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RESEARCH ARTICLE

Effective Utilization of Gypsum-Enriched Water Hyacinth (*Pontederia crassipes* Mart.) Chunks as Green Manure for Groundnut Fields

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ABSTRACT

Water hyacinth (*Pontederia crassipes* Mart. 1843) is an invasive weed species that poses a significant threat to aquatic ecosystems due to eutrophication caused by natural or anthropogenic effects. The cost of controlling these plants is high. Despite this challenge, water hyacinth offers beneficial and economic advantages, making it a valuable resource for recovery. Due to its invasive nature, water hyacinth causes ecological, social, and economic problems in tropical and subtropical areas. It can be controlled by lowering water levels (drawdown) to "strand" and desiccate the plants on exposed shorelines; however, the time required to dry large mats of the plant can be extended. Additionally, drawdowns and droughts trigger seed germination, rapidly re-establishing water hyacinth when water levels rise. Countries like India, China, Japan, and Vietnam have addressed the problem by utilizing the beneficial aspects of water hyacinth, thus avoiding the high costs of controlling it. This paper discusses one of the beneficial uses of water hyacinth: its application as green manure enriched with gypsum for groundnut fields (Alfisols) in tropical regions. Being an organic source, water hyacinth builds up soil organic matter and enriches the soil's physical, chemical, and biological properties. This approach demonstrates a significant increase in the agronomic growth parameters of groundnut plants.

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INTRODUCTION

Pontederia crassipes, formerly known as *Eichhornia crassipes* (Mart.) Solms was introduced as an ornamental crop from South America to the botanical gardens in Bengal by 1896, during the British colonial rule. Commonly referred to as Water Hyacinth, it belongs to the Pontederiaceae family. It was once part of the polyphyletic genus Pontederia, named after the Italian botanist and botany professor Giulio Pontedera. This free-floating plant has become one of the world's most notorious aquatic weeds, causing significant problems across tropical and subtropical continents. Water Hyacinth poses various challenges; its dense growth interferes with navigation, creating barriers that impede the movement of boats and waterways. It exhibits an annual growth pattern in temperate regions and persists as a perennial weed in tropical and subtropical climates. Propagation primarily occurs vegetatively through slender horizontal

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runners known as stolons. Chemical control of water hyacinth using herbicides like 2,4-D Amine has shown some effectiveness; however, such methods pose sustainability concerns and are not environmentally friendly (Hari and Srinivasan, 2023). It can be utilized as green manure, compost, feed for ruminants and non-ruminants, fish feed, and even as a phytoremediator to mitigate heavy metal contamination (Premalatha *et al*., 2019). Notably, Water Hyacinth can purify wastewater by absorbing dissolved nitrogen, phosphorus, and undesirable minerals, including heavy metals. Anaerobic degradation of water hyacinth has been shown to trigger substantial microbiological activity, contributing to enhanced decomposition and potential nutrient cycling (Rajasekaran, 2023).

MATERIALS AND METHODS:

In this study, Water Hyacinth is utilized as green manure and fortified with gypsum to enhance its efficacy. The research was conducted at the Agricultural College and Research Institute, Vazhavachanur, Tiruvannamalai (12.0728°N, 78.9891°E), situated in a tropical region characterised by Alfisols as the predominant soil class. Groundnut (VRI 10) was chosen as the target crop due to its popularity among the local farmers, though drought is a major limiting factor affecting groundnut yield (Vaithiyalingan, 2016). As we know, Water Hyacinth is an invasive aquatic weed that causes damage to water bodies and the aquatic ecosystem. In the motto of waste to worth and to protect our environment, Water Hyacinth was collected from Avaniyapuram pond near Vellakal, Madurai. The collected plants were shade dried for 4-5 days. Fresh Water Hyacinth contains 90% moisture and 15-20% solid materials. After the fifth day, plant parts are chopped into small pieces to increase the surface area. This research evaluated the utilization of Water Hyacinth as a green manure and its enrichment with gypsum for improved agricultural outcomes, explicitly focusing on conventional groundnut cultivation in Tamil Nadu.

BIOLOGY:

Pontederia, a perennial and fast-growing broad-leaved grass weed, proliferates abundantly in water bodies. It is a prime example of invasive and naturalized weeds, firmly establishing itself wherever it invades, such as in India. Pontederia exhibits rapid growth rates. Each inflorescence of Pontederia bears around 20 flowers, each capable of producing 3000-4000 seeds. These seeds sink to the bottom of water bodies and can remain viable for at least 20 years. Water Hyacinth possesses a unique type of parenchyma tissue known as aerenchyma. Aerenchyma is a spongy tissue that contains air spaces or channels, particularly in the hyacinth stem. This structure imparts buoyancy to the stem, enabling Water Hyacinth to float on the water surface.

Table 1. Scientific classification of Water Hyacinth

Rank	Classification
Kingdom	Plantae
Division	Spermatophyta
Subdivision	Angiospermae
Class	Monocotyledonae
Order	Commelinales
Family	Pontederiaceae
Genus	Pontederia
Species	*P. crassipes* (Mart.) 1843

Chemical Composition of Water Hyacinth

Fresh Water Hyacinth typically contains about 90% water and 15-20% solid materials (Ndimele *et al*., 2011). Its nutrient composition includes nitrogen (N) at levels ranging from 1.70% to 2.15%, phosphorus (P) ranging from 0.38% to 0.56%, and potassium (K) ranging from 2.68% to 3.45%. The protein content on a dry basis is reported to be between 9.14% and 14.37%. Moreover, Water Hyacinth is recognized as a carrier of heavy metals such as iron, magnesium, and zinc, making it suitable for phytoremediation purposes (Hasani *et al*., 2021).

Utilizing Water Hyacinth as a Green Manure

Water Hyacinth proliferates in water bodies due to eutrophication. It was collected from a eutrophied water body and subjected to shade drying. After drying, it was cut into small pieces, less than 3 cm in size, to increase the surface area and facilitate its effective utilization by crops. Various parts of the water hyacinth were used for green manure, which was applied to crops before sowing. Water Hyacinth serves as a rich source of nitrogen (N), phosphorus (P), potassium (K), and micronutrients, providing significant benefits to crops upon application (Canning, 2025). Its utilization has shown promising results, including increased soil microbial populations and enhanced microbial activity. This, in turn, leads to the accumulation of soil organic matter and improved soil aggregation (Begum *et al*., 2022).

Figure 1. Water bodies invaded by Water Hyacinth

Studies have indicated that the application of water hyacinth results in improved agronomic characteristics for plants. Additionally, it enhances the soil's water holding capacity, with treated soil increasing from 8.21% to 10.16% compared to untreated soil (Khan and Sarwar, 2002). Water hyacinth has been found to contain significant nutrient reserves. When processed through co-composting with cow dung and crop residues, it produces high-quality organic manure with elevated NPK levels (Prithiv Raj *et al*., 2019).

Figure 2. Site of Collection, Avaniyapuram Pond, Vellakal, Madurai

Figure 3. Shredded shade-dried Water hyacinth

Enrichment with Gypsum (Fortification)

Shade-dried cut pieces (less than 3 cm) of Water Hyacinth are enriched with calcium sulfate (gypsum) at 1:1. This enriched mixture is applied to the field before sowing and again during earthing up on the 45th day to enhance peg formation. Calcium is essential for strong shell formation and cell wall thickening (middle lamella), while sulfur is essential for increasing the oil content of groundnuts. The porous nature of the small Water Hyacinth pieces helps retain the gypsum, facilitating its slow release to the plants and significantly increasing yield. Gypsum application has long been recognised for improving soil physical properties, particularly in sodic and degraded soils, by enhancing structure and promoting calcium availability (Gashi *et al*., 2024).

Water hyacinth waste was collected, shade-dried, and cut into small pieces from water bodies. These pieces were then enriched with gypsum. The experiment was conducted using a Completely Randomized Design (CRD) across three trials. The treatments included: T1-Control, T2-Water hyacinth green manure, and T3-Water hyacinth green manure enriched with gypsum. Agronomic growth parameters of the crop were measured at 30, 60, and 90 days, as well as at the time of harvest.

Table 1. Effect on Plant Height and Width

PLANT HEIGHT AND WIDTH						
Number of Days After Sowing	T_1		T_2		T_3	
	Height (cm)	Width (cm)	Height (cm)	Width (cm)	Height (cm)	Width (cm)
30 DAS	10	5	19	9	20	10
60 DAS	13	7	33	12	35	14
90 DAS	15	10	45	14	47	16
At The Time of Harvest (95 DAS)	15	10	46	16	49	18

Figure 4. Stunted growth observed in the T1

Figure 5. Bunchy growth observed in the T2

Figure 6. Bunchy growth observed in the T3

RESULTS & DISCUSSION:

Upon observing the soil, it shows aggregation due to decomposition. Water hyacinth releases gum-like substances that aid in binding soil particles together.

From Table 1, agronomical growth parameters were calculated at the 30th, 60th, and 90th days and at the time of harvest. Results show that good plant height and width were achieved in T2 (Fig. 5) and T3 (Fig. 6), while stunted growth (maximum height 15 cm) was observed in the control T1 (Fig. 4). The maximum plant height of 49 cm was observed in T3,

Table 2. Effect on Fundamental Yield Parameters

NUMBER OF FILLED AND UNFILLED PODS						
Number of Days After Sowing	T1		T2		T3	
	Average Number of pods per plant	Average Number of filled pods/ plant	Average Number of pods per plant	Average Number of filled pods/ plant	Average Number of pods per plant	Average Number of filled pods/ plant
30 DAS	Flower initiation	Nil	Flower initiation	Nil	Flower initiation	Nil
60 DAS	10	Nil	15	Nil	19	Nil
90 DAS	14	9	23	19	25	21
At the time of harvest	19	12	25	20	30	25

Figure 7. Plant growth in the T1

Figure 8. Plant growth in the T2

Figure 9. Plant growth in T3

and 46 cm was observed in T2. The maximum width of 18 cm was observed in T3, and 16 cm in T2. Applying water hyacinth green manure to the field on the 45th day promotes soil aggregation during the earthing-up process, which helps in more peg formation compared to the control. The application of gypsum-enriched water hyacinth green manure further promotes numerous peg formations. Gypsum prevents soil compaction and loosens the soil, promoting easy peg penetration. Enrichment with water hyacinth promotes soil aggregation by releasing gummy substances, further promoting peg formation and preventing soil erosion due to external factors. Table 2 shows the number of filled and unfilled pods per plant. Results show that the maximum number of good-sized filled pods (25) is achieved in T3. In T2, a maximum number of 20 filled pods is observed, while a lower number of small-sized pods is observed in the control T1. This increment in yield aligns with the study that reported that combined application of organic materials and soil amendments such as gypsum has synergistically improved soil fertility and enhanced crop yield in groundnut systems (Balasubramanian & Palaniappan, 1994).

CONCLUSION:

The results indicate that the agronomic growth and yield parameters of the plants are significantly higher in T3 (Water Hyacinth green manure enriched with gypsum) compared to T2 (Water Hyacinth green manure) and T1 (Control). The growth and yield follow the trend: T1 < T2 < T3. Utilization of Water Hyacinth as green manure, particularly when enriched with gypsum, demonstrates significant improvements in plant growth and yield. This treatment also enhances soil structure and water-holding capacity. It promotes soil aggregation and prevents soil compaction, which paves the way for easy peg penetration and more peg formation. Good agronomical growth parameters are achieved from the experiment. Even though no amount of dry matter is not produced from the Water Hyacinth, due to its invasive nature

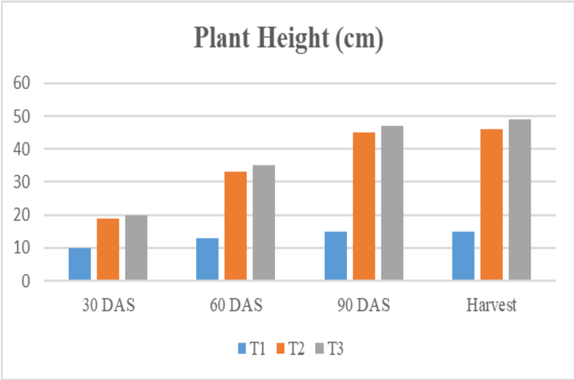

Figure 10. Effects on Plant Height

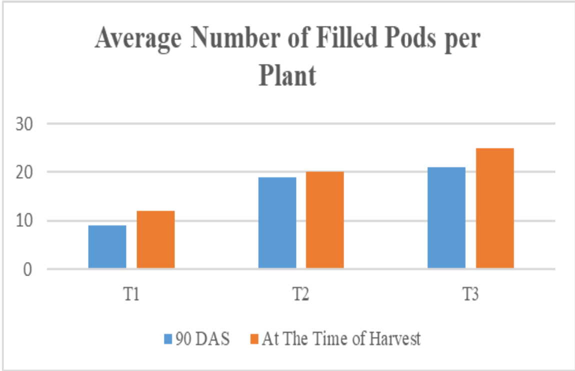

Figure 11. Effects on Average Number of Filled Pods per Plant

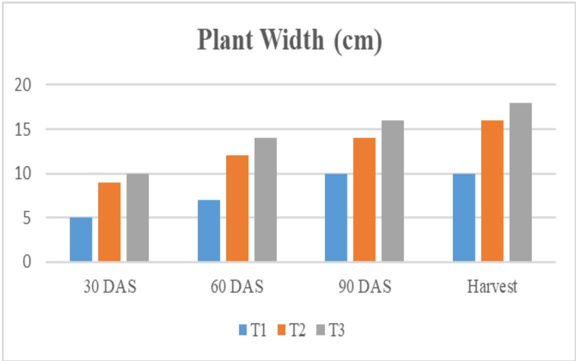

Figure 12. Effects on Plant Width

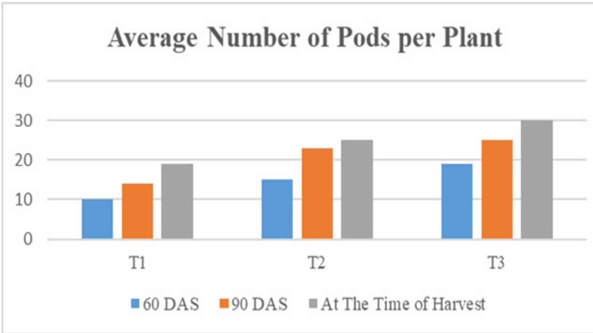

Figure 13. Effects on Average Number of Pods per Plant

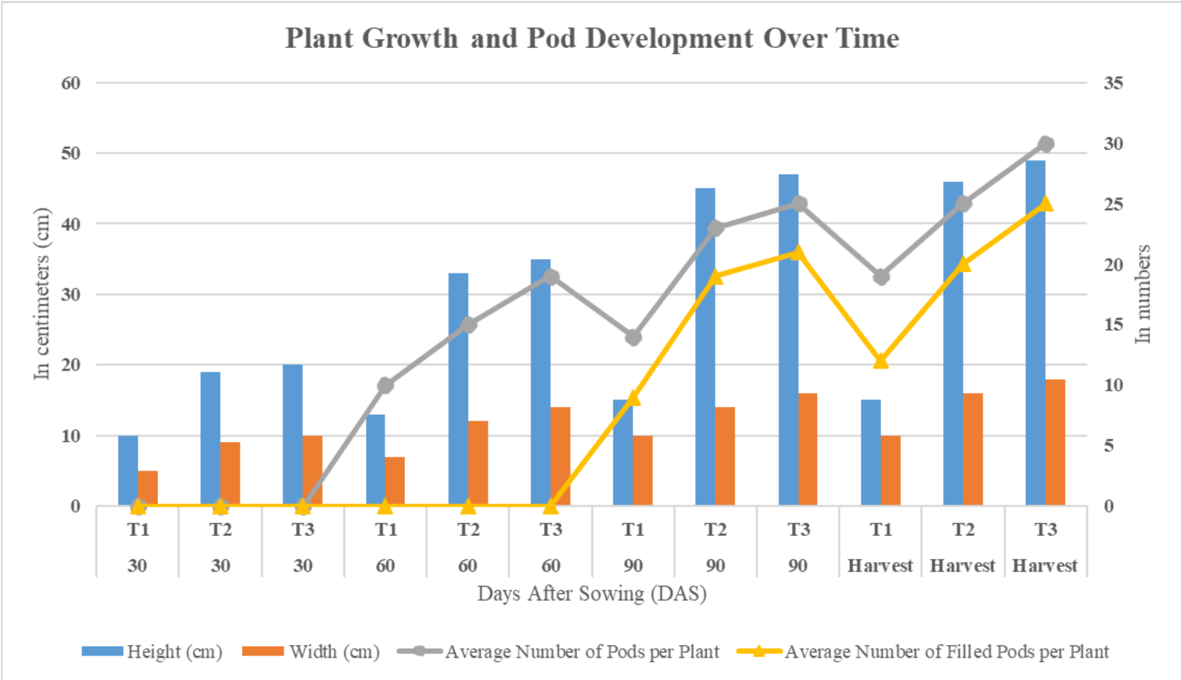

Figure 14: Graph Depicting the Effects of Incorporating Gypsum-Enriched Water Hyacinth Chunks on the Growth and Yield Parameters of Groundnut

and rapid multiplication rate, it can be collected large amounts from water bodies. Making Water Hyacinth into green manure and enrichment with gypsum is not laborious and time-consuming. It is the simplest, easiest, and least time-consuming method compared to other composting methods. It is an environment-friendly method that restores the natural balance and creates a healthy habitat for native plants and animals in our waterways by removing. Compared with other conventional methods, it is cost-effective, economical, and eco-friendly for small-scale farmers.

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Consent for publication

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Competing interest

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Authors contribution

Experiments-Pragadeeshwaran.

Writing-Pragadeeshwaran and Anto Rashwin

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