www.ThePharmaJournal.com

The Pharma Innovation

VR Ghuge
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SP Mehtre
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

JE Jahagirdar
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

VD Salunke
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

RR Dhutmal
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
VR Ghuge
Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Character association studies for Morpho-physiological parameters in soybean (*Glycine max* (L.) Merrill)

VR Ghuge, SP Mehtre, JE Jahagirdar, VD Salunke and RR Dhutmal

Abstract
In rainy season, seed yield (kg/plot) had highly significant and positive correlation with dry matter (30 DAS), absolute growth rate (AGR) and relative growth rate (RGR) (30 DAS). However, it had positive significant correlation with relative growth rate (RGR) (60 DAS) and net assimilation rate (NAR) (30 DAS), Seed yield (kg/plot) had highly significant and negative correlation with days to 50% flowering and days to maturity along with harvest index. However, seed yield possessed positive and highly significant correlation with number of pods per plant and biological yield. However, considering direct and indirect effects under variable seasons, the morpho-physiological traits *viz*; dry matter (g), absolute growth rate, relative growth rate and net assimilation rate while seed yield and its components *viz*; days to 50% flowering, days to maturity, number of pods per plant and oil content may be considered for improvement of soybean.

Keywords: Soybean, morpho-physiological traits, correlation, path analysis

Introduction
Soybean (*Glycine max* L. Merrill) is an important oil seed crop valued for high protein as well as for oil content. It has become wonder crop and is often designated as 'Golden Bean.' It is being used for the manufacture of the nutritional product for human being. The cake flours are extensively used as animal feed. Soybean is used for the preparation of milk, curd, cheese etc. and can be afforded by poor class people also. The crop also helps in increasing the fertility level of soil through symbiotic nitrogen fixation.

Cultivation of soybean in India was negligible in 1970s picked up recently. In India, during *kharif* 2019-20, area under soybean was 107.62 lakh ha, yield 836 kg/ha while production was 89.94 lakh MT. In Maharashtra, the area under soybean crop during *Kharif 2019*-20, was 37.37 lakh ha, with yield 971 kg/ha along with production of 36.30 lakh MT. In Marathwada region of Maharashtra state, the area under soybean crop was 17.99 lakh ha, with productivity of 855 kg/ha and production 16.2 lakh MT (SOPA, Databank 2019).

In breeding program to improve yield of crops, breeder has the choice to select yield directly or indirectly through yield related traits. Morpho-physiological traits, if correlated with grain yield in soybean, can be used as indirect selection for yield. The path coefficient analysis helps to partition correlation coefficient into direct and indirect effects (Saleem *et al*. 1999) [1] and can be used to supplement information on correlation coefficients. The correlation of yield with yield components and morphological traits has been studied extensively and used as a tool to improve seed yield of soybean (Mallik *et al*. 2006) [2]. But correlations among different characters can vary under different environments. Therefore, the present investigation to study correlation between seed yild and Morpho-physiological traits of Soybean Breeding Lines [*Glycine max* (L.) Merrill]" was undertaken.

Materials and Methods
Experimental materials
The experimental materials comprised of 75 soybean breeding lines (F₇) derived from four different crosses along with five checks *viz*; MAUS 162, MAUS 612, JS 93-05, JS 95-60, JS 97-52 and one parent i.e., AGS 25. These breeding lines were developed at Indian Institute of Soybean Research, Indore. The experimental materials was sown in a randomised block design with two replications. Each entry was sown in two row plot following 45 cm x 5cm spacing. The details of germplasm accessions, checks used in the experiment are presented in Table 1.

Table 1: Pedigree of Breeding Lines used in this experiment

SN.	Cross	Number of Breeding Lines
1	JS 93-05 x AGS 25	20
2	JS 95-60 x AGS 25	15
3	BC2F4 (JS 93-05 x AGS 25) x JS 93-05	20
4	PK-416 x AGS 25	20

Location
AICRP on Soybean, VNMKV, Parbhani is located at latitude of 19 °16` N and at longitude of 76°47` E and at a height of 409 M mean sea level.

Soil type of the experimental site
The soil at the experimental site was medium black clay.

Crop Management
The crop was raised following all the agronomical practices recommended for soybean. Two seeds were sown in each hill to facilitate emergence and to optimize uniform stand of plants. Just before sowing, fertilizers were applied at the rate of 30:60:30:20 Kg/ha of N, P, K and S respectively. After one week of germination, maitained one plant / hill by thinning.

Observations recorded
Five plants were selected from each treatment for observations at different critical stages. Dry matter at 30, 60, 90 days after sowing, leaf area at 30, 60, and 90 days after sowing, Absolute growth rate after 30 days of sowing, Absolute growth rate after 45 days of sowing, Absolute growth rate after 90 days of sowing, Relative growth rate after 30 days of sowing, Relative growth rate after 60 days of sowing, Relative growth rate after 90 days of sowing, Net assimilation rate after 30 days of sowing, Net assimilation rate after 60 days of sowing, Net assimilation rate after 90 days of sowing, Seed yield (kg/plot).

Statistical Analysis
Experimental data were analyzed statistically adopting the technique of analysis of variance (ANOVA) for randomized block design (RBD). The level of significance was observed at 5 percent probability (Gomez and Gomez, 1984) [3]. Correlation coefficients were obtained for combination of some of the traits under study. The correlation between different characters under study was estimated. All the statistical analysis were carried out using R-package and AGRISTAT software (R Core Team, 2020; Manivannan, N. 2014) [5, 4].

Results
Correlation and Path Analysis
The data on Pearson's correlation between seed yield and morpho-physiological traits are presented for rainy season in Figure 1 and 2 Seed yield (kg/plot) had highly significant and positive correlation with dry matter (30 DAS), absolute growth rate (AGR) and relative growth rate (RGR) (30 DAS).

However, it had positive significant correlation with relative growth rate (RGR) (60 DAS) and net assimilation rate (NAR) (30 DAS). While, rest of the characters possessed non-significant association with seed yield. Seed yield (kg/plot) had highly significant and negative correlation with days to 50% flowering and days to maturity along with harvest index. However, seed yield possessed positive and highly significant correlation with number of pods per plant and biological yield (kg/plot). The direct and indirect effects of morpho-physiological traits on seed yield from vegetative to harvesting phase are presented in Table 4.16.
Dry matter (90 DAS), Leaf area (90 DAS) and relative growth rate (RGR) (90 DAS) had positive and direct effect towards seed yield. However, direct and indirect effects of yield attributing traits on seed yield from vegetative to harvesting phase are presented in Table 4.17. 100 seed weight (g) exhibited positive but lowest direct effect towards seed yield. Days to maturity, biological yield (kg/plot) and harvest index recorded high and positive direct effects while rest of the characters recorded negative direct effect towards seed yield.

Discussion
In rainy season, seed yield (kg/plot) had highly significant and positive correlation with dry matter (30 DAS), absolute growth rate (AGR) and relative growth rate (RGR) (30 DAS). However, it had positive significant correlation with relative growth rate (RGR) (60 DAS) and net assimilation rate (NAR) (30 DAS) (Dogra et al., 2016) [7] Seed yield (kg/plot) had highly significant and negative correlation with days to 50% flowering and days to maturity along with harvest index. However, seed yield possessed positive and highly significant correlation with number of pods per plant and biological yield (Shree et al., 2017) [9].
Days to 50% flowering, days to maturity were found to have negative but highly significant correlation with seed yield under variable photoperiod. Number of pods per plant (60 DAS & 90 DAS) and oil content exhibited positive and significant correlation with seed yield (Kothule et al., 2003; Baig et al., 2017) [6, 8].
However, considering direct and indirect effects under variable seasons, the morpho-physiological traits *viz*; dry matter (g), absolute growth rate, relative growth rate and net assimilation rate while seed yield and its components *viz*; days to 50% flowering, days to maturity, number of pods per plant and oil content may be considered for improvement of soybean.
In path analysis, dry matter (90 DAS), Leaf area (90 DAS) and relative growth rate (RGR) (90 DAS) had positive and direct effect towards seed yield. However, direct and indirect effects of yield attributing traits on seed yield from vegetative to harvesting phase. 100 seed weight (g) exhibited positive but lowest direct effect towards seed yield. Days to maturity, biological yield (kg/plot) and harvest index recorded high and positive direct effects while rest of the characters recorded negative direct effect towards seed yield (Kothule et al., 2003; Baig et al., 2017) [6, 8].

Table 2: Pearson's Correlation (Rainy season) of seed yield with morpho-physiological traits from vegetative to harvesting phase

Traits	Dry Matter 30	Dry Matter 60	Dry Matter 90	Leaf Area 30	Leaf Area 60	Leaf Area 90	AGR 30	AGR 60	AGR 90	RGR 30	RGR 60	RGR 90	NAR 30	NAR 60	NAR 90	SYP
Dry Matter 30		0.386***	0.322**	0.089	0.082	0.009	0.415***	0.314**	0.1	0.997***	0.216	-0.029	0.943***	0.289**	0.102	0.327**
Dry Matter 60	0.386***		0.614***	0.062	0.113	0.035	0.419***	0.992***	-0.064	0.381*	0.0942***	-0.472***	0.342**	0.968***	-0.079	0.204
Dry Matter 90	0.322**	0.614***		-0.004	0.013	0.008	0.284*	0.612***	0.687***	0.323**	0.603***	0.317**	0.321**	0.609***	0.635***	0.157
Leaf Area 30	0.089	0.062	-0.004		0.688***	0.832***	0.081	0.049	-0.011	0.077	0.063	-0.067	0.242*	-0.107	-0.331**	0.168
Leaf Area 60	0.083	0.113	0.013	0.688***		0.844***	0.162	0.095	-0.027	0.071	0.091	-0.097	-0.145	-0.087	-0.374**	-0.015
Leaf Area 90	0.009	0.035	0.008	0.832***	0.844***		0.051	0.02	-0.014	-0.002	0.029	-0.08	-0.262	0.163	-0.372***	-0.045
AGR 30	0.415***	0.419***	0.284*	0.081	0.162	0.051		0.425***	-0.024	0.397***	0.448**	-0.176	0.377***	0.389***	-0.029	0.493***
AGR 60	0.314**	0.992***	0.612***	0.049	0.059	0.02	0.425***		-0.065	0.31**	0.973***	-0.472	0.275*	0.98**	-0.074	0.205
AGR 90	0.1	-0.064	0.687***	-0.011	-0.027	-0.014	-0.024	-0.065		0.103	-0.042	-0.886***	0.118	-0.061	0.919***	0.047
RGR 30	0.997***	0.381***	0.323**	0.077	0.071	-0.002	0.397***	0.31**	0.103		0.214	-0.021	0.943***	0.288**	0.113	0.312**
RGR 60	0.216	0.942***	0.603***	0.063	0.091	0.029	0.488***	0.973***	-0.042	0.214		-0.449***	0.175	0.951***	0.053	0.22*
RGR 90	-0.029	-0.472***	0.317**	-0.067	-0.079	-0.08	-0.176	-0.472***	0.886***	-0.021	-0.449***		0.014	0.449***	0.854***	0.026
NAR 30	0.943***	0.342**	0.321**	-0.242*	-0.145	-0.262*	0.377***	0.275*	0.118	0.943***	0.175	0.014		0.302**	0.222*	0.252*
NAR 60	0.289**	0.968***	0.609***	-0.107	-0.087	-0.163	0.389***	0.98***	-0.061	0.288**	0.951***	-0.449***	0.302**		0.001	0.194
NAR 90	0.102	-0.079	0.635***	-0.331**	-0.347**	-0.372***	-0.029	-0.074	0.919***	0.133	-0.053	0.854***	0.222*	0.001		0.072
SYP	0.327**	0.204	0.157	0.186	-0.015	-0.045	0.493***	0.205	0.047	0.312**	0.22*	-0.026	0.252*	0.194	0.072	

Note: *, ** indicates the correlation significant at 0.05 and 0.01 probability level

AGR 30 = Absolute growth rate after 30 days of sowing, AGR 60 = Absolute growth rate after 45 days of sowing, AGR 90 = Absolute growth rate after 90 days of sowing, RGR 30 = Relative growth rate after 30 days of sowing, RGR 60 = Relative growth rate after 60 days of sowing, RGR 90 = Relative growth rate after 90 days of sowing, NAR 30 = Net assimilation rate after 30 days of sowing, NAR 60 = Net assimilation rate after 60 days of sowing, NAR 90 = Net assimilation rate after 90 days of sowing, SYP = Seed yield (kg/plot).

Table 3: Direct and indirect effects of morpho-physiological traits on seed yield from vegetative to harvesting phase

Traits	DM 30	DM 60	DM 90	LA 30	LA 60	LA 90	AGR 30	AGR 60	AGR 90	RGR 30	RGR 60	RGR 90	NAR 30	NAR 60	NAR 90	SYP
DM 30	-0.157	0.062	0.004	-0.005	-0.003	0.003	-0.065	-0.028	0.001	0.070	-0.006	-0.009	0.132	-0.007	0.003	0.255*
DM 60	-0.060	0.162	0.010	-0.002	-0.003	-0.001	-0.023	-0.102	0.003	0.024	-0.020	-0.026	0.049	-0.024	0.009	0.209*
DM 90	-0.039	0.103	0.016	0.000	0.000	0.001	-0.018	-0.065	-0.005	0.019	-0.013	-0.003	0.031	-0.015	-0.012	0.184
LA 30	-0.016	0.005	0.000	-0.046	-0.025	0.105	-0.005	-0.003	0.000	0.005	-0.002	-0.001	-0.041	0.003	0.014	0.193
LA 60	-0.019	0.016	0.000	-0.042	-0.027	0.114	-0.006	-0.009	0.001	0.006	-0.003	-0.004	-0.044	0.002	0.017	-0.020
LA 90	-0.004	-0.001	0.000	-0.042	-0.027	0.114	-0.001	0.002	0.000	0.001	-0.001	-0.001	-0.055	0.004	0.014	-0.043
AGR 30	-0.168	0.060	0.005	-0.004	-0.002	0.002	-0.061	-0.030	0.001	0.065	-0.007	-0.009	0.142	-0.007	0.002	0.333**
AGR 60	-0.043	0.161	0.010	-0.001	-0.002	-0.002	-0.018	-0.103	0.003	0.018	-0.021	-0.026	0.035	-0.024	0.009	0.209*
AGR 90	0.010	-0.046	0.007	0.000	0.002	0.003	0.003	0.030	-0.010	-0.003	0.006	0.034	-0.012	0.008	-0.029	-0.030
RGR 30	-0.167	0.058	0.005	-0.004	-0.002	0.002	-0.061	-0.029	0.000	0.065	-0.006	-0.009	0.142	-0.007	0.002	0.320**
RGR 60	-0.043	0.162	0.010	-0.005	-0.003	0.005	-0.020	-0.103	0.003	0.020	-0.020	-0.027	0.031	-0.024	0.010	0.229*
RGR 90	0.033	-0.104	-0.001	0.002	0.003	-0.002	0.014	0.066	-0.009	-0.014	0.014	0.040	-0.029	0.016	-0.025	-0.146
NAR 30	-0.144	0.055	0.004	0.013	0.008	-0.044	-0.060	-0.025	0.001	0.064	-0.004	-0.008	0.144	-0.007	-0.003	0.207*
NAR 60	-0.043	0.159	0.010	0.005	0.002	-0.020	-0.018	-0.102	0.003	0.018	-0.020	-0.026	0.043	-0.024	0.007	0.204*
NAR 90	0.012	-0.045	0.006	0.019	0.014	-0.049	0.004	0.028	-0.009	-0.003	0.006	0.031	0.013	0.005	-0.032	0.012

R = 0.077

Note: *, ** indicates the correlation significant at 0.05 and 0.01 probability level.

DM 30 = Dry matter after 30 days of sowing, DM 60 = Dry matter after 60 days of sowing, DM 90 = Dry matter after 90 days of sowing, LA 30 = Leaf area after 30 days of sowing, LA 60 = Leaf area after 60 days of sowing, LA 90 = Leaf area after 90 days of sowing, AGR 30 = Absolute growth rate after 30 days of sowing, AGR 60 = Absolute growth rate after 45 days of sowing, AGR 90 = Absolute growth rate after 90 days of sowing, RGR 30 = Relative growth rate after 30 days of sowing, RGR 60 = Relative growth rate after 60 days of sowing, RGR 90 = Relative growth rate after 90 days of sowing, NAR 30 = Net assimilation rate after 30 days of sowing, NAR 60 = Net assimilation rate after 60 days of sowing, NAR 90 = Net assimilation rate after 90 days of sowing, SYP = Seed yield (kg/plot)

Table 4: Pearson's Correlation (Rainy season) of seed yield with morpho-physiological traits from vegetative to harvesting phase

Traits	Days to 50% flowering	Days to Maturity	PH 30	PH 60	PH 90	Pods 90	V100 SW	BYP	HI	SYP
Days to 50% flowering		0.961***	-0.063	-0.396***	-0.169	-0.261*	-0.065	-0.274*	-0.038	-0.365***
Days to Maturity	0.961***		-0.045	-0.41***	-0.2	-0.268*	-0.056	-0.295**	-0.002	-0.0373***
PH 30	-0.063	-0.045		0.362***	0.388***	-0.058	0.059	-0.132	0.14	-0.095
PH 60	-0.396***	-0.41***	0.362***		0.443***	0.125	0.007	0.166	0.019	0.228*
PH 90	-0.169	-0.2	0.388***	0.443***		-0.06	-0.188	-0.098	0.23*	0.003
Pods 90	-0.261	-0.268*	-0.058	0.125	-0.06		0.128	0.788***	-0.379***	0.8***
V100 SW	-0.065	-0.056	0.059	0.007	-0.188	0.128		0.156	-0.27	0.131
BYP	-0.274	-0.295**	-0.132	0.166	-0.098	0.788***	0.156		-0.655***	0.915***
HI	-0.038	-0.002	0.14	0.019	0.23*	-379***	-0.127	-0.655***		-0.301*
SYP	-0.365	-0.373***	-0.095	0.228*	0.003	0.8***	0.131	0.915	-0.301**	

Note: *, ** indicates the correlation significant at 0.05 and 0.01 probability level.

AGR 30 = Absolute growth rate after 30 days of sowing, AGR 60 = Absolute growth rate after 45 days of sowing, AGR 90 = Absolute growth rate after 90 days of sowing, RGR 30 = Relative growth rate after 30 days of sowing, RGR 60 = Relative growth rate after 60 days of sowing, RGR 90 = Relative growth rate after 90 days of sowing, NAR 30 = Net assimilation rate after 30 days of sowing, NAR 60 = Net assimilation rate after 60 days of sowing, NAR 90 = Net assimilation rate after 90 days of sowing, SYP = Seed yield (kg/plot)

Table 5: Direct and indirect effects of yield attributing traits on seed yield from vegetative to harvesting phase (Rainy season)

Traits	Days to 50% Flowering	Days to Maturity	PH 30	PH 60	PH 90	Pods 90	BYP	HI	100 SW	SYP
Days to 50% Flowering	-3.987	4.014	0.002	0.048	0.023	0.122	-0.487	-0.026	0.000	-0.381*
Days to Maturity	-3.987	4.014	0.002	0.048	0.023	0.122	-0.487	-0.026	0.000	-0.381*
PH 30	0.366	-0.368	-0.021	-0.046	-0.045	0.036	-0.259	0.100	0.000	-0.112
PH 60	1.684	-1.694	-0.008	-0.114	-0.051	-0.065	0.281	0.007	0.000	0.221*
PH 90	0.828	-0.833	-0.009	-0.053	-0.110	0.032	-0.165	0.147	-0.001	0.002
Pods 90	1.138	-1.146	0.002	-0.017	0.008	-0.426	1.621	-0.309	0.001	0.961**
BYP	1.150	-1.157	0.003	-0.019	0.011	-0.409	1.689	-0.401	0.001	0.927**
HI	0.171	-0.173	-0.004	-0.001	-0.027	0.219	-1.129	0.600	-0.001	-0.348*
100 SW	0.326	-0.327	-0.001	0.001	0.021	-0.070	0.288	-0.099	0.005	0.133

R = 0.102

Note: *, ** indicates the correlation significant at 0.05 and 0.01 probability level.

PH 30 = Plant height after 30 days of sowing, PH 60 = Plant height after 60 days of sowing, PH 90 = Plant height after 90 days of sowing, Pods 90 = Number of Pods per plant after 90 days of sowing, BYP = Biological Yield, HI = Harvest Index, 100 SW = 100 seed weight, SYP = Seed Yield (Kg/plot)

Conclusion

Finally, it can be concluded that for selection of better genotypes under variable season, the following important characters *viz*; dry matter, absolute growth rate, relative growth rate, net assimilation rate, leaf area, days to 50% flowering, days to maturity, harvest index, biological yield may be considered since, these parameters were found to have significantly correlated with seed yield.

References

1. Saleem MS, Ali M, Yousuf W, Harris AA. Path coefficient analysis of seed yield and quantitative traits in

chickpea (*Cicer arietinum* L.). Int. J Agric. Biol 1999;1:106-107.

2. Malik MFA, Qureshi AS, Ashraf M, Ghafoor A. Genetic variability of the main yield related characters in soybean. Int. J Agric. Biol 2006;8:815-819.

3. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley and Sons 1984.

4. Manivannan N. TNAUSTAT Statistical package 2014. Retrived from https://sites.google.com/site/tnaustat.

5. Core Team R. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria 2020. http://www.r-project.org/index.html.

6. Kothule VG, Bhalerao RK, Rathod TH. Effect of growth regulators on yield attributes, yield and correlation coefficient in soybean. Ann. Plant Physiol 2003;17(2):140-142.

7. Dogra AK, Srivastava A, Kaur J, Raj T. Correlation and path analysis of morpho-physiological traits with yield of soybean (*Glycine max* L. Merrill) genotypes under variable photoperiods. Indian J Eco 2016;43(1):197-201.

8. Baig KS, Kaware PP, Sarang DH, Chandrawat KS. Association analysis and morpho-physiological traits in soybean. Soybean Res 2017;15(1):18-24.

9. Shree Y, Ram S, Verma N, Ahmad E, Bhushan S, Kumar S. Correlation between yield and yield attributing traits in soybean (*Glycine max* L. Merrill). J Biotech. Crop Sci 2017;6(8):69-72.