OPEN ACCESS INTERNATIONAL JOURNAL OF SCIENCE & ENGINEERING

Development and Performance Evaluation of a Mechanized V-Shaped Vegetable Transplanter

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Abstract: ***India is the second-largest producer of vegetables globally, yet transplanting of vegetable seedlings remains largely manual, labor-intensive, time-consuming, and ergonomically demanding. Non-uniform planting and high labor costs further reduce productivity, particularly for small and marginal farmers. To address these challenges, a low-cost, manually operated, two-row mechanized vegetable transplanter with a V-shaped jaw mechanism was designed, fabricated, and evaluated. The transplanter performs multiple operations simultaneously, including hole formation, seedling placement, soil covering, and plant spacing marking. Field evaluation using 45-day-old tomato seedlings demonstrated a transplanting rate of 19 seedlings per minute, an actual field capacity of 2.912 ha·h^{-1}, and a time saving of approximately 52% compared to conventional manual transplanting. The lightweight design (4–5 kg), ergonomic configuration, and reduced labor requirement make the developed transplanter suitable for small and medium landholdings. The study confirms that the mechanized vegetable transplanter offers a practical, economical, and farmer-friendly alternative to traditional transplanting methods.***

Keywords- Vegetable transplanter; Mechanization; Ergonomic design; Small farmers; Field capacity

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I. INTRODUCTION

Vegetable cultivation plays a vital role in human nutrition, rural employment, and agricultural diversification in India. Despite significant growth in vegetable production, transplanting operations are still predominantly manual. Traditional transplanting requires bending or squatting postures, leading to drudgery, fatigue, and high labor input, typically ranging from 185 to 260 man-hours per hectare. Automatic and tractor-operated transplanters exist, but their high cost and operational complexity limit adoption by small farmers.

There is a clear need for affordable, simple, and ergonomically designed transplanting equipment that reduces labor dependence while maintaining planting accuracy and crop survival. This study focuses on the design, fabrication, and performance evaluation of a manually operated mechanized vegetable transplanter suitable for Indian farming conditions.

II.LITERATURE SURVEY

Vegetable transplanting is a vital operation in agricultural production and is widely recognized as one of the most labor-intensive field activities. To address challenges related to labour scarcity, high operational costs, and low productivity, numerous researchers have investigated the development and performance of manual, semi-automatic, mechanized, and automated vegetable transplanters.Several studies have reported on the design and evaluation of manual and animal-drawn vegetable transplanters, demonstrating significant improvements over conventional hand transplanting. These studies revealed higher field capacity and field efficiency, along with substantial reductions in labour requirement, time consumption, and cost of operation. Such transplanters were found to be economically viable and suitable for small and marginal farmers due to their simplicity and affordability

.Advancements in semi-automatic vegetable transplanters further enhanced transplanting performance by increasing field capacity and reducing human effort. Comparative field evaluations indicated that machine transplanting resulted in lower labour requirement, reduced operational cost, and improved crop growth parameters compared to traditional methods. However, variations in planting depth, seedling placement accuracy, and plant population were observed, suggesting the need for further design optimization.

Based on the reviewed literature, it is evident that although significant progress has been made in the development of vegetable transplanters, further improvements are required to enhance planting accuracy, operational reliability, adaptability to different crops, and cost-effectiveness. Mechanized and automated vegetable transplanting continues to be an important research area with strong potential to mitigate labour shortages and improve productivity in modern agricultural systems.

III.MATERIALS AND METHODS

3.1 User Survey and Need Analysis

A field survey was conducted in Borkhedi and Butibori regions of Nagpur district, Maharashtra, involving farmers, retailers, and home gardeners. The survey identified key issues with existing transplanting methods, including hand fatigue, spring failure, corrosion, and height incompatibility. Based on user feedback, ergonomic redesign, improved durability, and simplified mechanisms were prioritized.

3.2 Design Considerations

The transplanter was designed considering ergonomics, safety, stability, cost, and ease of operation. Anthropometric data were used to determine handle height, grip diameter, and lever dimensions to allow operation in a standing posture for both male and female users.

3.3 Construction Details

The developed transplanter consists of a mild-steel frame, a V-shaped jaw assembly, a PVC seedling feeding pipe, lever-operated jaw mechanism, plant spacing marker, and two support wheels. The jaw assembly forms uniform holes and releases seedlings by gravity when actuated. Locally available materials were used to minimize fabrication cost.

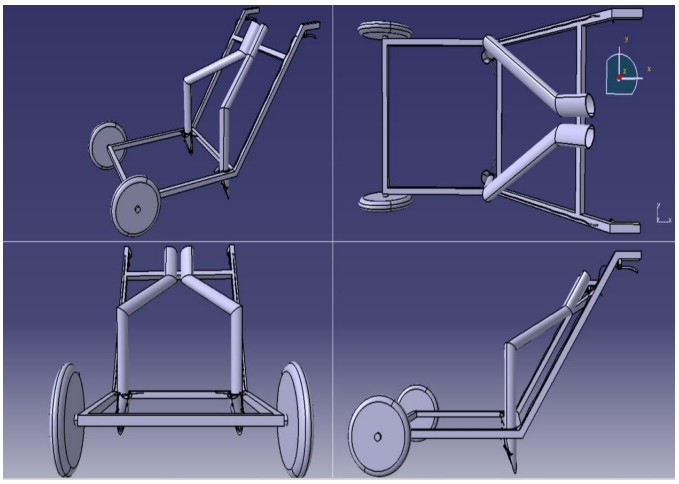

Figure 1: 3D Representation of vegetable V-Shaped Transplanter.

3.4 Field Evaluation

Performance testing was conducted on a 0.1 ha plot with tomato seedlings under vertisol soil conditions at 16–18% moisture content. Parameters evaluated included transplanting rate, speed of operation, field capacity, labor requirement, and time savings. Standard agricultural machinery evaluation formulas were used.

IV.RESULT AND DISCUSSION

The transplanter achieved an average transplanting rate of 19 seedlings per minute with a forward speed of 0.208 $km \cdot h^{-1}$. The calculated actual field capacity was 2.912 $ha \cdot h^{-1}$. Compared to manual transplanting, the developed machine reduced transplanting time by approximately 52%.

The ergonomic design allowed operators to work in a standing posture, significantly reducing physical strain. Field observations indicated minimal seedling damage, uniform planting depth, and satisfactory plant establishment comparable to manual methods.

Reduced labor dependency and low operational cost make the transplanter economically viable for small- scale farmers.

V.CONCLUSION

A low- cost, manually operated mechanized vegetable transplanter was successfully designed, fabricated, and tested. The machine effectively reduces labor requirement, transplanting time, and operator fatigue while maintaining planting quality. Its simplicity, lightweight construction, and affordability make it suitable for widespread adoption among small and marginal farmers. Further studies may focus on multi- crop adaptability and long- term field performance under varied soil conditions.

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