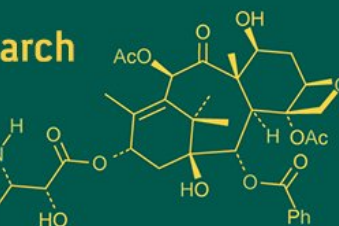
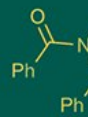


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Gund SS

Research Scholar, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Kshirsagar JK

Faculty, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Karnewar SD

Head and Faculty, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Bhoite KD

Faculty, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Burungule SV

Faculty, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Maharashtra, India

Sakolkar RM

Research Scholar, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Chavan NV

Research Scholar, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Corresponding Author:**Gund SS**

Research Scholar, Department of Genetics and Plant Breeding, Dr. Sharadchandra Pawar College of Agriculture, Baramati, Pune, Maharashtra, India

Path analysis for evaluating trait interrelationships and seed yield in moth bean [*Vigna aconitifolia* (Jacq.) Marechal]

Gund SS, Kshirsagar JK, Karnewar SD, Bhoite KD, Burungule SV, Sakolkar RM and Chavan NV

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Abstract

Moth bean (*Vigna aconitifolia* (Jacq.) Marechal) is a drought-tolerant pulse crop with considerable potential for arid and semi-arid environments. Twenty-eight genotypes were evaluated during Kharif 2025 using a randomized block design with three replications for 15 morphological and nutritional traits. Analysis of variance revealed significant genetic variability for all traits. Path coefficient analysis showed that number of pods per plant (0.37), number of branches per plant (0.27), chlorophyll content (0.26), plant height (0.22) and harvest index (0.22) exerted the strongest positive direct effects on seed yield. The results indicated that these traits could serve as important selection criteria for improving seed yield in moth bean breeding.

Keywords: Moth bean, genetic variability, path coefficient, seed yield, trait association

1. Introduction

Moth bean (*Vigna aconitifolia* (Jacq.) Marechal) is an important pulse crop well adapted to arid and semi-arid environments, particularly because of its drought tolerance and ability to perform under marginal growing conditions. In India, moth bean is cultivated mainly in Rajasthan, which accounts for a major share of its area and production, with cultivation also extending to other dry regions. The crop is valued for its multipurpose uses as food, fodder, cover crop and green manure. Nutritionally, moth bean seeds contain approximately 23.26% protein and 59% carbohydrates, along with fibre, minerals and other essential nutrients, making it an important source of dietary protein and energy. It is consumed mainly as dal and vegetables and is also widely used in traditional food products such as Bikaneri bhujia, mangori, dal vada and papad.

Despite its adaptability and nutritional importance, the productivity of moth bean remains relatively low, largely due to its cultivation on marginal soils with limited inputs and the restricted availability of improved cultivars suited to diverse agro-climatic conditions. Further improvement in productivity requires the identification and utilization of superior genetic variability for yield and its component traits. Considerable variation has been reported for characters such as plant height, maturity duration, number of pods per plant and seeds per pod, providing opportunities for genetic improvement through selection. Therefore, understanding the association among yield and its contributing traits is essential for developing effective selection strategies.

Seed yield is a complex quantitative character influenced by several component traits and their interactions. Direct selection for yield alone may therefore be less effective because of its complex inheritance and environmental influence. Correlation analysis provides information on the degree and direction of association between traits; however, it does not distinguish whether the observed association is due to a direct influence or is mediated through other characters. Path coefficient analysis overcomes this limitation by partitioning correlation coefficients into direct and indirect effects, thereby providing a better understanding of the relative contribution of individual traits to seed yield (Dewey and Lu, 1959) [1]. This approach is particularly useful for identifying reliable yield components that can be effectively utilized as selection criteria in breeding programmes.

Considering these aspects, the present investigation was undertaken to evaluate 28 moth bean genotypes for the association of yield and related traits and to determine their direct and indirect effects on seed yield through path coefficient analysis. The findings are expected to identify important yield-contributing traits that can be emphasized in selection programmes for improving seed yield in moth bean.

2. Materials and Methods

The field experiment was conducted during *Kharif* 2025 at the research farm of Dr. Sharadchandra Pawar College of Agriculture, Baramati, under semi-arid conditions. Twenty-eight moth bean (*Vigna aconitifolia* (Jacq.) Marechal) genotypes were evaluated in a Randomized Block Design (RBD) with three replications, following recommended agronomic practices. Observations were recorded on 15 quantitative and Qualitative traits, viz., days to 50% flowering (No.), days to maturity (No.), plant height (cm), number of branches per plant(No.), chlorophyll content (SPAD)(mg/g), relative water content (%), leaf area (cm²), canopy temperature depression (°C), number of pods per plant, pod length (cm), number of seeds per pod(No.), 100-seed weight (g), harvest index (%), protein content (%) and seed yield per plant (g). Analysis of variance was performed as suggested by Panse and Sukhatme (1985) to determine the significance of differences among genotypes. Genotypic correlation coefficients were estimated to assess the association among traits, and path coefficient analysis was carried out following Dewey and Lu (1959) ^[1] to partition the correlations into direct and indirect effects on seed yield per plant.

3. Results and Discussion

3.1 Analysis of Variance

The analysis of variance presented in Table 1 revealed significant differences among the 28 moth bean genotypes for all fifteen characters studied, indicating the existence of appreciable genetic variability in the experimental material. Significant variation was observed for phenological, physiological, yield and quality traits, including days to 50% flowering, days to maturity, plant height, number of branches per plant, chlorophyll content, relative water content, leaf area, canopy temperature depression, number of pods per plant, pod length, number of seeds per pod, 100-seed weight, harvest index, protein content and seed yield per plant. The significant differences among genotypes indicated the presence of adequate variability, providing scope for further evaluation of genetic parameters and selection of superior genotypes for yield improvement in moth bean. Similar variability for yield and associated traits has been reported in moth bean by Vir and Singh (2015) ^[14] and Raturi *et al.* (2019) ^[3].

3.2 Path Analysis

Phenotypic path coefficient analysis (Table 3, Figure 2) showed that number of pods per plant recorded the highest positive direct effect on seed yield per plant (0.46), followed by days to 50% flowering (0.33), number of branches per plant (0.17), plant height (0.17), chlorophyll content (0.15), harvest index (0.13) and relative water content (0.11). Smaller positive direct effects were observed for 100-seed weight (0.07), leaf area (0.04) and protein content (0.03). In contrast, days to maturity (-0.43), pod length (-0.06), canopy temperature depression (-0.04) and number of seeds per pod

(-0.03) showed negative direct effects. Number of pods per plant exhibited both a high positive direct effect (0.46) and strong positive correlation with seed yield (0.60**), indicating a substantial contribution to yield. Pod length (0.30**) and number of seeds per pod (0.33**) also showed positive correlations with seed yield despite their negative direct effects, largely because of favourable indirect effects through number of pods per plant. Protein content recorded a negative correlation with seed yield (-0.27*) despite its small positive direct effect, indicating that its negative association was mainly mediated through indirect effects. Overall, the results at both genotypic and phenotypic levels emphasized the importance of number of pods per plant and number of branches per plant, together with other positively contributing traits, as useful selection criteria for improving seed yield in moth bean.

Similarly, the genotypic path coefficient analysis (Table 2, Figure 1) revealed that number of pods per plant exerted the highest positive direct effect on seed yield per plant (0.37), followed by number of branches per plant (0.27), chlorophyll content (0.26), plant height (0.22) and harvest index (0.22). Relative water content (0.19), leaf area (0.13), number of seeds per pod (0.13), 100-seed weight (0.07) and pod length (0.07) also showed positive direct effects. In contrast, days to 50% flowering (-0.17), canopy temperature depression (-0.10), days to maturity (-0.05) and protein content (-0.001) exhibited negative direct effects. Despite its negative direct effect, days to 50% flowering showed a positive association with seed yield, mainly through indirect effects via number of pods per plant (0.21), number of branches per plant (0.10) and number of seeds per pod (0.09). These results indicated that number of pods per plant, branches per plant, chlorophyll content, plant height and harvest index were important determinants of seed yield at the genotypic level. Similar importance of yield-contributing traits in moth bean has been reported by Patil *et al.* (2007) ^[2], Raturi *et al.* (2019) ^[3] and Sahoo *et al.* (2022) ^[5].

Table 1: Analysis of variance for fifteen characters of twenty-eight moth bean genotype.

Sr. No.	Character	Mean sum of square		
		Replication	Treatment	Error
	DF	2	27	54
1	Days to 50% flowering (No.)	1.44	675.86**	0.67
2	Days to maturity (No.)	3.58	674.67**	1.76
3	Plant height (cm)	8.64	242.53**	35.00
4	Number of branches per plant (No.)	0.08	7.68**	0.14
5	Chlorophyll content (mg/g)	0.45	17.48**	0.87
6	Relative water content (%)	0.71	90.75**	1.15
7	Leaf area(cm ²)	0.008	2.14**	0.0049
8	Canopy temperature depression (°C)	0.90	9.32**	0.31
9	Number of Pods per Plant (No.)	1.57	12698.29**	1.63
10	Pod length (cm)	0.17	0.31**	0.09
11	Number of seeds per Pod (No.)	0.15	2.23**	0.10
12	100 Seed weight (g)	0.04	0.27**	0.01
13	Harvest index (%)	0.52	103.44**	0.97
14	Protein content(%)	0.08	3.95**	0.11
15	Seed yield per plant (g)	13.76	52.03**	8.24

*, ** significant at 5 and 1 percent, respectively.

Table 2: Estimates phenotypic direct (diagonal) and indirect effects (above and below diagonal) of component characters on Seed yield per plant.

Sr. No.	Character	Days to 50% flowering (No)	Days to maturity (No)	Plant height (cm)	No. of branches per plant (No)	Chlorophyll content (SPAD) (mg/g)	Relative water content (%)	Leaf area (cm ²)	Canopy temperature depression (°C)	No. of pods per plant (No)	Pod length (cm)	No. of Seeds per Pod (No)	100 Seed weight (g)	Harvest index (%)	Protein content (%)	Genotypic correlation with Seed yield per plant
1.	Days to 50% flowering	0.33	-0.42	0.08	0.06	0.03	0.03	0.00	-0.02	0.27	-0.03	-0.02	0.00	0.02	-0.07	0.35**
2.	Days to maturity	0.32	-0.43	0.08	0.06	0.03	0.03	0.00	-0.02	0.27	-0.03	-0.02	0.00	0.01	-0.01	0.32**
3.	Plant height	0.16	-0.20	0.17	0.03	0.06	0.02	-0.01	0.03	0.16	-0.03	-0.01	-0.02	0.01	-0.06	0.26*
4.	Number of branches per plant	0.12	-0.15	0.03	0.17	0.05	0.02	0.04	0.01	0.22	-0.02	-0.01	0.00	-0.02	-0.08	0.37**
5.	Chlorophyll content (SPAD)	0.07	-0.08	0.00	0.00	0.15	-0.02	0.04	0.04	0.08	-0.01	0.01	0.01	0.04	-0.08	0.23*
6.	Relative Water Content	0.09	-0.10	0.00	0.04	-0.03	0.11	-0.01	-0.01	0.12	-0.01	-0.01	0.01	0.01	-0.06	0.20
7.	Leaf area	-0.02	0.03	-0.03	0.00	-0.02	-0.04	0.04	0.01	0.03	0.02	0.03	0.00	-0.01	0.04	-0.01
8.	Canopy Temperature Depression	0.15	-0.20	0.02	0.01	0.02	0.02	-0.01	-0.04	0.06	-0.01	0.02	-0.01	0.01	-0.06	0.01
9.	No of Pods per Plant	0.19	-0.25	0.06	0.08	0.03	0.03	0.03	0.02	0.46	-0.03	-0.02	0.00	0.04	-0.04	0.60**
10.	Pod length	0.16	-0.22	0.08	0.05	0.03	0.02	-0.01	-0.01	0.23	-0.06	-0.01	-0.01	0.01	-0.03	0.30 **
11.	No. of seeds per Pod	0.23	-0.27	0.08	0.04	0.01	0.02	0.02	-0.01	0.29	-0.03	-0.03	-0.02	0.01	-0.01	0.33 **
12.	100 Seed weight	-0.02	0.02	-0.04	0.00	0.03	0.02	0.01	0.03	0.03	0.01	0.01	0.07	0.03	-0.06	0.14
13.	Harvest index	0.04	-0.03	-0.01	-0.02	0.04	0.01	0.02	0.06	0.13	0.01	0.02	0.02	0.13	-0.07	0.29**
14.	Protein Content	-0.01	0.03	0.001	-0.04	-0.04	-0.02	0.02	0.05	-0.16	0.01	0.03	-0.01	-0.04	0.03	-0.27 *

Residual effect (R): 0.550 *,** Significant at 5 and 1 percent, Respectively

Table 3: Estimates genotypic direct (diagonal) and indirect effects (above and below diagonal) of component characters on Seed yield of Per plant.

Sr. No.	Character	Days to 50% flowering (No)	Days to maturity (No)	Plant height (cm)	No. of branches per plant (No)	Chlorophyll content (SPAD) (mg/g)	Relative water content (%)	Leaf area (cm ²)	Canopy temperature depression (°C)	No. of pods per plant (No)	Pod length (cm)	No. of Seeds per Pod (No)	100 Seed weight (g)	Harvest index (%)	Protein content (%)	Genotypic correlation with Seed yield per plant
1.	Days to 50% flowering	-0.17	-0.04	0.13	0.10	0.05	0.05	-0.01	-0.05	0.21	0.05	0.09	-0.01	0.03	0.001	0.43*
2.	Days to maturity	-0.17	-0.05	0.13	0.10	0.05	0.05	-0.009	-0.05	0.22	0.05	0.09	-0.01	0.02	0.001	0.41*
3.	Plant height	-0.10	-0.03	0.22	0.07	0.007	-0.006	-0.03	-0.01	0.16	0.05	0.08	-0.02	-0.01	-0.005	0.37
4.	Number of branches per plant	-0.06	-0.02	0.05	0.27	0.003	0.05	-0.003	-0.001	0.18	0.03	0.03	-0.001	-0.03	0.002	0.49**
5.	Chlorophyll content (SPAD)	-0.04	-0.01	0.006	0.003	0.26	-0.03	-0.02	-0.01	0.07	0.02	0.01	0.02	0.07	0.003	0.34
6.	Relative Water Content	-0.05	-0.01	-0.01	0.07	-0.04	0.19	-0.05	-0.03	0.09	0.02	0.02	0.01	0.02	0.002	0.24
7.	Leaf area	0.01	0.00	-0.05	-0.005	-0.03	-0.07	0.13	0.03	0.02	-0.03	-0.01	0.005	-0.02	-0.001	-0.02
8.	Canopy Temperature Depression	-0.08	-0.02	0.03	0.001	0.04	0.05	-0.04	-0.10	0.05	0.01	0.02	-0.009	0.02	0.001	-0.02
9.	No of Pods per Plant	-0.10	-0.03	0.10	0.13	0.05	0.05	0.007	-0.01	0.37	0.05	0.09	0.004	0.06	0.003	0.75**
10.	Pod length	-0.13	-0.03	0.17	0.11	0.08	0.05	-0.06	-0.02	0.27	0.07	0.10	-0.008	0.02	0.002	0.61**
11.	No. of seeds per Pod	-0.13	-0.03	0.14	0.07	0.03	0.03	-0.01	-0.02	0.24	0.05	0.13	-0.02	0.03	0.001	0.50**
12.	100 Seed weight	0.01	0.002	-0.08	-0.001	0.06	0.03	0.01	0.01	0.02	-0.008	-0.03	0.07	0.05	0.002	0.15
13.	Harvest index	-0.02	-0.003	-0.009	-0.03	0.08	0.02	-0.01	-0.008	0.11	0.006	0.01	0.02	0.22	0.003	0.37*
14.	Protein Content	0.004	0.001	0.001	-0.07	-0.08	-0.04	0.02	0.01	-0.13	-0.01	-0.02	-0.02	-0.07	-0.001	-0.40*

Residual effect (R): 0.264 *,** Significant at 5 and 1 percent, Respectively

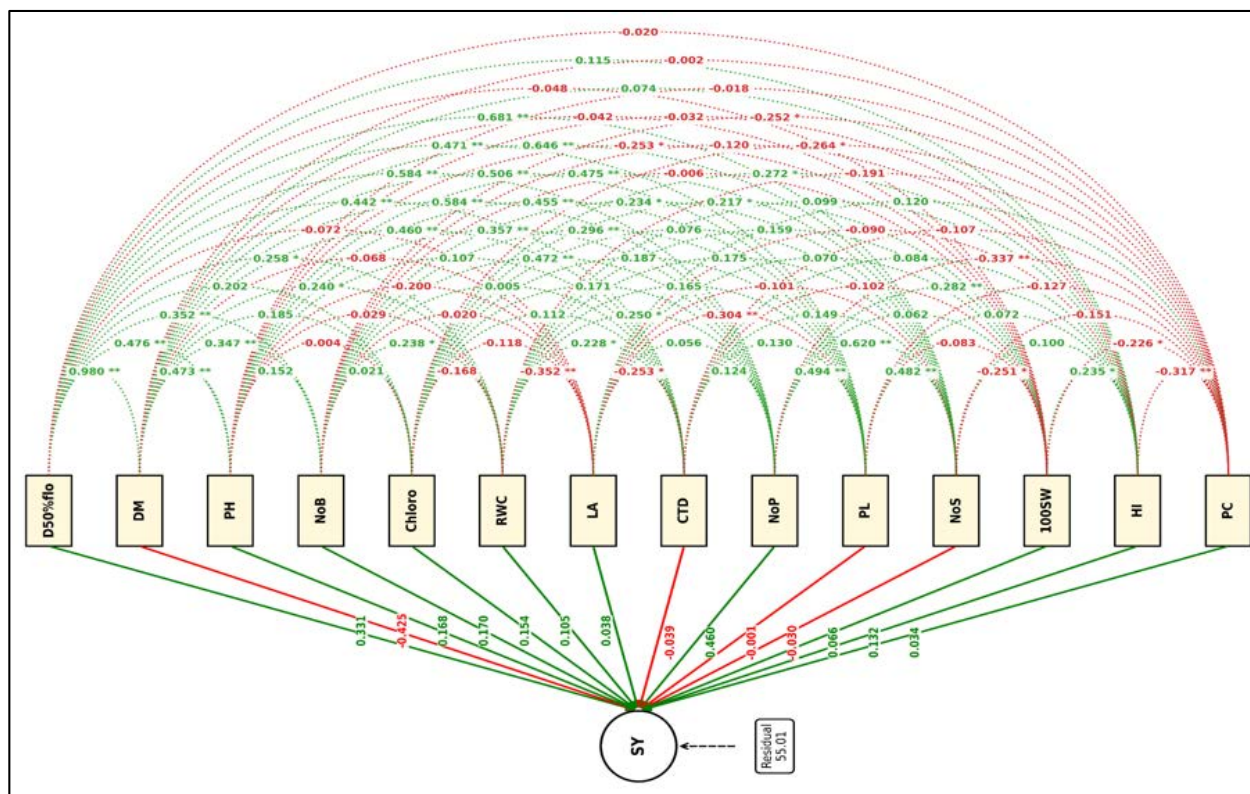


Fig 2: Phenotypic path coefficient analysis diagram

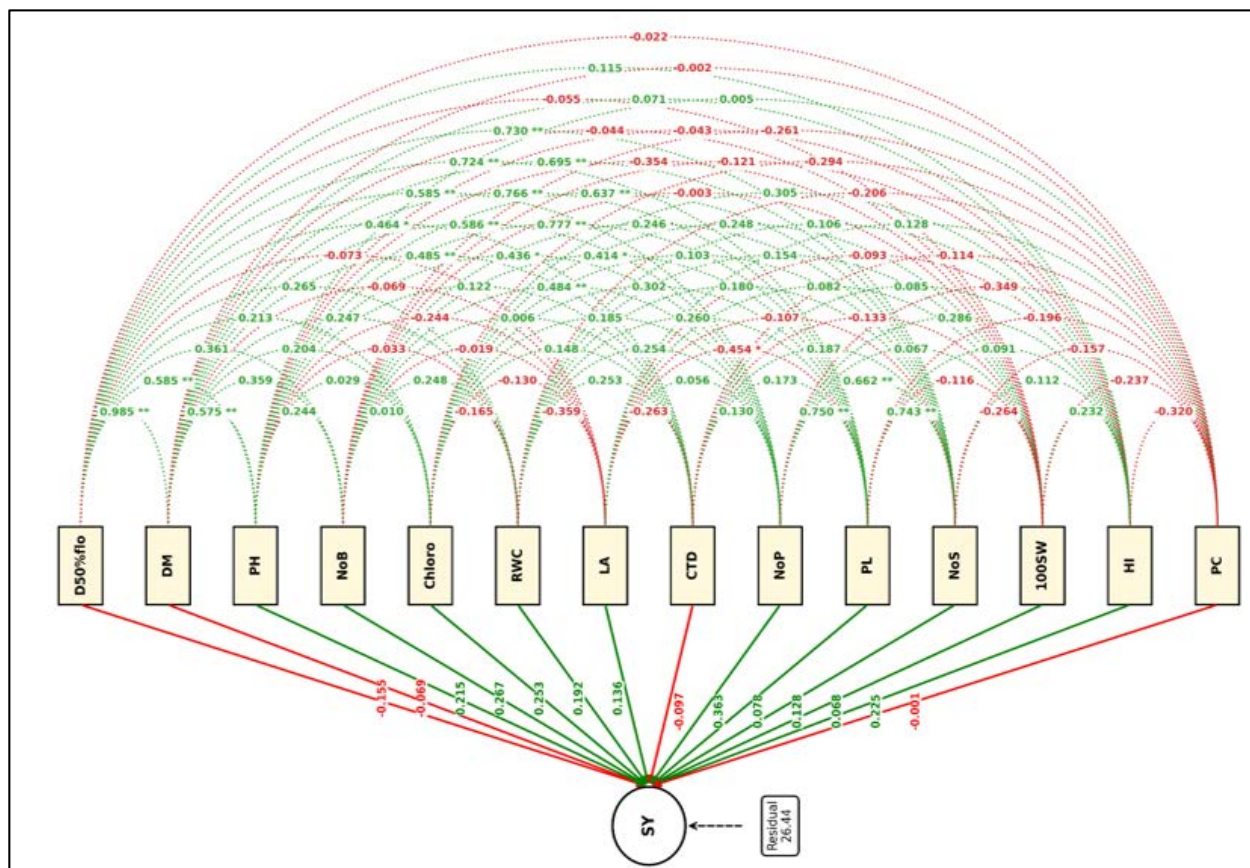


Fig 2: Genotypic path coefficient analysis diagram

4. Conclusion

Seed yield per plant in moth bean was primarily influenced by number of pods per plant, number of branches per plant, chlorophyll content, plant height and harvest index, which exhibited strong positive direct effects at the genotypic

level. At the phenotypic level, number of pods per plant showed the highest positive direct effect, followed by days to 50% flowering, number of branches per plant, plant height and chlorophyll content. Traits such as pod length and number of seeds per pod, despite showing positive

associations with seed yield, exerted negative direct effects at the phenotypic level, indicating the importance of indirect pathways through major yield components. Overall, the path coefficient analysis identified number of pods per plant and number of branches per plant as important selection criteria, with chlorophyll content, plant height and harvest index also contributing favourably to yield improvement. These findings highlight the usefulness of path analysis in identifying important yield-contributing traits and provide a basis for effective selection of superior genotypes in moth bean breeding programmes.

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6. Conflict of Interest

The authors confirm that there are no competing interests associated with the publication of this research work.

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