

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.909.055>

Correlation Coefficient and Path Analysis Study in Different Soybean Genotypes Based on Yield and Yield Contributing Traits

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ABSTRACT

The present investigation entitled Study of Correlation coefficient and path analysis in Different Soybean Genotypes Based on Yield and Yield Contributing Traits was undertaken to study the interrelation between variables means correlation and path analysis among thirty genotypes of soybean. These genotypes were evaluated during *Kharif*, 2018 in a randomized block design with three replications. Observations were recorded on days to 50 percent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight (g), seed yield per plant (g), SPAD value, protein content (%), oil content (%). The genotypic correlation coefficients were high in magnitude than their corresponding phenotypic correlation coefficients for all the characters. The seed yield per plant showed a highly significant positive association with number of pods per plant, number of seeds per pod, 100 seed weight, SPAD value, plant height, days to 50 percent flowering, oil content, number of primary branches per plant and 50 percent flowering at genotypic level. Path coefficient analysis based on genotypic correlation indicate that number of pod per plant (0.5291) registered the maximum positive direct effect on seed yield per plant followed by 100 seed weight (0.4061), number of seeds per pod (0.2882), plant height (0.2111) and days to 50 percent flowering recorded the highest negative direct effect of -0.3126 followed by SPAD value -0.0827, days to maturity -0.0155. The number of primary branches per plant recorded the direct effect but low magnitude (0.0080).

Keywords

Soybean,
Correlation,
Path coefficient,
Traits, Yield

Article Info

Accepted:
07 August 2020
Available Online:
10 September 2020

Introduction

Soybean (*Glycine max* L. Merrill) is considered a miracle crop due to its extraordinary qualities. It is grown in East and South East Asia mainly for food, feed, and medicinal purposes. This plant contains about 38-42% of high-quality protein, 6% ash, 29% carbohydrate, and 17 to 24% oil, comprising

85% polyunsaturated fatty acids with two essential fatty acids. Soybean ($2n=40$) belongs to the Leguminosae family and is believed to have originated in northeastern China and distributed in the USA, Brazil, Argentina, China, India, etc.

Today it ranks first in oilseed production (contribution 58 %) followed by rapeseed,

groundnut, and sunflower. In India, it occupied an area of 10.97 mha with a production of 13.46 mt and a productivity of 1120 kg ha⁻¹ (Anonymous, 2018-19).

In India, major soybean-producing states are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Gujarat, Andhra Pradesh Uttar Pradesh and Chhattisgarh.

The continuous improvement of soybean depends on the information about genetic variability, genetic parameters, and their application, that assists the breeders in the reliable selection process.

Yield is a complex polygenic character, resulting from multiple interactions between many yield-contributing traits. Associations between these traits can be evaluated by correlation analysis, which helps in the simultaneous selection for more than one character.

Correlation coefficients alone are inadequate to interpret cause and effect relationships among traits associated with yield, whereas path coefficient analysis allows a better understanding of associations between different characters, by breaking down correlation coefficients associated with the main character into direct and indirect effects (Rahman *et al.*, 2011, 2012; Hossain *et al.*, 2015).

Path coefficient analysis provides an effective means to partition correlation coefficients into unidirectional and alternative pathways, thus permitting a critical examination of the specific factors that produce a given correlation; this can then be employed to formulate an effective selection program.

This investigation provides information that could lead to the development of desirable genotypes in future breeding programs.

Materials and Methods

To study 30 different soybean genotypes collected from Agricultural Research Station, Kasbe-Digraj, Sangli (Table 1).

Experimental methods

Field experiment

The field experiment consisting of 30 soybean genotypes was undertaken at Agricultural Research Station, Kasbe-Digraj, Sangli. To study recommended agronomic practices were followed to raise good crops. The detail of the experiment is as follows.

- a) Season – *Kharif*, 2018
- b) Design – RBD (Randomized Block Design)
- c) Plot size – 5 X 2 meter
- d) Date of sowing – 12 July 2018
- e) Spacing – 45 X 5 cm
- f) Number of genotypes – 30
- g) Fertilizer Dose – 30: 60:30 Kg NPK/ha

Details of observations Recorded

Following observations on the five randomly selected plants from each experimental plot in each replication and averages were worked out *viz.*, days to 50 percent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight (g), seed yield per plant (g), SPAD value, protein content (%), oil content (%).

Results and Discussion

Correlation coefficient

The genotypic and phenotypic correlation for eleven characters studied is presented in Table 2. As the genotypic correlation as well as phenotypic correlation important from a

breeding point of view, those only are described below:

Association between seed yield and its components

The seed yield per plant showed a highly significant and positive association with number of pods per plant (0.54), followed by number of seeds per pod (0.43), 100 seed weight (0.41), SPAD value (0.37), plant height (0.33), days to 50% flowering (0.27), oil content (0.140). The character number of primary branches per plant (0.04) showed a positive but non-significant association with seed yield per plant. The character days to maturity (-0.06) and protein content (-0.02) are negative and non-significant association with seed yield per plant.

Exactly similar trend was observed at the phenotypic level, where seed yield per plant recorded the highly significant and positive association with number of pods per plant (0.51), followed by the number of seeds per pod (0.39), 100 seed weight (0.35), SPAD value (0.32), plant height (0.31), days to 50% flowering (0.27). The characters number of primary branches per plant (0.02) and oil content (0.01), protein content (0.001), showed positive but non-significant association with seed yield per plant. Days to maturity (-0.06) showed negative and non-significant association seed yield per plant. These results confirmed the earlier findings of Faisal *et al.*, (2006), Shahu *et al.*, (2013), Ghodrati *et al.*, (2013) and Chandel *et al.*, (2014) reported the seed yield per plant was highly significant and positively correlated with number of pods per plant. Malek *et al.*, (2014) and Ali *et al.*, (2015) found seed yield per plant showed highly significant and positively correlated with days to 50 percent flowering, days to maturity. Mahbub *et al.*, (2015) recorded the seed yield per plant revealed highly significant and positively

correlated with the number of pods per plant, number of seeds per pod, 100 seed weight, and plant height. Koraddi *et al.*, (2013) estimated seed yield per plant showed highly significant and positively correlated with days to 50 percent flowering, number of pods per plant, 100 seed weight.

The interrelationship between yield components

The interrelationship between component characters at the genotypic level is presented below:

Genotypic correlations

Days to 50% flowering was highly significant and positively correlated with oil content (0.81) followed by plant height (0.77), days to maturity (0.73), number of seeds per pod (0.50), 100 seed weight (0.36), seed yield per plant (0.27), SPAD value (0.22), number of pod per plant (0.17). It showed a negative and non-significant correlation with protein content (-0.08), number of primary branches per plant (-0.08).

A similar result was reported by Aditya *et al.*, (2011), Mahbub and shirazy (2016), and Dubey *et al.*, (2014) for plant height.

Days to maturity was highly significant and positively correlated with oil content (1.08) followed by plant height (0.41), number of seeds per pod (0.31), number of primary branches per plant (0.15), It showed positive but non-significant correlation with SPAD Value (0.06) and 100 seed weight (0.02). Days to maturity were non-significant and negatively correlated with protein content (-0.001), seed yield per plant (-0.06) and it showed a negative but significant correlation with the number of pods per plant (-0.14). A similar result was reported by Iqbal *et al.*, (2010), Dubey *et al.*, (2014), and Malek *et al.*,

(2014) for the height of plant and number of primary branches per plant.

Plant height showed a significant and positive correlation with oil content (0.50) followed by 100 seed weight (0.35), number of seeds per pod and seed yield per plant (0.33), SPAD value (0.20,) number of pods per plant (0.19) and number of primary branches (0.13). It was negatively and non-significantly correlated with protein content (-0.10). Similar results reported by Dubey *et al.*, (2014) and Mahbub and Shirazy (2016) for the number of pods per plant.

The number of primary branches per plant was positive and significantly correlated with SPAD value (0.24) and the number of pods per plant (0.17). It showed a positive but non-significant correlation with protein content (0.05) and seed yield per plant (0.04). It showed a negative and non-significant correlation with oil content (-0.004), 100 seed weight (-0.09) and it showed a negative but significant correlation number of seeds per pod (-0.15). A similar result was reported by Jain and Ramgiriy (2000) for the number of pods per plant.

The number of pods per plant showed a highly significant and positive correlation with seed yield per plant (0.54) followed by SPAD value (0.49) and the number of seeds per pod (0.30). Whereas it showed a positive and significant correlation with protein content (0.07) and oil content (0.01). It showed a negative and non-significant correlation with 100 seed weight (-0.03). Similar results were reported by Ghodrati *et al.*, (2013) and Khan *et al.*, (2018) for seed yield per plant.

The character number of seeds per pod had a highly significant and positive correlation with seed yield per plant (0.43) followed by oil content (0.43), SPAD value, (0.30), and

100 seed weight (0.19). It had a positive but non-significant correlation with and protein content (0.06). A similar result was reported by Dubey *et al.*, (2014) and Mahbub and Shirazy (2016) for seed yield per plant. In case of 100 seed weight had a positive and highly significant correlation with oil content (0.54) followed by seed yield per plant (0.41), SPAD value (0.26) and protein content (0.001). Similar results were reported by Mahbub and Shirazy (2016) for seed yield per plant.

The physiological character SPAD value showed a highly significant and positive correlation with oil content (0.68) followed by seed yield per plant (0.37) and protein content (0.14). The Protein content showed a positive and significant correlation with oil content (0.50). The association of protein content with seed yield per plant was negative and non-significant (-0.02). Oil content had a positive and significant association with seed yield per plant (0.14) at the genotypic level.

Phenotypic correlation

Days to 50% flowering was highly significant and positively correlated with plant height (0.72) followed by days to maturity (0.68), number of seeds per pod (0.48), 100 seed weight (0.33), seed yield per plant (0.27), oil content (0.26), SPAD value (0.17), number of pod per plant (0.16). It showed a negative and non-significant correlation with the number of primary branches per plant (-0.04) and protein content (-0.09). Similar results were reported by Dubey *et al* (2014) for days to maturity, number of seeds per pod, and Malek *et al.*, (2014) for days to maturity. Ngon *et al.*, (2006) for 100 seed weight. Days to maturity was highly significant and positively correlated with plant height (0.38), followed by oil content (0.33), number of seeds per pod (0.27), It showed positive but non-significant correlation with number of primary branches

per plant (0.07), SPAD Value (0.05) protein content (0.02), Days to maturity was non-significant and negatively correlated with 100 seed weight(-0.006), seed yield per plant (-0.06) and it showed negative and significant correlation with number of pods per plant (-0.13). Similar results reported by Kumar *et al.*, (2014) for 100 seed weight, Khan *et al.*, (2018) for seed yield per plant.

Plant height showed a significant and positive correlation with 100 seed weight (0.32), followed by seed yield per plant (0.31), number of seed per pod (0.29), number of pods per plant (0.17), oil content (0.16), SPAD value (0.15) and it showed positive but non-significant correlation with number of primary branches (0.09). It showed negatively and non-significantly correlated with protein content (-0.03). Similar results reported by Dubey *et al.*, (2014) for the number of seeds per pod, Aditya *et al.*, (2011) number of pods per plant.

The number of primary branches per plant was significant and positively correlated with the number of pods per plant (0.13). and It showed positive but non-significant correlation with SPAD value (0.06), seed yield per plant (0.02) and It showed negative and non-significant correlation with oil content (-0.01), protein content (-0.02), 100 seed weight (-0.05) and number of seeds per pod (-0.11). Similar results reported by Aditya *et al.*, (2011) for the number of pods per plant and seed yield per plant.

The number of pods per plant showed a highly significant and positive correlation with seed yield per plant (0.51) followed by SPAD value (0.42) and the number of seeds per pod (0.27). Whereas, it showed positive and significant correlation with protein content (0.06) and It showed a negative and non-significant correlation with 100 seed weight (-0.01) and oil content (-0.02). Similar

results reported by Aditya *et al.*, (2011) for seed yield per plant. Dubey *et al.*, (2014) for 100 seed weight. The character number of seeds per pod had a highly significant and positive correlation with seed yield per plant (0.39) followed by SPAD value (0.24), 100 seed weight (0.17) and it had a positive but non-significant correlation with oil content (0.11) and protein content (0.05). Similar results reported by Dubey *et al.*, (2014) for seed yield per plant.

100 seed weight depicted highly significant and positive correlation with seed yield per plant (0.35), and SPAD value (0.24) and it showed positive but non-significant correlation with oil content (0.12) followed by and protein content (0.03). Similar results reported by Aditya *et al.*, (2011) for seed yield per plant.

The physiological character SPAD value showed a highly significant and positive correlation with seed yield per plant (0.32) and oil content (0.18). It showed positive but non-significant correlation protein content (0.06).

The Protein content showed a positive but non-significant correlation with seed yield per plant (0.001) and it showed a negative and non-significant correlation with oil content (-0.05). The association of oil content with seed yield per plant was positive but non-significant (0.01). Oil content had a positive and significant association at the phenotypic level. Similar findings were reported by Iqbal *et al.*, (2010) for seed yield per plant.

In the present investigation, the genotypic correlation coefficients were high in magnitude than their corresponding phenotypic correlation coefficients for all the characters. The seed yield per plant showed a highly significant positive association with number of pods per plant, number of seeds

per pod, 100 seed weight, SPAD value, plant height, days to 50% flowering, oil content, number of primary branches per plant and 50 % flowering at genotypic level. These results confirmed the earlier findings of Faisal *et al.*, (2006), Ali *et al.*, (2015), and Mahbub *et al.*, (2015).

Path analysis

The direct and indirect effects of the studied characters on the seed yield per plant at genotypic levels are presented in Table 3 and Fig. 1.

Direct effect

Path coefficient analysis based on genotypic correlation indicates that the number of pods per plant (0.5291) registered the maximum positive direct effect seed yield per plant followed by 100 seed weight (0.4061), number of seeds per pod (0.2882), plant height (0.2111). Days to 50 % flowering recorded the highest negative direct effect of -0.3126 followed by SPAD value -0.0827, days to maturity -0.0155. The number of primary branches per plant recorded the direct effect but low magnitude (0.0080). A similar finding was reported by Rajanna *et al.*, (2000) and machikowa and Laosuwan (2011) for the number of pods per plant and 100 seed weight, Salimi and Moradi (2012) for 100 seed weight. Koraddi *et al.*, (2013) and Balla and Ibrahim (2017) for the number of pods per plant and height of plant, Malek *et al.*, (2014) for the number of pods per plant and 100 seed weight. Dubey *et al.*, (2014) and Akram *et al.*, (2016) for days to 50 percent flowering and days to maturity.

Indirect effect

Days to 50 % flowering

Days to 50% flowering recorded the maximum positive indirect effect of (0.0274)

via the number of primary branches per plant. The maximum negative indirect effect of -0.0556 was seen *via* the number of pods per plant followed by SPAD value (-0.0693), 100 seed weight (-0.1154), number of seeds per pod (-0.1580), days to maturity (-0.2302), and plant height (-0.2431). Similar results were reported by Akram *et al.*, (2016) for plant height, number of pods per plant, and 100 seed weight. Dubey *et al.*, (2014) for the number of pods per plant.

Days to maturity

Days to maturity recorded the maximum positive indirect effect of (0.0022) *via* the number of pods per plant. The maximum negative indirect effect of was seen *via* 100 seed weight (-0.0004) followed by SPAD value (-0.0010), number of primary branches per plant (-0.0024), number of seeds per pod (-0.0049), plant height (-0.0064) and days to 50 % flowering (-0.0114). Similar results reported by Akram *et al.*, (2016) for the number of pods per plant. Dubey *et al.*, (2014) for the number of primary branches per plant and plant height.

Height of plant

The character height of plant recorded the maximum positive indirect effect of (0.1642) *via* days to 50 percent flowering followed by days to maturity (0.0866), 100 seed weight (0.0753), number of seeds per pod (0.0710), SPAD value (0.0424), number of pods per plant (0.0406), number of primary branches per plant (0.0275). Similar results were reported by Akram *et al.*, (2016) for 100 seed weight. Dubey *et al.*, (2014) for days to 50 percent flowering, days to maturity, number of seeds per pod.

Number of primary branches per plant

Primary branches per plant recorded the maximum positive indirect effect of (0.0020)

via SPAD value, followed by the number of pods per plant (0.0014), days to maturity (0.0012), Plant height (0.0010).

The maximum negative indirect effect of (-0.0007) was seen via days to 50% flowering and 100 seed weight followed by the number

of seeds per pod (-0.0012). Similar results were reported by Akram *et al.*, (2016) for number of pods per plant and days to maturity, Dubey *et al.*, (2014) for number of pods per plant, plant height, number of seeds per pod, Abady *et al.*, (2013) for plant height.

Table.1 List of genotypes along with pedigree included in the studies

Sr.no.	Name of genotype	Pedigree
1	BAUS-100	JS 20-30/JS 335
2	CAUMS-1	Selection from NRC 2012-6-3-1-4-3
3	DS-3109	Pusa 12/F4C7-32
4	DS-3110	Pusa 12/F4C7-32
5	DSb-33	DSb 21/JS 95-60
6	GJS-3	Germ plasm line KB -85
7	Himso-1688	NRC 2007/B1-19
8	Himso-1689	NRC 2008/G-1-12
9	JS-21-71	JS 20-63/JS 95-60
10	JS-21-72	SL 738/JS 95-60
11	KDS-1009	AMS 99 33/EC 241780
12	KDS-1073	JS 20-05/EC 241780
13	KS-113	Selection from KS 103
14	MACS-1566	RKS 24/NRC 55
15	MACS-1620	RKS 25/NRC 55
16	NRC-138	JS 97-52/NRC 107
17	NRC-139	JS 97-52/NRC 101
18	NRC-146	Selection from 6A-34
19	NRC-147	Indigenous collection (IC 210)
20	NRC-148	NRC 7/AGS 191
21	NRCSL-2	JS 335/SL 525 EDV of JS 335
22	PS-1634	JS 9752/PS 1225
23	PS-1637	JS 9752/PK 472
24	RSC-11-15	JS 335/PS 1024
25	RSC-11-17	JS 97-52/JS 93-05
26	RVS-2007-4	RVS 2000-10/JS 95-60
27	RVS-2011-10	JS -335/PK 1042
28	KS-103	JS 335/EC 241780
29	KDS -726	JS 9305/EC 241780
30	KDS - 753	JS 9305/EC 241780

Table.2 Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient for eleven different characters of Soybean genotypes

Observations	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches/plant	No. of pods/plant	No. of seeds/pod	100 seeds weight (g)	SPAD Value	Protein (%)	Oil (%)	Seed yield/plant (g)
Days to 50% flowering	1.00	0.73**	0.77**	-0.08	0.17*	0.50**	0.36**	0.22**	-0.08	0.81**	0.27**
Days to maturity	0.68 **	1.00	0.41**	0.15*	-0.14*	0.31**	0.02	0.06	-0.001	1.08**	-0.06
Plant height (cm)	0.72**	0.38 **	1.00	0.13*	0.19*	0.33**	0.35**	0.20*	-0.10	0.50**	0.33**
No. of primary branches/plant	-0.04	0.07	0.09	1.00	0.17*	-0.15*	-0.09	0.24**	0.05	-0.004	0.04
No. of pods/plant	0.16*	-0.13*	0.17*	0.13*	1.00	0.30**	-0.03	0.49**	0.07	0.01	0.54**
No. of seeds/pod	0.48**	0.27**	0.29**	-0.11	0.27 **	1.00	0.19*	0.30**	0.06	0.43**	0.43**
100 seeds weight (g)	0.33 **	-0.006	0.32 **	-0.05	-0.01	0.17*	1.00	0.26**	0.001	0.54**	0.41**
SPAD Value	0.17*	0.05	0.15*	0.06	0.42 **	0.24 *	0.24 *	1.00	0.14*	0.68**	0.37**
Protein (%)	-0.09	0.02	-0.03	-0.02	0.06	0.05	0.03	0.06	1.00	0.50**	-0.02
Oil (%)	0.26 **	0.33**	0.16*	-0.01	-0.02	0.11	0.12	0.18*	-0.05	1.00	0.14*
Seed yield/plant (g)	0.27**	-0.06	0.31**	0.02	0.51**	0.39**	0.35**	0.32**	0.001	0.01	1.00

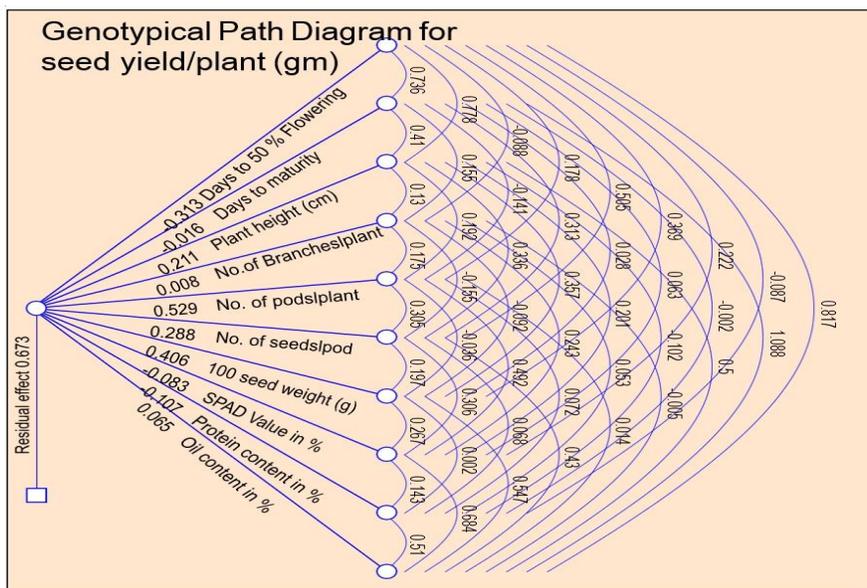
*Significant at 5% level, ** Significant at 1% level

Table.3 Direct and indirect effect of eight different yield and yield contributing characters of soybean

Observations	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches/plant	No. of pods/plant	No. of seeds/pod	100 seeds weight (g)	SPAD Value	Seed yield/plant (g)
Days to 50% flowering	-0.3126	-0.2302	-0.2431	0.0274	-0.0556	-0.1580	-0.1154	-0.0693	0.2733
Days to maturity	-0.0114	-0.0155	-0.0064	-0.0024	0.0022	-0.0049	-0.0004	-0.0010	-0.0646
Plant height (cm)	0.1642	0.0866	0.2111	0.0275	0.0406	0.0710	0.0753	0.0424	0.3331
No. of primary branches/plant	-0.0007	0.0012	0.0010	0.0080	0.0014	-0.0012	-0.0007	0.0020	0.0454
No. of pods/plant	0.0940	-0.0744	0.1017	0.0928	0.5291	0.1612	-0.0192	0.2602	0.5433
No. of seeds/pod	0.1456	0.0903	0.0969	-0.0446	0.0878	0.2882	0.0567	0.0881	0.4317
100 seeds weight (g)	0.1498	0.0113	0.1448	-0.0372	-0.0147	0.0799	0.4061	0.1082	0.4159
SPAD Value	-0.0183	-0.0052	-0.0166	-0.0201	-0.0407	-0.0253	-0.0220	-0.0827	0.3773

Residual effect = 0.6728

Fig.1 Genotypic path diagram for seed yield



Number of pods per plant

The character number of pods per plant recorded the maximum positive indirect effect of (0.2602) via SPAD value followed by the number of seeds per pod (0.1612), plant height (0.1017). A similar result was reported by Dubey *et al.*, (2014) for the number of seeds per pod. Balla and Ibrahim (2017) for plant height. Malek *et al.*, (2014) for pods per plant.

Number of seeds per pod

The character number of seeds per pod recorded the maximum positive indirect effect of (0.1456) via days to 50 % flowering followed by plant height (0.0969), days to maturity(0.0903), SPAD value (0.0881), number of pods per plant (0.0878), 100 seed weight (0.0567). The maximum negative indirect effect of (-0.0446) was seen via the number of primary branches per plant. A similar result was reported by Dubey *et al.*, (2014) for 100 seed weight, Silva *et al.*, (2014) for the number of pods per plant.

100 seed weight (g)

The character 100 seed weight recorded the maximum positive indirect effect of (0.1498) via days to 50 % flowering followed by plant height (0.1448), SPAD value (0.1082), number of seeds per pod (0.0799), days to maturity (0.0113). The maximum negative indirect effect of (-0.0147) was seen via the number of pods per plant followed by the number of primary branches per plant (-0.0372). Similar results were reported by Akram *et al.*, (2016) for days to 50 percent flowering and plant height, Dubey *et al.*, (2014) number of seeds per pod.

SPAD value

The physiological character SPAD value recorded maximum negative indirect effect of (-0.0052) was seen via days to maturity followed by plant height (-0.0166), days to 50 % flowering (-0.0183), number of primary branches per plant (-0.0201), 100 seed weight (-0.0220), number of seed per pod (-0.0253) and number of pod per plant (-0.0407).

In the present investigation, the character number of pods per plant (0.5291) registered the maximum positive direct effect seed yield per plant followed by 100 seed weight (0.4061), number of seeds per pod (0.2882), plant height (0.2111). Days to 50 % flowering recorded the highest negative direct effect of -0.3126 followed by SPAD value -0.0827, days to maturity -0.0155. Which confirmed with the finding of Balla and Ibrahim (2017) for the number of pods per plant and height of plant, Malek *et al.*, (2014) for the number of pods per plant and 100 seed weight. Dubey *et al.*, (2014) and Akram *et al.*, (2016) for days to 50 percent flowering and days to maturity.

In conclusion the seed yield per plant was a significant and positive correlation with variables *viz.* number of pods per plant, number of seeds per pod, 100 seed weight, SPAD value, plant height, days to 50% flowering, and number of primary branches at genotypic level. The number of pods per plant (0.529) registered the maximum positive direct effect seed yield per plant followed by 100 seed weight (0.406), number of seeds per pod (0.288) and plant height (0.211). The number of primary branches per plant recorded the direct effect but low magnitude (0.008). Days to 50% flowering recorded the highest negative direct effect of -0.312 followed by SPAD value -0.082 and days to maturity -0.015.

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How to cite this article:

Pawar, M. G., S. B. Chaudhary, V. S. Pawar and Chavan, S. B. 2020. Correlation Coefficient and Path Analysis Study in Different Soybean Genotypes Based on Yield and Yield Contributing Traits. *Int.J.Curr.Microbiol.App.Sci.* 9(09): 434-444.

doi: <https://doi.org/10.20546/ijcmas.2020.909.055>