

Skewness and Kurtosis as Indicators of Gene Action Governing Pre-Harvest Sprouting Tolerance in Greengram (*Vigna radiata* L. Wilczek)

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ABSTRACT

Present study was conducted using 250 individuals of F₂ population derived from a cross between pre harvest sprouting tolerance genotype PUSA M 19111 and a susceptible genotype LGG 668 to analyze inheritance pattern and gene action of PHS traits in greengram. Sixteen traits pertaining to pre-harvest sprouting (PHS) were studied to determine their distribution patterns. The inheritance studies through chi square analysis revealed that PHS tolerance was found to be predominantly governed by complementary gene action. Further the associated traits namely, water imbibition by seeds and pods (%), hard seeds (%), hard seed (%) in pods, epicuticular wax content, alpha amylase activity (at harvest, 24 hours, 48 hours and 72 hours after germination), pod length, pod beak length, pod wall thickness, surface area, and pre-harvest sprouting (%), exhibited positive skewness with platykurtic distribution. This suggests the presence of complementary gene action, with necessary stringent selection for rapid genetic gain due to the involvement of numerous genes. Conversely, fresh seed germination (%) and pod diameter (mm) displayed negative skewness and platykurtic distribution, indicating the influence of multiple genes with duplicate epistasis interaction. In these cases, mild selection pressure may be sufficient to achieve relatively quick genetic improvement.

Keywords: Greengram, Inheritance, Pre-harvest sprouting, Skewness, Kurtosis, Frequency

Introduction

Pulses, belonging to the family fabaceae, are an inte-

gral part of the human diet, particularly for vegetarian people. Pulses are superior to cereals and other food crops in terms of protein content and constitute

a primary source of essential amino acids in vegetarian diets in India. It provides a significant amount of protein (240 g/kg), carbohydrates (630 g/kg), and a range of micronutrients (Satyanarayana *et al.*, 2022). Apart from the high nutritional content, soil fertility restoration through biological nitrogen fixation is a key factor for sustainable agriculture (Dhunde *et al.*, 2021). India is the leading producer and consumer of greengram, covering 19.20% of the country's pulse acreage and contributing 14.1% to total pulse production. Major green gram growing states include Rajasthan, Madhya Pradesh, Karnataka, Maharashtra, Odisha, Tamil Nadu, Bihar, Andhra Pradesh and Uttar Pradesh, which account for about 90% of the total area and production. In 2022-2023, India produced approximately 3,680 thousand tonnes of greengram from 5,550 thousand hectares, with an average productivity of 663 kg/ha (IIPR, 2024). In Andhra Pradesh, annual production was 5 thousand tonnes from 2.71 thousand hectares, with an average productivity of 541 kg/ha. Despite its nutritional and economic significance, greengram is highly susceptible to pre-harvest sprouting (PHS), particularly under humid or unseasonal rainfall conditions, which severely reduces seed quality, germination, and market value. Improving tolerance to PHS has therefore become a key breeding objective in greengram improvement programme.

The study of **skewness** and **kurtosis** offers valuable insights into the genetic control of complex traits such as PHS tolerance. While skewness reflects the nature of gene action (Fisher *et al.*, 1932), kurtosis helps in determining the number of genes involved (Robinson *et al.*, 1949). A trait with normal distribution shows zero skewness and kurtosis, whereas deviations indicate genetic regulation and environmental influences. Skewed distributions generally suggest the role of non-additive gene action, particularly epistasis (Poorni *et al.*, 1977). Positive skewness is linked with complementary gene action, while negative skewness indicates duplicate gene action. Similarly, a leptokurtic distribution suggests control by a few major genes, whereas a platykurtic distribution implies polygenic inheritance with many minor genes (Poorni *et al.*, 1977). The present investigation was therefore aimed at understanding the genetic basis of pre-harvest sprouting tolerance in greengram, focusing on the type of gene action and the number of genes involved, to enhance selection efficiency and accelerate breeding for PHS-resistant varieties.

Materials and Methods

The materials chosen for this objective consisted of two greengram genotypes *i.e.*, PUSA M 19111 (PHS tolerant) and LGG 668 (PHS susceptible). The crossing programme was conducted in kharif 2024, and the true F₁s were identified and advanced to F₂ generation during *rabi*, 2024. A total of 250 F₂ individual plants were developed and evaluated for PHS and its associated traits during summer, 2025 at RARS, Lam, Guntur. Each F₂ plant was sown in a row of 4m length with a spacing of 30 x 10 cm, without replication. The recommended packages of practices were followed throughout the crop period. Observations were recorded on water imbibitions by seeds (%), fresh seed germination (%), number of hard seed (%), water imbibitions by pods (%), number of hard seed in pods (%), epicuticular wax content (mg/g), alpha-amylase activity (at harvest, 24 hours, 48 hours and 72 hours, respectively), pod length (cm), pod beak length (mm), pod diameter (mm), pod wall thickness (mm), surface area (cm²) and pre-harvest sprouting (%). Each plant was tested for PHS value and categorized as tolerant (<10% PHS value), moderately tolerant (10-30%), susceptible (30-70%) and highly susceptible (>70%) as per Gore *et al.* (2024), Verma *et al.* (2024) and Lamichaney *et al.* (2023). The PHS classification of 250 F₂ population of the cross, PUSA M 19111 x LGG 668 is represented in Table 1. The adjusted mean values of each accessions of quantitative trait were used to estimate coefficient of skewness and kurtosis using JMP version 7.0.

Results and Discussion

Genetic studies on inheritance of PHS

Based on the Chi square analysis of 250 F₂ individual plants for PHS tolerance, the calculated value was less than χ^2 table values against degrees of freedom at (3.84) 5% & (6.64) 1% of significance level, indicating a non-significant deviation between the observed and expected segregation ratio. The observed ratio of tolerant (132) to susceptible (118) plants closely fits the expected 9:7 distribution, which is characteristic of complementary gene action. The result of chi square test is given in Table 2. This suggests that tolerance to pre-harvest sprouting in greengram is governed by the interaction of two non-allelic genes, where the presence of at least one

dominant allele at both loci is necessary for the expression of tolerance. Similar results were reported by Lan *et al.* (2005) in F_2 population of Tibetan semi-wild wheat, Ogbonnaya *et al.* (2008) in F_2 population of wheat, Sompong *et al.* (2012) observed similar pattern of inheritance in seed phytate in greengram and Hara *et al.* (2020) in F_2 population of buckwheat.

Skewness and kurtosis in F_2 population of PUSA M 19111 x LGG 668

The 250 F_2 population of cross PUSA M 19111 x LGG668 was ranged from 3.17 to 84.91 % for 51.33 to 100.00 % for fresh seed germination (%), 0.00 to 46.66 for number of hard seeds (%). 30.16 to 90.29 % for water imbibition by pods (%), 0.00 to 74.58 for number of hard seeds (%) in pods, 1.35 to 7.96 mg

Table 1. PHS classification of 250 F_2 population of the cross, PUSA M 19111 x LGG 668

PHS reaction	No. of plants	Classification
Tolerant	16	132
Moderately tolerant	116	
Susceptible	84	118
Highly susceptible	34	

for epicuticular wax content, 4.93 to 17.22 gm for alpha-amylase activity at harvest, 7.07 to 36.77 gm at 24 hours after germination, 12.09 to 99.25 gmat 48 hours after germination, 8.57 to 43.48 gm at 72 hours after germination, 5.00 to 9.17 cm for pod length, 2.67 to 9.00 mm for pod beak length, 0.15 to 0.42 mm for pod diameter, 2.97 to 5.41 mm for pod wall thickness, 6.58 to 13.29 cm² for surface area and 3.93 to 98.14% for pre-harvest sprouting (Table 3, Figure 1). Among the tested, the traits namely percent water imbibition by seeds, percent hard seeds, percent water imbibition by pods, percent hard seed in pods, epicuticular wax content, alpha amylase activity at harvest, 24 hours, 48 hours and 72 hours after germination respectively, pod length, pod beak length, pod wall thickness, surface area and pre-harvest sprouting (%) were positively skewed with platykurtic. It indicates that dominance based complementary gene interaction involving large number of genes having decrease effect. The skewness was positive indicating that predominance of dominant alleles as opinioned by (Roy *et al.*, 2000). The negative skewness with platykurtic was observed in fresh seed germination (%) and pod diameter (mm). These traits were controlled by large number of dominant genes with increasing effect

Table 2. Chi square test for inheritance of PHS tolerance in greengram

Cross	No. of plants	Observed value		Expected value		Calculated χ^2 Value
		Tolerant	Susceptible	Tolerant	Susceptible	
PUSA M 19111 x LGG 668	250	132.00	118.00	140.63	109.38	1.21

Table 3. Minimum and Maximum values of traits associated with pre-harvest sprouting

S.No.	Trait	Minimum	Maximum
1.	Water imbibitions by seeds (%)	3.17	84.91
2.	Fresh seed germination (%)	51.33	100.00
3.	Number of hard seed (%)	0.00	46.66
4.	Water imbibitions by pods (%)	30.16	90.29
5.	Number of hard seed in pods (%)	0.00	74.58
6.	Epicuticular wax content (mg/g)	1.35	7.96
7.	Alpha-amylase activity (at harvest)	4.93	17.22
8.	Alpha-amylase activity (24 hours)	7.07	36.77
9.	Alpha-amylase activity (48 hours)	12.09	99.25
10.	Alpha-amylase activity (72 hours)	8.57	43.48
11.	Pod length (cm)	5.00	9.17
12.	Pod beak length (mm)	2.67	9.00
13.	Pod diameter (mm)	0.15	0.42
14.	Pod wall thickness (mm)	2.97	5.41
15.	Surface area (cm ²)	6.58	13.29
16.	Pre-harvest sprouting (%)	3.93	98.14

and duplicate gene interaction in the inheritance (Table 4). Imtiaz *et al.*, (2007), described similar findings of frequency distribution for PHS traits in back cross derived wheat lines. It showed that stringent

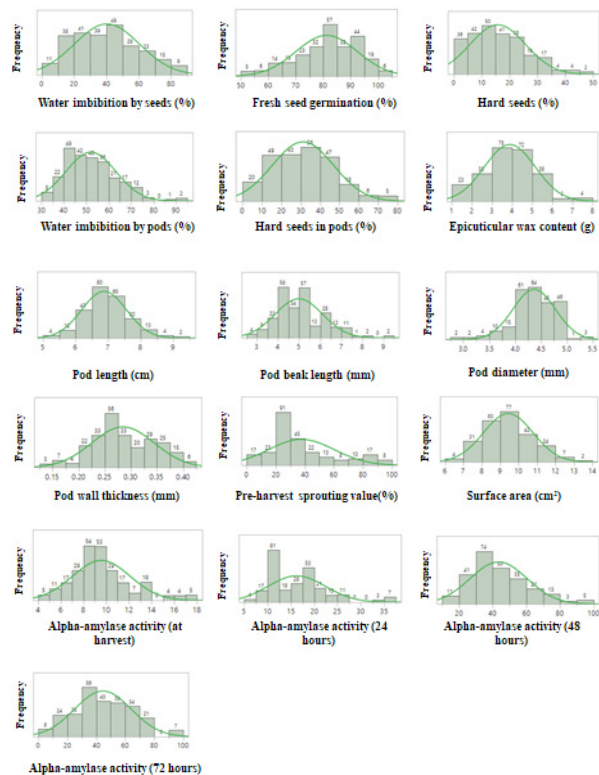


Fig. 2. Frequency distribution graphs of the traits associated with pre-harvest sprouting (%)

selection process is advised to achieve quick genetic gain since they are governed by a large number of genes with complementary gene action.

Conclusion

The present investigation on pre-harvest sprouting (PHS) and its associated traits in greengram revealed complex patterns of inheritance. The chi-square segregation analysis in the cross PUSA M 19111 × LGG 668 showed a good fit to the expected 9:7 ratio with a non-significant χ^2 value, thereby confirming the involvement of complementary gene action. This demonstrates that the expression of PHS tolerance requires dominant alleles at two independent loci and tolerance is lost when either locus is homozygous recessive. In support of this, skewness and kurtosis analyses indicated the predominance of non-additive gene effects, with both complementary and duplicate interactions influencing the inheritance of pre-harvest sprouting tolerance in greengram. Overall, the results highlight the genetic complexity of PHS tolerance in greengram and emphasize the importance of skewness, kurtosis, and segregation studies in identifying the nature of gene action. These insights provide a strong basis for the formulation of breeding strategies, particularly biparental mating and recurrent selection, to accumulate favorable alleles and develop high yielding, sprouting tolerant cultivars suitable for climate resili-

Table 4. Skewness and Kurtosis of F_2 population from the cross PUSA M 19111 × LGG 668

S.No.	Trait	Skewness	Kurtosis	TYTypes
1.	Water imbibitions by seeds (%)	0.306	-0.660	Platykurtic
2.	Fresh seed germination (%)	-0.602	-0.220	Platykurtic
3.	Number of hard seed (%)	0.709	0.062	Platykurtic
4.	Water imbibitions by pods (%)	0.638	0.399	Platykurtic
5.	Number of hard seed in pods (%)	0.281	-0.320	Platykurtic
6.	Epicuticular wax content (mg/g)	0.233	0.268	Platykurtic
7.	Alpha-amylase activity (at harvest)	0.841	0.917	Platykurtic
8.	Alpha-amylase activity (24 hours)	1.134	1.532	Platykurtic
9.	Alpha-amylase activity (48 hours)	0.842	0.894	Platykurtic
10.	Alpha-amylase activity (72 hours)	0.138	-0.413	Platykurtic
11.	Pod length (cm)	0.334	0.596	Platykurtic
12.	Pod beak length (mm)	0.671	0.612	Platykurtic
13.	Pod diameter (mm)	-0.510	0.870	Platykurtic
14.	Pod wall thickness (mm)	0.044	-0.517	Platykurtic
15.	Surface area (cm ²)	0.314	-0.043	Platykurtic
16.	Pre-harvest sprouting (%)	1.037	0.262	Platykurtic

Skewness: positive (+) and negative (-), Kurtosis value less than 3 indicates platykurtic, more than 3 leptokurtic and three indicates mesokurtic

ient agriculture.

Conflict of Interest- None

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