The Pharma Innovation Journal 2023; 12(11): 987-991

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(11): 987-991

www.thepharmajournal.com
Received: 26-09-2023
Accepted: 29-10-2023

Bhumika Singh Lodhi
Department of Genetics and Plant Breeding, College of Agriculture, RVSKVV, Indore, Madhya Pradesh, India

Sunil Holkar
Department of Genetics and Plant Breeding, College of Agriculture, RVSKVV, Indore, Madhya Pradesh, India

Arzoo Dhakad
Department of Genetics and Plant Breeding, College of Agriculture, RVSKVV, Indore, Madhya Pradesh, India

Amit Jha
Department of Agronomy, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Monika Chouhan
Department of Agronomy, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Pramod Kumar
Department of Agronomy, College of Agriculture, JNKVV, Jabalpur, Madhya Pradesh, India

Corresponding Author:
Bhumika Singh Lodhi
Department of Genetics and Plant Breeding, College of Agriculture, RVSKVV, Indore, Madhya Pradesh, India

Dissecting yield determinants in soybean cultivation: A path coefficient analysis of morpho-physiological traits and their impacts

Bhumika Singh Lodhi, Sunil Holkar, Arzoo Dhakad, Amit Jha, Monika Chouhan and Pramod Kumar

Abstract
This study investigates the direct and indirect determinants of soybean yield, utilizing path coefficient analysis to unravel the complex relationships between yield-contributing traits. Soybean, as a vital global crop, presents significant challenges in yield maximization, necessitating an advanced understanding of the genetic and phenotypic factors at play. Our research identified strong positive correlations between grain yield per hectare and several morpho-physiological traits, with days to 50 percent podding, pod weight per plant, and biological yield having the most pronounced direct positive effects on yield. Conversely, traits such as days to pod initiation, number of pods per plant, and number of primary branches exhibited positive correlations but negative direct effects, suggesting their yield contributions are mediated through indirect effects. The findings underscore the importance of considering these intricate dynamics in breeding strategies to enhance soybean production. This paper contributes to the existing literature by providing a refined perspective on trait selection, supported by both our data and corroborations from previous studies. The insights gained from this study offer valuable implications for breeding programs, aiming to optimize yield through targeted selection and management of key soybean traits.

Keywords: Path coefficient analysis, path diagram, soybean

Introduction

Soybean [*Glycine max* (L.) Merrill], a member of the Leguminosae family, stands as a global agricultural cornerstone, not only for its significant contribution to the world's oil and protein supply but also for its multifaceted utility in food, feed, and industrial applications (Bhuva *et al.*, 2020) [5]. As the world grapples with the escalating demands for sustainable and nutritious food sources, soybean emerges as a crop of paramount importance due to its high protein (approximately 40%) and oil content (about 20-22%), rich in unsaturated fatty acids and devoid of cholesterol. The strategic cultivation of soybean spans across diverse climatic zones, from tropical to temperate, with leading production concentrated in the USA, Brazil, Argentina, China, and India (Baraskar *et al*., 2015) [4].

Despite its widespread cultivation and inherent adaptability, the maximization of soybean yield remains a complex challenge, influenced by a myriad of biotic and abiotic factors. The intricate interplay between these factors necessitates a nuanced understanding of the direct and indirect determinants of yield (Balla *et al*., 2017) [2]. In the realm of agricultural research and breeding programs, the enhancement of yield is a paramount objective, often pursued through the indirect selection of desirable plant ideotypes. This approach underscores the need to unravel the genetic correlation coefficients between yield and its component characters, a task that demands sophisticated biometrical techniques (Lodhi *et al*., 2023) [9].

Path coefficient analysis, a statistical tool that provides insights into the cause-and-effect relationships among various plant traits, stands as a critical methodology in this context. By dissecting the direct and indirect contributions of different morpho-physiological characters to yield, path analysis facilitates a more informed selection process in breeding programs.

In light of the aforementioned context, this research paper aims to delve into the direct and indirect effects on the yield of soybean, employing path coefficient analysis as the primary investigative tool. Through this analysis, we aspire to illuminate the intricate network of relationships among yield-determining traits, thereby contributing to the refinement of breeding strategies and the advancement of soybean cultivation practices globally.

Material and Methods

During the kharif season of 2022, a study was conducted at the Dryland Agriculture Research Center, College of Agriculture, Indore, Madhya Pradesh, to evaluate 63 unique soybean genotypes alongside three regional standards: JS 20 98, JS 20 116, and JS 20 34. Utilizing a randomized block design with two replications, the genotypes were arranged in paired rows with 10 cm plant spacing and 45 cm row spacing. Data on primary branch count, plant height, number of pods, seed yield, and weight of pods were collected from five randomly selected plants per plot. Key growth milestones and yield (kg/ha) were recorded, and the harvest index was calculated to assess yield efficiency. Path coefficient analysis was conducted to determine the direct and indirect effects of the observed traits on seed yield.

Statistical Analysis

Path coefficient analysis, as proposed by Wright (1921, 1934) [16, 17] and further elaborated by Dewey and Lu (1959) [18], was employed to estimate the direct and indirect contributions of various traits to the total correlation coefficients with seed yield. This analysis, a form of standardized partial regression, quantifies the direct influence of one variable on another and facilitates the decomposition of the correlation coefficient into its constituent direct and indirect effects.

The direct effects were calculated as follows-

$$P_1Y = \sum_{i=1}^{k} C_{1k}\, r_k Y$$

$$P_2Y = \sum_{i=1}^{k} C_{2k}\, r_k Y$$

$$P_kY = \sum_{i=1}^{k} C_{ki}\, r_k Y$$

Residual effect was obtained as per formula given below-

$$R = \sqrt{1 - \sum d_i\, r_{ij}}$$

Result and Discussion

In preceding investigations, we meticulously analysed the Correlations (Fig 1) between yield and its contributing factors. Our findings highlighted a prominent correlation of seed yield per hectare with the biological yield, with other salient traits like pod weight per plant, pod number per plant, plant stature, primary branch number, time to mid-podding, harvest index, and pod initiation period closely trailing in correlation strength. Our analysis discerned exclusively positive correlations at both the genotypic and phenotypic levels (Lodhi *et al*., 2023) [9]. Direct selection predicated on yield alone may not be entirely reliable, given that effective seed selection is contingent upon comprehensive insights into genetic variability and the interplay between yield-contributing traits and the actual grain yield. It is in this context that integrating correlation studies with path coefficient analysis becomes invaluable, offering a refined perspective on the intricate dynamics between various traits and grain yield. Specifically, path analysis emerges as a robust mechanism to dissect genotypic correlation coefficients into their direct and indirect components, enhancing our comprehension of their relevance to grain yield (Balla *et al*., 2017) [2].

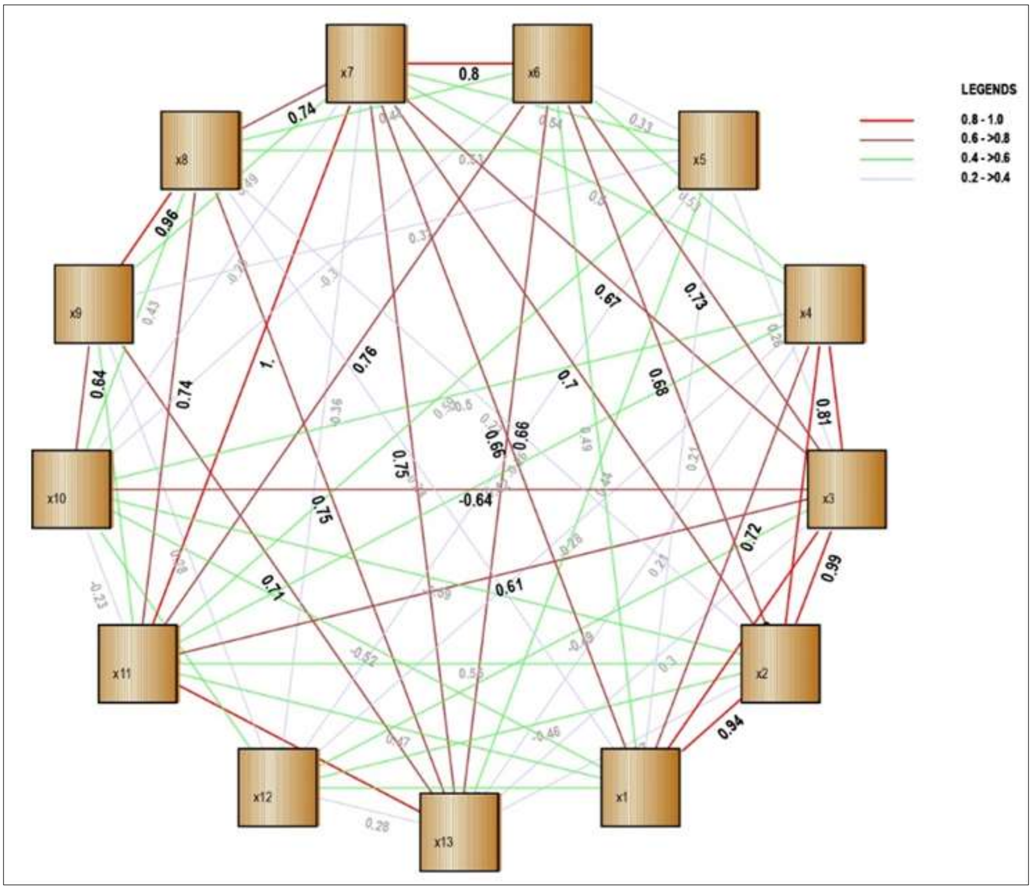


Fig 1: Genotypical correlations

Grain yield demonstrated (Table 1 & 2) a pronounced positive direct impact from days to 50 percent podding (1.628), with pod weight per plant (1.436), biological yield (0.565), plant height (0.238), and grain yield per plant (0.16) also contributing significantly, while other traits had a minimal direct effect. Notably, attributes such as biological yield, pod weight per plant, and days to 50% podding not only correlated strongly with grain yield but also exerted substantial direct influences, underscoring the genuine causative relationships between these traits and yield. Hence, prioritizing these traits in direct selection strategies could substantially elevate grain production.

On the flip side, characteristics like days to pod initiation (-1.376), number of pods per plant (-0.962), and number of primary branches per plant (-0.381) correlated positively yet had a negative direct effect on grain yield, implying that their contribution to yield is mediated through strong indirect positive effects. Therefore, selecting for these traits without considering their indirect influences might inadvertently compromise soybean yield.

Grain yield per hectare is positively affected indirectly by various growth factors (Fig 1). Days to 50 percent podding impacts yield through its effects on flowering and pod initiation times, seed weight, plant maturity, and pod weight. Additionally, pod weight per plant boosts yield via primary branch number, and plant height and pod number also contribute through the days to 50 percent podding. Finally, pod initiation time influences overall biological yield and the Harvest Index.

Similar findings regarding the influence of biological yield on grain yield have been corroborated by Kale *et al*. (2022) [8], Bhuva *et al*. (2020) [5], Baraskar *et al*. (2015) [4], and Banerjee *et al*. (2022) [3]. The impact of the number of pods per plant and the count of primary branches has been documented by Dubey *et al*. (2015) [7], while the significance of plant height has been echoed by Patil *et al*. (2011) [13], Mahbub *et al*. (2015) [11], Balla *et al*. (2017) [2], Akram *et al*. (2016) [1]. Silva *et al*. (2015) [14] and Thakur *et al*. (2015) [15] have reported on the number of pods per plant, whereas Chandel *et al*. (2017) [6] have highlighted the roles of both biological yield and the number of primary branches.

In contrast, Patil *et al*. (2011) [13], Machikowa *et al*. (2011) [10], and Nagarajan *et al*. (2015) [12] have presented divergent results regarding the number of pods per plant. Similarly, Baraskar *et al*. (2015) [4], Bhuva *et al*. (2020) [5] have found conflicting outcomes for both the number of pods per plant and the count of primary branches.

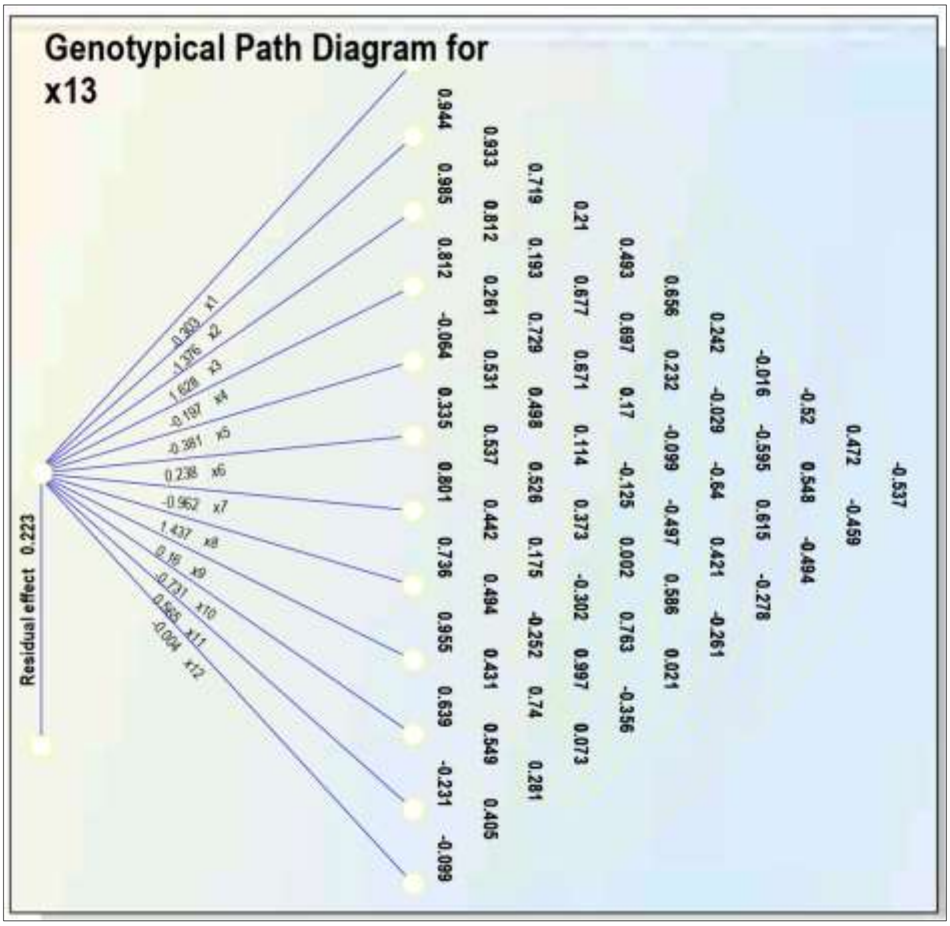
Table 1: Genotypic Path table indicating direct and indirect effect of independent traits on grain yield. Residual effect 0.2233

	Days to 50% Flowering	**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)**	**Harvest index**	**Grain yield (kg/ha)**
Days to 50% Flowering	-0.303	-0.286	-0.283	-0.218	-0.064	-0.149	-0.198	-0.073	0.005	0.157	-0.143	0.163	0.176
Days to Pod Initiation	-1.299	-1.376	-1.355	-1.117	-0.265	-0.932	-0.958	-0.319	0.039	0.818	-0.753	0.632	0.274
Days to 50% Podding	1.519	1.604	1.628	1.322	0.425	1.186	1.092	0.276	-0.162	-1.042	1.001	-0.804	0.303
Days to Physiological Maturity	-0.142	-0.159	-0.160	-0.197	0.013	-0.104	-0.098	-0.022	0.025	0.098	-0.083	0.054	0.207
No. of primary branches per plant	-0.080	-0.074	-0.099	0.024	-0.381	-0.127	-0.204	-0.201	-0.142	-0.001	-0.223	0.099	0.437
Plant height	0.117	0.161	0.173	0.126	0.079	0.238	0.191	0.105	0.042	-0.072	0.182	0.005	0.656
No. of pods per plant	-0.631	-0.67	-0.645	-0.479	-0.516	-0.770	-0.962	-0.707	-0.475	0.242	-0.959	0.343	0.745
Pod weight per plant	0.348	0.334	0.244	0.163	0.756	0.635	1.057	1.436	1.372	0.619	1.063	0.104	0.750
Grain yield per plant	-0.003	-0.005	-0.016	-0.020	0.059	0.028	0.079	0.153	0.160	0.102	0.087	0.045	0.705
Hundred seed weight	0.379	0.435	0.467	0.363	-0.001	0.221	0.184	-0.315	-0.467	-0.731	0.168	-0.296	0.061
Biological yield (kg/ha)	0.266	0.309	0.347	0.238	0.331	0.431	0.563	0.418	0.309	-0.130	0.564	-0.056	0.905
Harvest index	0.002	0.002	0.002	0.001	0.001	-0.0001	0.002	-0.001	-0.001	-0.002	0.001	-0.004	0.285

Table 2: Phenotypic Path table indicating direct and indirect effect of independent traits on grain yield.

	Days to 50% Flowering	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	Bio-logical yield (kg/ha)	Harvest index	Grain yield (kg/ha)
Days to 50% Flowering	0.025	-0.104	0.128	-0.002	-0.002	0.022	-0.009	-0.044	-0.035	0.018	0.15	-0.105	0.04
Days to Pod Initiation	0.023	-0.113	0.135	-0.002	-0.002	0.031	-0.009	-0.04	-0.045	0.02	0.19	-0.08	0.11
Days to 50% Podding	0.022	-0.107	0.143	-0.002	-0.002	0.035	-0.009	-0.031	-0.065	0.022	0.23	-0.087	0.14
Days to Physiological Maturity	0.017	-0.086	0.109	-0.002	0.005	0.027	-0.006	-0.011	-0.08	0.017	0.18	-0.055	0.11
No. of primary branches per plant	0.002	-0.007	0.007	0.0003	-0.036	0.029	-0.009	-0.15	0.25	-0.001	0.304	-0.071	0.31**
Plant height	0.006	-0.041	0.057	-0.0006	-0.012	0.087	-0.01	-0.103	0.13	0.008	0.54	-0.064	0.59**
No. of pods per plant	0.012	-0.056	0.068	-0.0007	-0.016	0.045	-0.02	-0.24	0.35	0.005	0.39	-0.06	0.48**
Pod weight per plant	0.003	-0.015	0.014	-0.0001	-0.017	0.03	-0.015	-0.316	0.51	-0.012	0.31	-0.015	0.47**
Grain yield per plant	-0.002	0.009	-0.01 7	0.0003	-0.016	0.02	-0.012	-0.290	0.55	-0.019	0.28	0.034	0.54**
Hundred seed weight	-0.01	0.054	-0.073	0.001	-0.001	-0.016	0.002	-0.088	0.25	-0.043	-0.10	0.09	0.06
Biological yield	0.005	-0.027	0.041	-0.001	-0.014	0.059	-0.009	-0.123	0.19	0.005	0.79	-0.13	0.78**
Harvest index	-0.006	0.023	-0.031	0.001	0.006	-0.014	0.003	0.012	0.047	-0.01	-0.27	0.40	0.16

Residual effect = 0.1247



x1= Days to 50% Flowering, x2 = Days to pod initiation, x3 = Days to 50% podding, x4 = Days to physiological maturity, x5 = No. of primary branches per plant, x6 = Plant height, x7 = No. of pods per plant, x8 = Pod weight per plant, x9 = Grain yield per plant, x10 = Hundred seed weight, x11 = Bio-logical yield (kg/ha), x12= Harvest index, x13 = Grain yield (kg/ha)

Genotypical Path Diagram for x13

Conclusion

In conclusion, our comprehensive research has elucidated the complex network of correlations and direct effects among various phenotypic traits and their ultimate influence on grain yield per hectare. Through detailed correlation and path coefficient analyses, we have identified days to 50 percent podding, pod weight per plant, and biological yield as key traits with both strong correlations and direct positive effects on grain yield, making them prime candidates for direct selection in yield enhancement strategies. Contrarily, traits such as days to pod initiation, number of pods per plant, and number of primary branches, despite their positive correlations, exhibit negative direct effects, highlighting the necessity to consider indirect effects in selection processes to avoid potential yield reduction. Our findings align with and extend upon previous studies, offering a nuanced understanding that can significantly inform and refine breeding programs. The integration of both correlation studies and path coefficient analysis is indispensable for dissecting the genotypic relationships and providing a more strategic approach to improving soybean yield through targeted trait selection.

References

1. Akram S, Hussain BN, Al Bari MA, Burritt DJ, Hossain MA. Genetic Variability and Association Analysis of Soybean (*Glycine max* (L.) Merrill) for Yield and Yield Attributing Traits. Plant Gene. 2016;7(13):1-11.
2. Balla MY, Ibrahim SE. Genotypic correlation and path coefficient analysis of soybean [*Glycine max* (L.) Merr.] for yield and its components. Agric Res Tech. 2017;7(3):1-5.
3. Banerjee J, Shrivastava MK, Amrate PK, Singh Y, Upadhyay A, Soni M. Genetic variability and association of yield contributing traits in advanced breeding lines of soybean. Electronic Journal of Plant Breeding. 2022;13(2):597-607.
4. Baraskar VV, Vachhani JH, Kachhadia VH, Patel MB, Barad HR. Correlation and path analysis for seed yield in soybean [*Glycine max* (L.) Merrill]. Electronic Journal of Plant Breeding. 2015;6(2):570-573.
5. Bhuva RB, Babariya CA, Movaliya HM, Gadhiya JA, Balar VS. Correlation and Path Analysis for Seed Yield in Soybean [*Glycine max* (L.) Merrill], Ind. J Pure App. Biosci. 2020;8(4):375-380.
6. Chandel K, Patel N, Sharma L, Gali S. Genetic variability, correlation coefficient and path analysis for yield and yield attributing characters in soybean (*L. merrill*) Glycine max. Green Farming. 2017;8(3):547-551.
7. Dubey N, Shrivasthava AN, Avinashe HA, Jaiwar S. Genetic variability, correlation and path analysis for yield and yield contributing characters in soybean (*Glycine max* L.). Electronic Journal of Plant Breeding. 2015;6(1):318-325.
8. Kale DG, Lal GM, Kautikrao J. Character association and path coefficient analysis for seed yield and its contributing traits in soybean (*Glycine max* (L.) Merrill). The Pharma Innovation Journal. 2022;11(12):692-697.
9. Lodhi BS, Holkar S, Dhakad A, Chouhan M, Kumar P. Correlations between Yield and Yield - Attributing Traits and their Influence on Soybean. Biological Forum – An International Journal; c2023, 15(10).
10. Machikowa T, Laosuwan P. Path coefficient analysis for yield of early maturing soybean. Songklanakarin Journal of Science & Technology; c2011, 33(4).
11. Mahbub MM, Rahman MM, Hossain MS, Mahmud F, Kabir MM. Genetic variability, correlation and path analysis for yield and yield components in soybean. American-Eurasian Journal of Agricultural & Environmental Sciences. 2015;15(2):231-236.
12. Nagarajan D, Kalaimagal T, Murugan E. Correlation and path coefficient analysis for yield and yield attributes in soybean, *Glycine max* L (Merr). International Journal of Farm Sciences. 2015;5(3):28-34.
13. Patil SS, Naik MR, Patil PP, Shinde DA. Genetic variability, correlation and path analysis in soybean. Legume Research-An International Journal. 2011;34(1):36-40.
14. Silva AF, Sediyama T, Silva FCS, Bezerra ARG, Ferreira LV. Correlation and path analysis of soybean yield components. International Journal of Plant, Animal and Environmental Sciences. 2015;5(1):177-179.
15. Thakur DK, Nag SK, Gendley TK, Patel RK. Character association and path coefficient analysis for seed yield and its contributing traits in soybean [*Glycine max* (L.) Merrill]. The Bioscan. 2015;10(4 Supplement 2):1947-1950.
16. Wright S. Correlation and causation. J Agric Res. 1921;20:557-585.
17. Wright S. The method of path coefficients. Ann Math Stat 1934;5:161-215.
18. Dewey DR, Lu K. A correlation and path-coefficient analysis of components of crested wheatgrass seed production 1. Agronomy journal. 1959 Sep;51(9):515-518.