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Review on enhancing henna harvesting: Addressing manual labor challenges

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Abstract

Henna (*Lawsonia inermis* L.) is a perennial plant that is widely used in traditional medicine and its potential for broader therapeutic applications. It is known for its resilience in drought-prone areas and minimal water requirements, which makes it a valuable opportunity for farmers in semi-arid regions of India to boost their incomes. The plant is rich in bioactive compounds, including carbohydrates, proteins, flavonoids, phenolic compounds, alkaloids, tannins, xanthones, and terpenoids, and its diverse range of pharmacological properties underscores the plant's significance in traditional medicinal and industrial domains, with a productive lifespan extending up to 25 years. Despite its importance, there is limited information on the design and development of specialized henna harvesting machines. This review focuses on the challenges associated with manual harvesting, such as musculoskeletal disorders, physical fatigue, and physical toll on workers. Moreover, it addresses the risks of injuries related to manual handling, reducing the incidence of injuries, and decreasing labor costs. This technological advancement would ultimately lead to a more streamlined, productive, and profitable harvesting process.

Keywords: Henna, arid regions, crop cultivation, harvesting technologies

Introduction

Henna (*Lawsonia inermis* L.) is a perennial plant esteemed for its diverse applications across cosmetic, medicinal, and industrial domains, with a productive lifespan extending up to 25 years. In India, it is commonly referred to as Mehndi and is integral to various socio-cultural events such as weddings and festivals [1]. Both Ayurvedic and Unani medicinal systems utilize henna leaves and other plant parts due to their therapeutic properties [2]. Henna flowers yield essential oils that are highly sought after in the perfume industry, while the plant itself is recognized for its wide range of medicinal benefits [3]. The plant prefers hot climates and is indigenous to the region stretching from the Islamic Republic of Iran to northern India [2], including North Africa, the Arabian Peninsula, the Middle East, and South Asia [4]. Optimal growth conditions for henna include rich, fine sandy or medium-textured, well-drained soils [5].

Research by [6] indicates that henna thrives in tropical savannah and arid tropical zones, particularly within latitudes of 15° to 25° north and south of the equator. The plant achieves its highest dye content in temperatures ranging from 35º to 45ºC and prefers saline soils. The maximum lawsone content is developed under the dry and harsh conditions typical of arid environments [6]. Rajasthan, India, is the leading global producer of henna, with approximately 40,000 hectares dedicated to its cultivation. The majority of this production is concentrated in Sojat, a town within the Pali district, which accounts for 95% of the region's output. Historical data reveals that in 1955, India produced 2,800 tons of henna, with Rajasthan contributing only 5% of this total. However, by the 2018-19 period, Rajasthan's contribution had increased significantly to 90%. The Pali district, notably Sojat City, is the primary hub of henna production in India, with over 250 processing units operating in the area [7]. The district's henna cultivation spans approximately 32,000 hectares, generating annual revenues exceeding 400 million Indian Rupees. Sojat, renowned globally for its high-quality henna, occupies about 66% of the cultivated area within Pali [3]. Currently, 40-50% of the total henna produced is exported, with France, Syria, Algeria, Tunisia, Bahrain, and Jordan being the principal importing countries. France is the leading importer of henna leaves, followed by the UK, while henna powder is also imported by various countries in the Middle East, Northern Africa, and the USA [8].

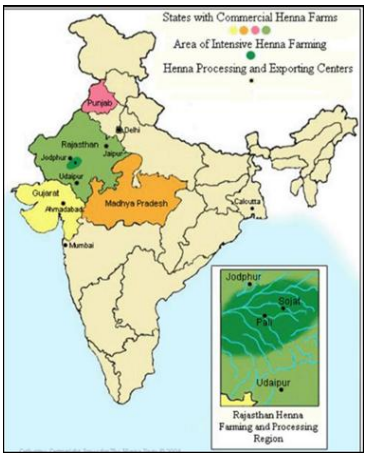

Fig 1: Indian states with henna cultivation areas

Importance of henna

Henna (*Lawsonia inermis* L) is a significant dye plant cultivated in various countries, including India, Pakistan, Sudan, Iran, Yemen, Morocco, Niger, and Egypt [3]. This versatile plant is rich in a diverse array of bioactive compounds, such as carbohydrates, proteins, flavonoids, phenolic compounds, alkaloids, tannins, xanthones, terpenoids, quinones, and fatty acids. In India, the traditional application of mehndi, or henna paste, to the hands and feet has been a cultural practice for centuries. Its popularity in India is partly attributed to its cooling effects, which provide relief during the scorching summer months. Historically, henna leaf extract has been employed for dyeing various materials, including skin, hair, fingernails, leather, silk, and wool [9].

The therapeutic potential of henna extends beyond its use as a dye. Its leaf powder and oil have demonstrated notable efficacy in treating diseases caused by bacteria, fungi, and parasitic nematodes [10-12]. Furthermore, other parts of the henna plant—including the flowers, seeds, roots, stem, and bark—contain additional polyphenols, xanthones, alkaloids, and terpenoids. These compounds exhibit a broad spectrum of biological activities, including antimicrobial, antiparasitic, anti-sickling, antipyretic, analgesic, hypoglycemic, anti-inflammatory, immunostimulant, and antioxidant effects [13-18]. The diverse range of pharmacological properties underscores the plant's significance in traditional medicine and its potential for broader therapeutic applications.

Harvesting methods of henna crop

Seeds of henna are typically sown between March and April. The saplings are then transplanted into the field in August, with a spacing of 30 x 30 cm. Henna can also be propagated effectively through stem cuttings. Following the rainy season, the plants require one or two irrigations and periodic weeding. The initial harvest occurs in March-April, when both leaves and entire branches are collected [19]. It is crucial to harvest before the leaves turn fully yellow to ensure optimal quality [3]. Harvesting is a critical aspect of henna cultivation, representing approximately 32 percent of the total cultivation cost [20]. The cultivation process encompasses a series of operations from propagation to harvesting. Henna can be propagated either through stem cuttings or seedling transplantation. The crop reaches maturity for harvesting after three years. It is typically harvested twice a year—firstly in October-November and then again in April-May. During the harvesting process, branches with leaves are cut close to the ground, with the cross-sectional diameter of the cut ranging from 10 to 30 cm, depending on the plant's maturity [5]. Despite its importance, there is limited information on the design and development of specialized henna harvesters. Traditionally, a sharp-edged curved sickle and gloves are used for cutting henna stems. Some large-scale farmers in the Pali district have attempted to use mechanical harvesters to reduce labor costs; however, these efforts have faced challenges, particularly with leaf loss due to the vibration of the harvester's cutter bar [3]. The development of more effective harvesting technology remains a significant area for improvement in henna cultivation.

Fig 2: a) Heavy sickle used in manual henna harvesting b) Leather gloves to protect palm from injury

Harvesting challenges of henna crop

The harvesting of henna involves a labor-intensive process that requires the simultaneous execution of two key tasks: gripping the stem with one hand and cutting it with a sickle using the other. This method is both inefficient and time-consuming, contributing significantly to worker fatigue and discomfort. Henna stems are notably woody, and their cutting demands a sharp-edged, curved sickle. Despite its necessity, this manual harvesting technique is fraught with difficulties, including high levels of physical strain and low operational efficiency. Consequently, there is a pressing need to develop or enhance existing harvesting systems to facilitate a more efficient and less physically taxing process [3]. Traditionally, the harvesting operation involves cutting branches close to the ground with a heavy sickle, while the worker uses leather gloves to hold the plant and protect their hands from injury (Fig. 2a and 2b). Manual harvesting of henna is particularly challenging due to the rigidity of the stems, which requires skilled labor and leads to significant physical strain and potential musculoskeletal disorders among workers. The demanding nature of the task, combined with the scarcity of skilled labor, results in high labor costs [5].

Workers must frequently shift their posture from standing to squatting while cutting the henna crop, which increases their heart rate and energy expenditure, leading to rapid fatigue. Furthermore, the repetitive use of hand tools can cause pain in the shoulders (affecting the supraspinatus and deltoid muscles), wrists (particularly the extensor pollicis brevis muscle), and forearms (including the extensor digitorum and extensor carpi radialis brevis muscles). Additionally, the use of a sickle often results in minor injuries to both hands during the harvesting process. Given these challenges, there is a critical need for improvements in harvesting technology to reduce the physical demands and improve efficiency in henna cultivation.

Advancement for harvesting of henna crop

Henna, known for its drought tolerance and minimal water requirements, presents a valuable opportunity for farmers in semi-arid regions of India to enhance their income. As a perennial plantation crop, henna offers the advantage of continuous returns over a longer period compared to

seasonal crops, which necessitate replanting annually. Additionally, henna's export potential can support farmers and foster the development of small-scale industries [13]. Looking ahead, the development of a specialized henna harvesting machine is essential. Such a harvester would significantly improve the efficiency and speed of crop cutting and handling compared to traditional manual methods, which is crucial for meeting the demands of peak agricultural seasons. Mechanizing henna harvesting offers a sustainable solution to reduce the labor intensity of the task, thereby decreasing reliance on manual labor.

A henna harvester would not only minimize crop damage, potentially enhancing profitability, but also alleviate the physical strain on workers. By addressing the challenges associated with manual harvesting, such as musculoskeletal disorders and physical fatigue, a well-designed harvesting machine can improve worker safety and productivity. This mechanization would effectively reduce drudgery and mitigate the risks of injuries related to manual handling, ultimately supporting a more efficient and profitable henna cultivation process.

Conclusion

Henna, recognized for its resilience in drought-prone areas and low water requirements, offers a significant opportunity for farmers in semi-arid regions of India to boost their incomes. Unlike seasonal crops that require annual replanting, henna, as a perennial plantation crop, provides extended financial returns over several years. Its potential for export also creates avenues for farmers to engage in global markets and stimulates the growth of small-scale industries within the region. To further enhance the efficiency and profitability of henna cultivation, the development of a specialized henna harvesting machine is imperative. Such a machine would dramatically improve the speed and efficiency of harvesting compared to the current manual methods, which are both time-consuming and labor-intensive. Implementing mechanization in henna harvesting is not just about increasing operational efficiency; it is also about creating a sustainable solution that reduces the heavy reliance on manual labor.

By adopting mechanized harvesting, the potential for minimizing crop damage increases, thereby potentially boosting overall profitability. Moreover, it addresses the physical toll on workers, reducing the risk of musculoskeletal disorders and physical fatigue associated with manual harvesting. A well-engineered henna harvester would alleviate the physical strain on workers, decrease the incidence of injuries, and lower labor costs. This technological advancement would ultimately lead to a more streamlined, productive, and profitable henna cultivation process, enhancing the viability of henna farming as a sustainable and economically beneficial practice in semi-arid regions. The shift towards mechanization not only promises improved efficiency but also ensures better working conditions and increased profitability for farmers, contributing to the broader goal of sustainable agricultural development.

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