26 **	0.04
Days to Pod Initiation	G	-	0.98 **	0.81 **	0.19	0.68 **	0.69 **	0.23	-0.029	-0.59 **	0.54 **	-0.46 **	0.27 *
	P	-	0.95 **	0.76 **	0.06	0.36 **	0.49 **	0.13	-0.081	-0.47 **	0.24 **	-0.20 *	0.11
Days to 50% Podding	G		-	0.81 **	0.26 *	0.73 **	0.67 **	0.17	-0.09	-0.64 **	0.61 **	-0.49 **	0.306 *
	P		-	0.76 **	0.05	0.40 **	0.47 **	0.098	-0.12	-0.51 **	0.28 **	-0.22 *	0.14
Days to Physiologic al Maturity	G			-	-0.06	0.53 **	0.49 **	0.11	-0.12	-0.49 **	0.42 **	-0.27 *	0.21
	P			-	-0.13	0.31 **	0.32 **	0.034	-0.14	-0.41 **	0.22 **	-0.14	0.11
No. of primary branches per plant	G				-	0.33 **	0.54 **	0.53 **	0.37 **	0.002	0.58 **	-0.26 *	0.44 **
	P				-	0.34 **	0.45 **	0.46 **	0.44 **	0.03	0.38 **	-0.17 *	0.31 **
Plant height	G					-	0.80 **	0.44 **	0.17	-0.30 *	0.76 **	0.02	0.65 **
	P					-	0.51 **	0.33 **	0.23 **	-0.18 *	0.68 **	-0.16	0.59 **
No. of pods per plant	G						-	0.74 **	0.49 **	-0.25 *	0.99 **	-0.36 **	0.75 **
	P						-	0.75 **	0.63 **	-0.11	0.49 **	-0.15	0.48 **
Pod weight per plant	G							-	0.95 **	0.43 **	0.74 **	0.072	0.75 **
	P							-	0.92 **	0.28 **	0.38 **	-0.038	0.47 **
Grain yield per plant	G								-	0.64 **	0.55 **	0.28 *	0.71 **
	P								-	0.45 **	0.35 **	0.086	0.54 **
Hundred seed weight	G									-	-0.23	0.41 **	0.06
	P									-	-0.13	0.23 **	0.06
Biological yield (kg/ha)	G										-	-0.09	0.91 **
	P										-	-0.34 **	0.78 **
Harvest index	G											-	0.28 *
	P											-	0.16

*, ** are p= 0.05 and 0.01% respectively

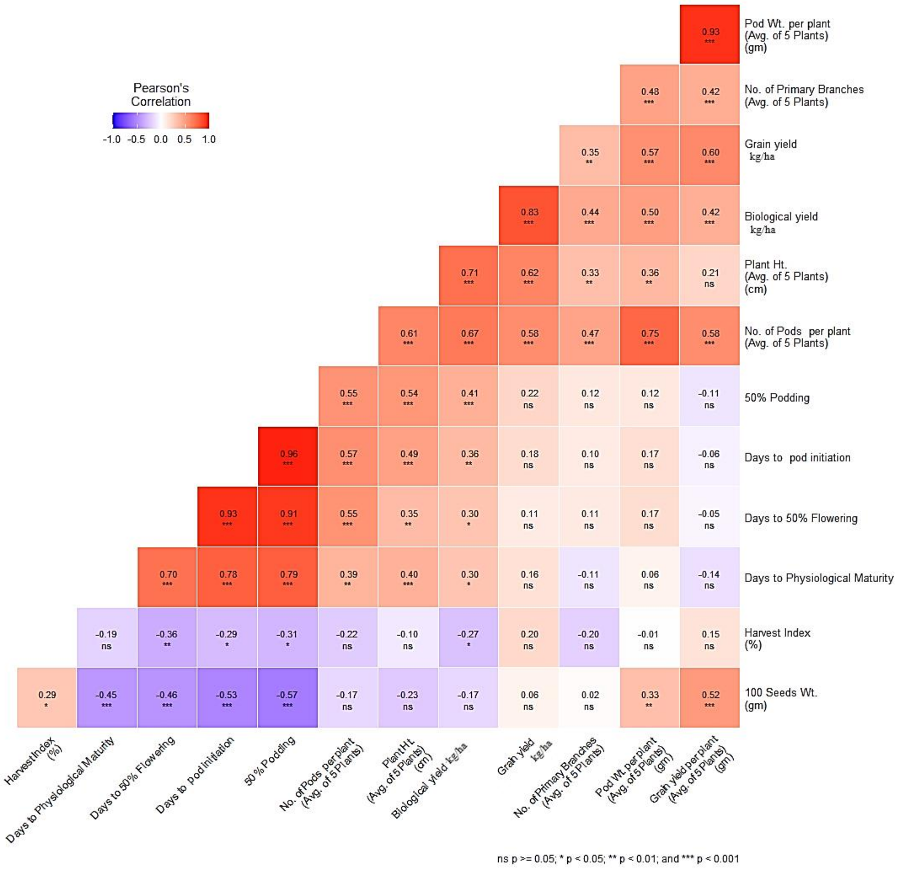

Fig. 1. Heat Map: Genotypic Correlation among yield and its component traits in soybean genotypes.

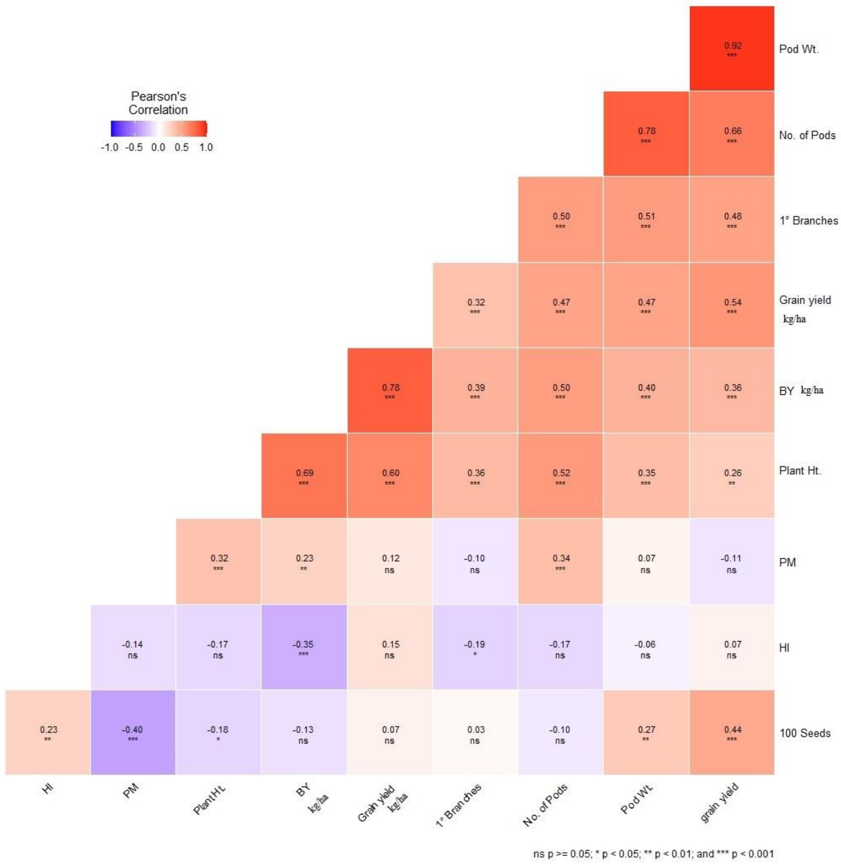

Fig. 2. Heat Map: Phenotypic Correlation among yield and its component traits in soybean genotypes.

FUTURE SCOPE

Future research should delve into the environmental factors influencing these correlations, utilize advanced genomic techniques to uncover underlying genetic determinants, and probe deeper into the physiological reasoning for observed relationships. Further, contrasting findings in literature underline the need for meta-analyses. Integration of farmer experiences and real-world applications can bridge research with on-ground agricultural challenges.

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Conflict of Interest. None.

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