Moth Bean: An Untapped Potential Medico-Therapeutic Plant in Need of Policy Support

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Abstract

The moth bean (Vigna aconitifolia (Jacq.) Marechal), a neglected and underutilised legume crop (NUCL), has significant therapeutic potential due to its high protein content, amino acids, unsaturated fats, minerals, and vitamins. Legumes are used not just as food but also as fodder. Because of its many variants, India is a valuable plant genetic resource (PGR) for traditional remedies and a promising candidate for new and modern pharmaceutical applications like the antibacterial drug Vicilin. In preparation for potential larger applications, this abstract investigates the morphology of moth beans under saline stress and their diverse therapeutic qualities. As the plant endures environmental dangers and climate change, the moth's high genetic diversity and exceptional thermo-drought resistance are highly beneficial for the production of phytochemicals.

Additionally them from, converting NULC to agro-beneficial crops will support local farmers, researchers, and legislators across the globe. Therefore, there is a great need to involve community awareness, legislative support and research support for phytochemical screening and validation. Crops with inherent adaptive characteristics are more tolerant to biotic and abiotic stresses (salinity stresses).

Keywords: Abiotic Stress, Salinity, Moth bean, Neglected and underutilized crops, Therapeutics.

1. INTRODUCTION

There are many legumes native to arid and semi-arid regions of India and Pakistan, including moth beans (*Vigna aconitifolia* (Jacq.) Marechal) (Gayacharan et al., 2023; Vijendra et al., 2016). Despite its resilience to harsh environmental conditions and nutritional and therapeutic potential, moth bean remains a neglected and underutilized legume crop (NUCL). The recognition of its nutritional and medicinal properties highlights the need for renewed focus and policy support to enhance its cultivation and utilization(Singh et al., 2022). In addition to being an excellent source of protein, essential amino acids, unsaturated fats, vitamins, and minerals, moth beans are also a good source of fibre. It is known for its high nutritional value and is utilized as Food and fodder. Its potential medicinal properties, including antibacterial effects attributed to compounds like Vicilin, make it a promising candidate for pharmaceutical applications (Tiwari, Kalim, Bangar, et al., 2018).

Moreover, the moth bean's genetic diversity and adaptability to adverse environmental conditions, such as salinity stress, underscore its importance as a resilient crop in climate change. Moth bean is celebrated for its high protein content, making it a vital food source in regions where protein deficiency is common. It also contains essential amino acids for human health (Tiwari, Kalim, Bangar, et al., 2018; Tiwari, Kalim, Tyagi, et al., 2018). This Food's nutritional value is enhanced by the presence of unsaturated fats, which are good for cardiovascular health, as well as a variety of vitamins (including B-complex vitamins) and minerals (including iron, calcium, and phosphorus).

1.1 Effect of Salinity Stress on Morphology

Morphological Changes: Abiotic stresses such as salinity severely affect plant growth and productivity. Moth bean, however, exhibits remarkable tolerance to salinity stress. In salinity stress conditions, plant height is reduced, leaf size is reduced, and root growth is stunted, as shown in Figure 1. Despite these changes, the moth bean maintains its overall growth and productivity better than many other crops.

Adaptive Mechanisms: The adaptive mechanisms of moth beans to salinity stress include osmotic adjustment, ion homeostasis, and the activation of antioxidant defence systems. These mechanisms enable the moth bean to survive and produce under adverse conditions, making it a resilient crop suitable for cultivation in saline and arid regions.

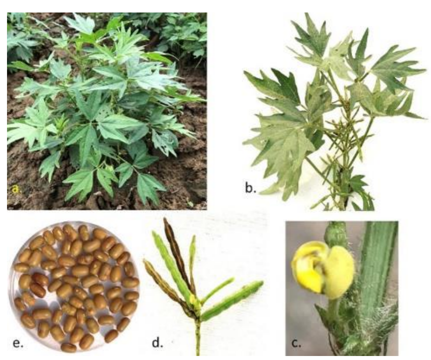

Figure 1: Morphological Key Features of Moth Bean.

1.2 Need of Policy Support for Moth Bean

Moth bean (*Vigna aconitifolia*) holds promise as a plant species with significant medico-therapeutic potential, yet it remains largely unexplored in mainstream healthcare and pharmaceutical research. This underutilized legume, traditionally cultivated in arid and semi-arid regions, possesses bioactive compounds and nutritional attributes that could be harnessed for various health benefits. However, realizing its full potential requires dedicated policy support and strategic initiatives. Firstly, policy support is crucial for promoting research and development into the medicinal properties of moth bean. Government funding and incentives can encourage scientists and researchers to conduct comprehensive studies on its bioactive components, pharmacological activities, and potential therapeutic applications. This support would facilitate the exploration of moth bean's efficacy in treating specific diseases and health conditions, thereby contributing to the diversification of therapeutic options in healthcare. Secondly, policy frameworks are needed to facilitate the integration of moth bean into mainstream medicine and healthcare systems. It includes establishing regulatory guidelines for producing, processing, and marketing moth bean-based products, ensuring their safety, efficacy, and quality standards. By creating a conducive regulatory environment, policymakers can promote the commercialization of moth bean-derived pharmaceuticals, nutraceuticals, and functional foods, thereby enhancing consumer access to its health benefits.

Moreover, policy support can drive initiatives to promote sustainable cultivation practices of moth beans. It includes incentivizing farmers to adopt organic farming methods, conservation practices, and biodiversity-friendly approaches. Such initiatives support environmental sustainability and ensure a consistent and high-quality supply of moth beans for medicinal and therapeutic purposes.

2. LITERATURE REVIEW

A member of the Fabaceae family, the moth bean (*Vigna aconitifolia* L.) is also known as mat bean, matki bean, mout bean, dew gram, or Turkish gram. In India, it is grown for its pods and seeds, both of which are immature. Moth beans are an important food source, especially in developing nations, because of their nutritional and high protein content (Adsule, 1996; Bravo et al., 1998; Kadam et al., 1985).

There are several species of moth bean in the Fabaceae family and the genus Vigna, such as mung beans, black grams, cowpeas, and moth beans. Despite its nutritional benefits, the edible species *Vigna aconitifolia* is underutilized (Takahashi et al., 2016). Due to its favourable climate, it thrives in tropical climates and can be cultivated in infertile soil, making it a staple in Southeast Asia, particularly in Rajasthan, India. Predominantly a Kharif crop, moth bean is grown during the monsoon season from June to November. The plant is known as dew beans, haricot mats, mat beans, moth grams, matkis, and Turkish grams. Food, fodder, feed, and green manure are all offered by moth bean, which is also an economical protein source (Sedani et al., 2021).

Many abiotic stresses such as heat, cold, moisture, and salinity severely affect crop production worldwide. Plant productivity and yield are negatively affected by morphological, physiological, biochemical, and molecular changes caused by abiotic stresses (Naya et al., 2007). Global warming predictions predict temperatures will rise 2–6°C by 2100 (Peck & Teisberg, 1992). Heat stress damages plant cell membranes through reactive oxygen species and oxidative stress. Growing, developing, and yielding of plants are all affected by temperature ((Mittler et al., 2012). Plants must, therefore, be able to adapt to extreme conditions in order to survive. The agricultural industry should select stress-tolerant varieties (Mahajan & Tuteja, 2005).

3. METHODOLOGY

Sample Collection: This study used Agro-climatic regions in India to collect different moth bean genotypes. These genotypes were cultivated under controlled conditions to ensure uniformity in growth parameters.

Nutritional Analysis: Nutritional analysis of moth bean seeds was conducted using standard procedures. The Kjeldahl method was used to measure protein content, and HPLC was used to measure amino acid composition. A GC-MS analysis was performed to determine the composition of lipids, including unsaturated fats. Besides spectrophotometric methods, atomic absorption spectroscopy (AAS) was used to quantify vitamin and mineral contents.

Phytochemical Screening: Phytochemical screening was done to identify bioactive compounds in moth bean seeds. Methanolic extracts of the seeds were prepared and subjected to qualitative analysis for alkaloids, flavonoids, tannins, saponins, and phenolic compounds. Quantitative analysis was performed using HPLC and GC-MS.

Salinity Stress Experiment: The effect of salinity stress on moth bean morphology was examined by growing plants under controlled conditions under various salinity levels (0, 50, 100, 150 mM NaCl). Morphological parameters such as plant height, leaf size, root length, and biomass were measured. Physiological responses, including osmotic adjustment and ion homeostasis, were also assessed.

Statistical Analysis: Data collected from nutritional and phytochemical analyses and salinity stress experiments were subjected to statistical analysis using SPSS software. Statistical analysis, an analysis of variance, and post hoc tests were performed to determine whether differences between treatments were significant.

4. RESULTS AND DISCUSSION

Nutritional Analysis: In analyzing the nutritional content of moth bean seeds, essential amino acids, unsaturated fats, vitamins, and minerals were found to be high. Table 1 shows the summary of the nutritional composition: According to the nutritional analysis, moth bean seeds contain a significant amount of protein (24-26%), essential amino acids (lysine, leucine, and valine), as well as unsaturated fats (linoleic and oleic acids). Vitamins B1, B2, B3, and B6 were also significant in the seeds, confirming their high nutritional value. The comparative analysis of nutritional factors and vitamins is shown in Table 2-3.

Table 1: Nutritional Composition of Moth Bean Seeds

Nutrient	Amount per 100g
Protein	24-26 g
Essential Amino Acids	(Lysine, Leucine, Valine)
Unsaturated Fats	(Linoleic Acid, Oleic Acid)
Vitamins (B1, B2, B3, B6)	Significant amounts
Minerals (Iron, Calcium, Phosphorus)	Significant amounts

Table 2: Analysis of nutritional factors in moth bean seeds

Component	(Tresina et al., 2017)	(Opara et al., 2017)	(Bhadkaria et al., 2021)
Saponin (mg 100g-1)	-	0.65	-
Total free phenolics (g 100g-1)	1.46	0.15	0.05-1.03
Flavonoid (g 100 g-1)	-	0.13	0.25
Tannins (g 100 g-1)	0.65	2.89	0.13-0.30
Phytic acid (g 100 g-1)	0.42	-	1.74
Trypsin inhibitor activity (TIU mg-1)	28.30	-	-
Oligosaccharides (g 100 g-1)	-	-	-
Raffinose	0.54	-	-
Stachyose	1.68	-	-
Verbascose	1.26	-	-
Phyto haemagglutinating activity* (HU mg-1 protein	-	-	1.60-18.48
Blood Group (A)	32	-	-
Blood Group (B)	133	-	-
Blood Group (o)	18	-	-

Table 3: An analysis of the vitamin content of moth bean seeds

Element (mg 100 g-1)	(Usda, 2019)	(Opara et al., 2017)	(Tresina et al., 2017)
Vitamin A	32(IU)	14.65 (IU)	-
Thiamin	0.562	0.23	-
Riboflavin	0.091	0.45	-
Niacin	2.8	0.47	28.08
Ascorbic	4	42.25	59.10
Vitamin E	-	0.25	-
Pantothenic acid	1.54	-	-

Phytochemical Screening: Phytochemical screening identified several bioactive compounds in moth bean seeds. Phytochemical screening identified several bioactive compounds with medicinal properties. Vicilin exhibited antibacterial activity, and other compounds demonstrated antioxidant properties.

Vicilin, a major storage protein, strongly inhibits Gram-positive and Gram-negative bacteria. Other identified compounds, such as flavonoids and phenolic acids, demonstrated antioxidant properties, supporting the potential use of moth bean in managing oxidative stress-related conditions, as shown in Figure 4-5.

Table 4: Phytochemical Composition of Moth Bean Seeds

Compound	Detected Presence	Activity
Vicilin	Present	Antibacterial
Flavonoids	Present	Antioxidant
Phenolic Acids	Present	Antioxidant
Saponins	Present	Antimicrobial, Anti-inflammatory
Tannins	Present	Antioxidant, Antimicrobial

Table 5: Analyzing the fatty acid composition of moth bean seeds

Fatty Acid (%)	(Tresina et al., 2017)	(Kamani et al., 2020)
Myristic acid (C14:0)	02	0.21
Palmitic acid (C16:0)	16	23
Palmitoleic acid (C16:1)	09	-
Stearic acid (C18:0)	07	-
Oleic acid (C18:1)	18	-
Linoleic acid (C18:2)	22	31
Linolenic acid (C18:3)	20	19
Eicosenoic acid (C20:1)	04	-
Saturated fatty acid	26	27
Polyunsaturated fatty acid	74	50

Salinity Stress Experiment: Moth bean plants showed significant tolerance to salinity stress. Morphological changes were observed at higher salinity levels, such as reduced plant height, smaller leaf size, and stunted root growth, as shown in Table 6. However, the plants maintained overall growth and productivity. Physiological responses included increased osmotic adjustment by accumulating compatible solutes and efficient ion homeostasis, contributing to the plant's resilience under salinity stress. Moth beans were studied under different salinity levels to see how their morphology changed due to salinity stress. The results showed significant tolerance to salinity stress with observable morphological changes.

Table 6: Morphological Changes under Salinity Stress

Salinity Level (mM NaCl)	Plant Height (cm)	Leaf Size (cm^2)	Root Length (cm)	Biomass (g)
0	45	20	15	50
50	40	18	13	45
100	35	15	10	40
150	30	12	8	35

Genetic Diversity and Resilience: The genetic diversity among the collected moth bean genotypes was evident from the morphological and physiological variations observed, as shown in Table 7. Genotypes with superior thermo-drought tolerance and salinity resistance were identified, highlighting the potential for breeding programs to enhance these traits. The resilience of the moth bean to environmental stresses positions it as a viable crop for cultivation in regions affected by climate change. Genetic diversity was assessed by evaluating various moth bean genotypes' morphological and physiological traits. The results highlighted significant variability and resilience among genotypes, particularly in thermo-drought tolerance and salinity resistance.

Table 7: Genetic Diversity and Stress Tolerance

Genotype	Thermo-Drought Tolerance	Salinity Resistance	Key Traits
Genotype 1	High	High	Deep root system, efficient water use
Genotype 2	Moderate	High	Heat-shock protein expression
Genotype 3	High	Moderate	Osmotic adjustment
Genotype 4	Low	Moderate	Antioxidant defense activation

5. CONCLUSION

The moth bean, or *Vigna aconitifolia*, is a legume that remains underutilized despite its high nutritional and medicinal potential. Its high protein content, rich nutritional profile, and resilience to environmental stresses make it a valuable crop for future agricultural and pharmaceutical applications. There is a pressing need for policy support, community awareness, and focused research efforts to unlock its full potential. In addition to enhancing food security and supporting sustainable agriculture, we can discover new therapeutic agents by cultivating and utilizing moth beans. Legislative and research initiatives will be critical for the moth bean to become a cornerstone of modern medicine and agro-beneficial practices.

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