

Design and construction of a ridger adapted to the conditions of the communal land of Eloxochitlán, Zacatlán, Puebla

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ABSTRACT: This document presents the design and construction of an agricultural furrower, a project developed by students of the Electromechanical Engineering program in collaboration with faculty from the ITESNP-CA-05 academic body, Development and applied research in embedded and electromechanical systems at the National Technological Institute of Mexico/Technological Institute of the Sierra Norte of Puebla. The initiative arises as a direct response to a significant problem in the Zacatlán region, in the Eloxochitlán communal land, where agricultural producers face considerable difficulties in acquiring suitable and affordable farming implements. The primary objective of the research is to provide a tool that is not only accessible but also more user-friendly for local farmers, facilitating their soil preparation work, as most of the land they work on is sloped. The design of the furrower prototype focused on the use of locally available and low-cost materials, prioritizing functionality and ease of maintenance. The main components include rectangular tubular steel (PTR) for the sturdy structure, an 18-inch motorcycle rim cleverly adapted to optimize momentum and traction on the terrain, a 5HP two-stroke gasoline engine with a pulley that suits the power required for this task, and wheels commonly used on hand trucks, chosen for their durability and availability. This selection of materials reflects an engineering approach, where creativity in reuse and resource accessibility is key to the success of the project in an environment with viable and accessible resources. The methodology that guided the development of this study was the Engineering Design Process (EDP). This systematic and iterative approach allowed the team to address the problem in a structured manner, from identifying the need to building and testing the prototype. The design was created in SolidWorks, and the preliminary tests were carried out within the facilities of the Higher Technological Institute of the Sierra Norte of Puebla, in an environment adapted to simulate working conditions. During these tests, the furrower demonstrated its functional capacity by creating furrows 5 cm wide and 4 cm deep. The result of this initial experiment was rated as having good functionality, validating the design and simulation of the furrower. This success establishes a promising foundation for future iterations and more thorough evaluations of the implement.

KEYWORDS-Construction, Design, Simulation, Ridger

Date of Submission: 08-04-2026

Date of acceptance: 20-04-2026

I. INTRODUCTION

The communal land of Eloxochitlán belongs to the municipality of Zacatlán, Puebla. It is situated at an altitude of 2,121 meters and is made up of 90 communal land members. It is located 4 minutes from the municipal seat. Its population in 2020 consists of 194 inhabitants, of whom 103 are women and 91 are men. The percentage of illiterate population is 4.12%, and the labor force over 12 years old is 51.55%. In this situation, the agricultural producers of Eloxochitlán face great difficulties in acquiring agricultural tools that are suitable and affordable, mainly due to their high cost, which limits the mechanization of fieldwork and directly affects productivity by reducing the efficiency and yield of their crops. In light of this reality, there is a need to seek accessible alternatives adapted to their conditions, allowing them to work more efficiently and improve their quality of life. The primary objective of the research is to provide a tool that is not only accessible but also more user-friendly for local farmers, facilitating their soil preparation work, as the lands they work on are mostly sloped.

It is therefore possible to design and build a furrower adapted to the conditions of the communal land of Eloxochitlán, Zacatlán, Puebla to improve the quality of life of the community's farmers. With the implementation of a furrower, productive efficiency in the field will be boosted, reducing costs for the benefit of the region. This approach is supported by studies such as García-Arias (2023), who examined the use of agricultural machinery by mechanization service providers in Catamayo, an area with clayey and rocky soils.

For land preparation, disc plows, furrowers, cultivators, and 95 hp tractors are used. For his part, Méndez Uvidia, A. L. (2025) conducted a diagnosis on the level of agricultural mechanization in corn cultivation in Santa Elena. Among the main limitations identified is the high cost of machinery, which restricts its acquisition and forces many farmers to resort to renting. In addition, there is the difficulty of accessing financing, which represents an additional obstacle to the adoption of new technologies.

Walter, M. G. (2025), validated the technical specifications of the 13 HP DUCATI DTL 13000 two-wheel tractor for primary tillage tasks for corn planting. The study was carried out on clay soil with an organic matter content of 0.99%. For land preparation, a moldboard plow was used, which required 6.89 HP of the 13 HP available on the motor-cultivator, which recorded a traction force of 459.5 kg and a fuel consumption of 0.9 gallons/day. In comparison, the use of a yoke of oxen with a moldboard plow proved to be more economical, requiring only 1.36 HP of power. In the same line of seeking efficient mechanization alternatives, Montoya Fernández, J. M. et al. (2025) developed a manual agricultural tool optimized through CAD, CAM, and FEA. Starting from a physical prototype, they applied reverse engineering, generated a CAD model, manufactured a functional 3D prototype, and validated its performance through finite element simulation.

Additionally, Nixon da Rosa, et al. (2024) proposed a prototype with a furrow-hoeing implement, which showed superior results in some variables due to the preservation of the limited moisture present at the time of sowing. In contrast, localized preparation with rotary cultivators showed unfavorable performance in certain variables due to the initial condition of water deficit. For his part, Guamangate Vargas, J. M. (2024), proposed two alternatives of furrowers attached to a YTO motor-cultivator, designed using the Pahl and Beitz model and evaluated both technically and economically. The design considers structural strength, load capacity, cost, and ease of use, offering a balanced and functional tool for farmers in the region. Naula Alvarracin, in 2024, evaluated the efficiency of a manual weeding tool using two treatments: treatment 1 (hoe) and treatment 2 (furrower). Reduced costs were obtained using the first treatment.

Manobanda Mainato, J. P. (2024), evaluated the effect of soil compaction from slipping under conventional and minimum tillage for corn cultivation. Using a randomized complete block design, soil physical properties and operating costs were analyzed, employing drones and GPS for georeferencing. He states that minimum tillage better preserves soil properties, reduces slipping, working time, and costs compared to conventional tillage. Flores-Torres, et al. (2021) is consulted for the design and optimization of a furrow opener's tine, aiming to reduce its mass without compromising structural strength. The design was carried out in CAD, with a theoretical-numerical analysis that showed a high correlation between calculated and simulated results. For the optimization, two methodologies were applied: Central Composite Design with Response Surface Methodology and Simulated Annealing. Both allowed a reduction of up to 25% in mass compared to the initial design, while also lowering material acquisition and manufacturing costs.

The proposal by Ayub Siddique, et al. (2025) is studied for evaluating the effect of engine speed on the traction of an electric tractor during plowing. The results showed that L-2500 offered the best performance and is the most efficient option, although it varies depending on soil conditions, while L-2800 reduced slippage but increased energy loss.

II. METHODOLOGY

The methodology used for the development, simulation, and construction of the furrower was the Engineering Design Process (EDP), under the following phases: requirements determination, design, simulation, construction, and testing. The main components of the furrower include rectangular tubular iron (RTI), an 18-inch rim, a 5HP two-stroke gasoline engine with a pulley, wheels commonly used on hand trucks, electrodes, belt, galvanized metal, power source, and a grinder. To determine the requirements, a visit was made to the communal land of Eloxochitlán with the purpose of identifying the tools available among the communal land members for carrying out their agricultural work, as shown in figures 1 and 2.

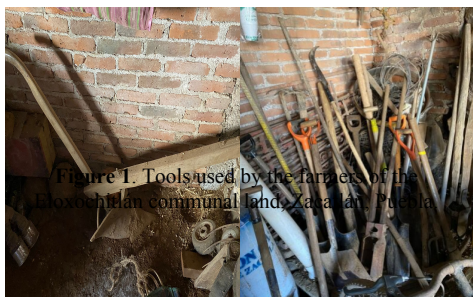


Figure 1. Tools used by the farmers of the Eloxochitlán communal land, Tlaxcala, Puebla.



Figure 2. Members of the Academic Body ITESNP-CA-05, Development and Applied Research in Embedded and Electromechanical Systems of the Technological Institute of the Sierra Norte of Puebla and the communal land Commission of Eloxochitlán, Eng. Filiberto Carmona Soto.

The needs and constraints present in the communal land of Eloxochitlán were identified, among which inaccessibility and the lack of adequate agricultural implements for farmers stand out. Faced with this situation, the academic team focused on designing and building a furrowing tool that is accessible and easy to use, taking into account limitations such as the availability of low-cost local materials, as well as limited time and resources. To achieve this, the furrowing methods used in the region were thoroughly analyzed, identifying why they were not suitable for the conditions and capacities of the farmers. The decision to develop a furrower responded to the unmet need in the agricultural community, arising from the lack of access to machinery, tools, and specialized personnel. The design of the agricultural furrower was conceived as a robust and functional machine, developed to meet the needs of local agriculture, with a focus on accessibility and easy maintenance. Functionality and ease of upkeep were prioritized, opting for low-cost materials that are locally available. Therefore, the design and simulation of the furrower is carried out using SolidWorks, as shown in Figure 3.

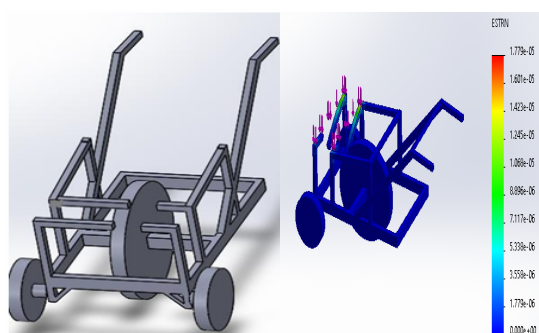


Figure 3. Design and simulation of the furrower created in SolidWorks. Source: Own elaboration.

For the construction of the furrower, the previously selected materials were used. The frame was made with rectangular tubular iron (PTR), an 18-inch motorcycle wheel was adapted for the drive system, a two-stroke gasoline engine was incorporated, and caster wheels were installed to facilitate support and transportation of the equipment. The construction involved the collaboration of students from the Electromechanical Engineering program, who participated in cutting, welding, and assembly tasks according to the design developed for the furrower, as shown in Figure 4.

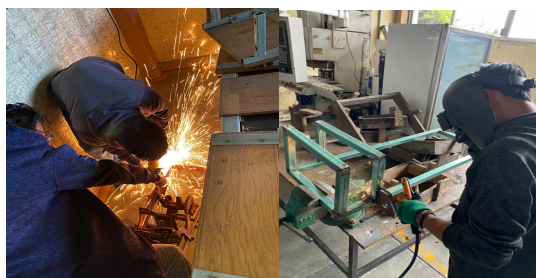


Figure 4. Electromechanical Engineering students cutting and welding the furrower according to the previously prepared design. Source: Own elaboration

III. RESULTS

The main frame was constructed with rectangular tubular steel (PTR), chosen for its excellent strength-to-weight ratio, which ensures the durability of the machine without excessively increasing its weight. In addition, its ease of manufacturing and welding, along with its availability and affordable cost in the region, contribute to the economic feasibility of the implement. The power unit consists of a two-stroke gasoline engine, chosen for its simplicity, lighter weight, and high power-to-weight ratio, characteristics ideal for small agricultural machinery. The engine was selected for its reliability and for the availability of spare parts and maintenance experience in the region, factors that are fundamental for the long-term sustainability of the equipment. The drive mechanism includes an 18-inch motorcycle wheel, whose adaptation optimizes traction and grip on the ground, facilitating both soil cutting and machine propulsion. This solution reflects an efficient use of reused resources, helping to keep manufacturing costs low.

For the formation of furrows, ridges with optimized geometry were designed to promote uniform furrowing and resistance to soil wear. As for the support and transportation system, 'hand truck' wheels were used, known for their durability and ability to carry loads on uneven terrain. Their wide local availability

reduces costs and simplifies repairs, strengthening the farmers' autonomy. Figure 5 shows the finished prototype of the furrower.



Figure 5. Finished prototype of the furrower. Source: Own elaboration.

The selection of materials and components demonstrates the application of engineering principles, combining design, functionality, and material properties. This approach responds to the need to develop technology suitable for the region, prioritizing accessibility, sustainability, and low environmental impact. The use of common and reused parts not only reduces initial and maintenance costs but also promotes local resilience.

Tests and Evaluation of the Furrower. Preliminary tests were conducted in a controlled environment within the institute, simulating field conditions. The prototype demonstrated its functional capability by creating furrows 5 cm wide and 4 cm deep, achieving a "good response" that validated the concept and the basic functionality of the design. However, this can vary between 4 and 7 cm, depending on factors such as soil moisture and the cultivated variety. Figure 6 shows one of the tests conducted.



Figure 6. Operational test of the furrower at the ITSSNP facilities. Source: Own elaboration.

In the first test, there was particle dispersion that, due to the speed, hit the user with force. For this reason, in the second test, the use of a face shield and protective uniform was implemented, as shown in Figure 7.



Figure 7. Use of face shield and protective uniform to carry out the second operational test of the furrower

IV. DISCUSSION

Unlike what García-Arias (2023) pointed out, who reported the use of agricultural machinery by service providers in Catamayo, an area characterized by clayey and rocky soils where disc plows, furrowers, cultivators, and 95 hp tractors predominated for soil preparation, the present study proposes the design and

construction of a smaller-scale furrower, aimed at local contexts with limited resources, low-cost materials, and a focus on accessibility and sustainability. Complementarily, it differs from the study by Méndez Uvidia (2025), who assessed the level of agricultural mechanization in maize cultivation in Santa Elena and highlighted the high cost of machinery and financing difficulties as the main limitations, which force farmers to resort to renting. In contrast, the present work focuses on the design and evaluation of a low-cost furrower. This approach aims to offer an accessible and sustainable alternative that allows producers to reduce dependence on machinery rental while simultaneously strengthening productive autonomy through the use of locally available and easy-to-maintain materials.

Likewise, Walter (2025) validated the technical specifications of the two-wheeled tractor DUCATI DTL 13000 with 13 HP in primary tillage operations for corn. Unlike this study, the present work focuses on the design and evaluation of a low-cost furrower, built with accessible materials and reused components. The goal is not only to measure technical efficiency but also to promote accessibility, easy maintenance, and sustainability in agricultural contexts with limited resources. Montoya Fernández, J. M. et al. (2025) developed a manual agricultural tool using CAD, CAM, and FEA, while the present research focuses on design and simulation with SolidWorks. Meanwhile, Nixon da Rosa et al. (2024) proposed a prototype with a furrow-hoe, showing results in preserving the limited available moisture during planting. Unlike that study, which focused on optimizing performance under water deficit conditions, this study centers on the design and evaluation of a low-cost furrower, prioritizing accessibility, simple maintenance, and the use of local materials.

Thus, the proposal differs from the furrowers developed by Guamangate Vargas, J. M. (2024) since he uses the Pahl and Beitz design model, whereas the present study is based on the Engineering Design Process, integrating design, simulation, and practical construction of the implement adapted to local resources. Unlike the proposal by Naula Alvarracin, J. I. (2024), who evaluated the efficiency of a manual weeding tool through two treatments, the present study focuses on the design and evaluation of a low-cost furrower, with an emphasis on accessibility, easy maintenance, and the use of local materials, aiming to offer a sustainable alternative that enhances the productive autonomy of farmers beyond merely reducing costs.

Taking into account the proposal by Manobanda Mainato, J. P. (2024), who evaluated the effect of wheel slip in soil preparation for maize under conventional and reduced tillage, reducing costs and operation time through the use of drones and GPS, the present study focuses on the design and evaluation of a low-cost furrower, prioritizing accessibility, simple maintenance, and the use of local materials, rather than the optimization of tillage or the reduction of wheel slip. On the other hand, it differs from the proposal by Flores Torres et al. (2021), who designed and optimized the rudder of a furrower using CAD and methodologies such as Composite Central Design and Simulated Tempering to reduce the mass by up to 25% without compromising structural strength, and from Ayub Siddique et al. (2025), who evaluated the effect of motor speed on the traction of an electric tractor during plowing, as the present study focuses on the design and evaluation of a low-cost furrower, prioritizing accessibility, easy maintenance, and the use of local materials. Unlike these works, the focus is not solely on structural optimization or engine performance, but on providing a practical, economical, and sustainable alternative for farmers with limited resources.

V. CONCLUSION

The prototype of the agricultural furrower proved to be functional, accessible, and suitable for local conditions. Its PTR frame, two-stroke engine, and traction mechanism with a motorcycle tire ensured strength, power, and efficiency. The edges and 'small devil' wheels facilitated the formation of uniform furrows and transportation over uneven terrain, while the use of local and recycled materials reduced costs and promoted sustainability. Preliminary tests confirmed the prototype's ability to produce furrows 5 cm wide and 4 cm deep, validating its design and functionality. Overall, it offers a practical, economical, and safe tool that facilitates soil preparation on sloped land.

VI. Future Work

Although the initial results were satisfactory, the need to implement improvements based on more thorough testing, user feedback, and the consideration of aspects such as long-term safety and durability is acknowledged. To consolidate the development of the implement, it will be essential to carry out a more extensive optimization

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