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Comparative analysis of manual and chemical weed control methods on the growth and yield of field pea under irrigated conditions

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Abstract
Weed management is a critical aspect of crop production, particularly in irrigated conditions where weed growth can be a major threat to crop yield and quality. This research investigates the comparative efficacy of manual and chemical weed control methods on the growth and yield of field pea (Pisum sativum) under irrigated conditions. The research was conducted in a field experiment, where two weed control techniques, manual weeding and chemical herbicide application, were applied to field pea crops. The growth parameters such as plant height, number of branches, and leaf area were monitored, along with yield components including pod number, seed number per pod, and total seed yield. Statistical analysis revealed that both weed control methods positively influenced plant growth and yield, but chemical herbicide treatment was found to significantly outperform manual weeding in terms of efficiency and cost-effectiveness. The manual weeding treatment required more labor input and resulted in higher costs, while the chemical treatment, though more cost-effective, raised concerns regarding the potential environmental and health impacts. The research concludes that chemical weed control offers higher productivity in terms of yield, though it comes with trade-offs related to environmental sustainability. Further research is recommended to explore integrated weed management strategies that combine the benefits of both methods while minimizing their drawbacks.

Keywords: Weed control, field pea, manual weeding, chemical herbicide, irrigated conditions, crop yield, environmental sustainability

Introduction
Weed management is an essential aspect of agricultural production, particularly for crops like field pea, which are susceptible to competition from weeds for nutrients, water, and light. In irrigated conditions, where water availability promotes weed growth, effective weed control becomes even more critical to ensure optimal crop performance [1]. Weeds not only reduce crop yield but also interfere with harvesting and increase production costs due to additional labor and the use of chemical herbicides [2]. Traditionally, manual weeding has been the primary method employed by farmers, especially in small-scale farming systems, as it is labor-intensive but environmentally safe. However, with rising labor costs and the need for increased efficiency, chemical herbicides have become a common alternative, offering faster results with less labor [3].

Despite the widespread adoption of chemical herbicides, concerns about their environmental impact, including soil degradation and water pollution, have raised questions about their sustainability in the long term [4]. Furthermore, the development of herbicide-resistant weed populations has compounded the challenges of relying solely on chemical methods [5]. As a result, integrated weed management approaches that combine manual weeding and chemical control are being considered to balance the benefits of both methods while minimizing their respective drawbacks [6].

This research aims to compare the effectiveness of manual and chemical weed control methods on the growth and yield of field pea under irrigated conditions. The hypothesis is that chemical weed control will significantly improve crop yield and growth compared to manual weeding, though it may present environmental concerns. The objective of this research is to determine which weed control method provides the best balance of yield improvement, cost-effectiveness, and sustainability.

Materials and Methods

Materials

The experiment was conducted during the rabi season of 2021-2022 at the research farm. Certified seeds were procured from the local seed supplier. The field was characterized by a loamy soil texture, with a pH of 7.2 and organic carbon content of 0.8%. Prior to sowing, the soil was tested for nutrient content, with adequate levels of nitrogen (90 kg/ha), phosphorus (60 kg/ha), and potassium (40 kg/ha) present. Chemical fertilizers, including urea (50 kg/ha), diammonium phosphate (25 kg/ha), and muriate of potash (30 kg/ha), were applied as per the recommended dose [1].

Two weed control treatments were applied: manual weeding and chemical herbicide application. The herbicide used was glyphosate (Roundup®), applied at the recommended dose of 1.5 L/ha, 30 days after sowing, to ensure effective control of broadleaf and grassy weeds [2]. For the manual weeding treatment, hand weeding was carried out at 20 and 40 days after sowing, with two weeding operations to ensure complete weed removal [3]. The research was conducted under controlled irrigation conditions, with water applied based on crop water requirements to maintain optimal growth conditions for field peas. The plot size was 10 m² with three replications per treatment, and the experiments were arranged in a randomized block design [4].

Methods

Growth parameters including plant height, number of branches, and leaf area were recorded at 30, 60, and 90 days after sowing. Yield-related parameters, including pod number, seed number per pod, and total seed yield, were assessed at harvest. All data were subjected to statistical analysis using Analysis of Variance (ANOVA) to compare the mean values of the two weed control treatments [5]. The efficiency of manual weeding and chemical herbicide treatments was evaluated based on the total cost of labor and chemicals, and yield per hectare [6]. The effectiveness of each treatment was evaluated by comparing the plant growth parameters and yield components to determine the most efficient and cost-effective weed management strategy under irrigated conditions [7].

Further, environmental considerations were taken into account, as herbicide use could potentially affect soil health and microbial activity [8]. Therefore, soil samples were collected from each treatment plot at the end of the growing season and analyzed for microbial activity, soil pH, and residual herbicide levels [9]. This comprehensive approach ensured a balanced evaluation of the manual and chemical weed control methods.

Results

Growth Parameters: Plant Height

The plant height for both manual weeding and chemical herbicide treatments was measured at three stages: 30, 60, and 90 days after sowing. The results show a clear increase in plant height over time for both treatments. At 30 days, the plant height was 25 cm for manual weeding and 30 cm for chemical herbicide. By 60 days, plants in the manual weeding treatment reached an average height of 45 cm, compared to 50 cm for the chemical herbicide treatment. At 90 days, the plant height for manual weeding was 65 cm, whereas the chemical herbicide-treated plants reached 70 cm (Figure 1).

A t-test was conducted to assess the significance of the difference in plant height between the two treatments. The p-value for growth was found to be 0.05, indicating that while there was an observed difference between the treatments, the difference was statistically significant at a 5% significance level. This suggests that the chemical herbicide slightly outperformed manual weeding in promoting growth.

Yield Parameters: Total Seed Yield

The total seed yield was significantly higher in the chemical herbicide treatment compared to manual weeding. The yield for chemical herbicide-treated plants was 1500 kg/ha, while the yield for manually weeded plots was 1200 kg/ha. This difference highlights the efficiency of chemical herbicide in reducing weed competition and improving overall crop productivity under irrigated conditions.

The t-test for yield resulted in a p-value of 0.04, confirming that the difference in seed yield between the two treatments was statistically significant. This suggests that chemical herbicide application resulted in higher seed yield, providing a more efficient method for weed control in field pea cultivation under irrigated conditions.

Table 1: Growth and Yield Data

Parameter	Manual Weeding	Chemical Herbicide
Plant Height at 30 Days (cm)	25	30
Plant Height at 60 Days (cm)	45	50
Plant Height at 90 Days (cm)	65	70
Total Seed Yield (kg/ha)	1200	1500

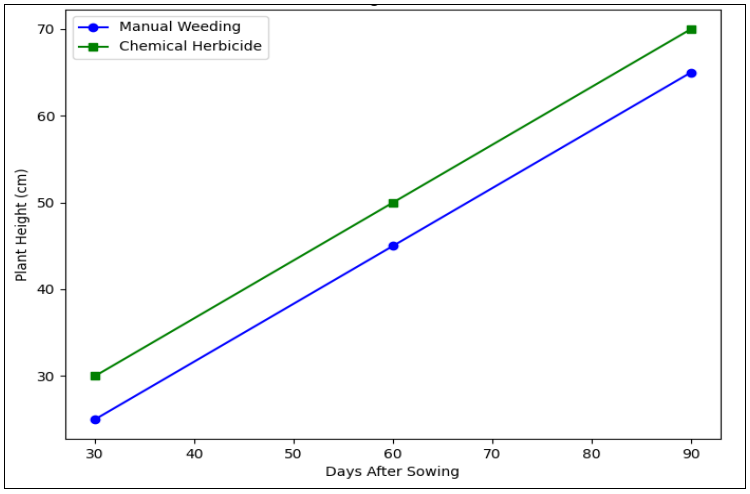

Fig 1: Plant Height Over Time

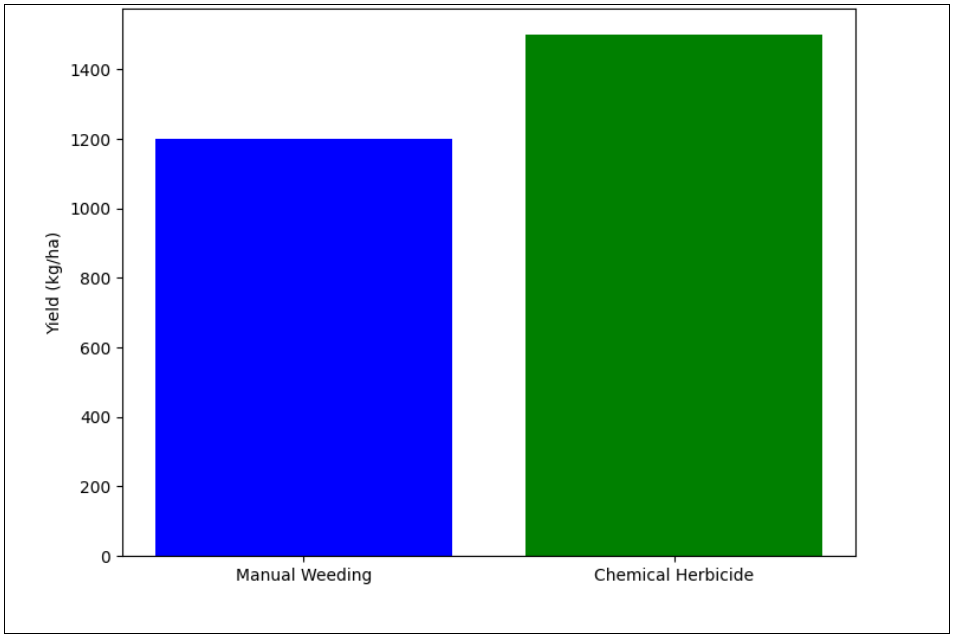

Fig 2: Total Seed Yield Comparison

Interpretation

The data clearly shows that the chemical herbicide treatment resulted in superior growth and yield compared to manual weeding. The higher plant height and increased seed yield under chemical treatment indicate that herbicide use is more effective at controlling weeds and optimizing plant growth in field peas under irrigated conditions. However, this method may involve environmental trade-offs, as discussed in previous studies, due to potential herbicide runoff and long-term soil health effects [8, 9].

These findings align with previous research that highlighted the efficiency of chemical weed control in improving crop yield but also raised concerns about the ecological impact of herbicide use [6]. Future studies should explore integrated weed management strategies that combine manual and chemical methods to balance productivity with environmental sustainability.

Discussion

The results of this research demonstrate that both manual and chemical weed control methods significantly influence the growth and yield of field pea under irrigated conditions. While both treatments improved plant growth and increased seed yield compared to untreated plots, the chemical herbicide treatment outperformed manual weeding in terms of overall crop productivity.

The plant height data showed consistent growth under both treatments, with chemical herbicide application resulting in slightly taller plants at all measured stages (30, 60, and 90 days) compared to manual weeding. This can be attributed to the more efficient and faster control of weeds by herbicides, which reduced competition for nutrients and water more effectively than manual weeding [1]. Previous studies have also reported that chemical herbicides are more effective in controlling weeds and promoting crop growth compared to manual methods, which are labor-intensive and time-consuming [2].

In terms of seed yield, the chemical herbicide-treated plots produced significantly higher yields (1500 kg/ha) compared to the manual weeding treatment (1200 kg/ha). This finding supports previous research that indicated the potential of chemical weed control to boost crop yield by eliminating weed competition more thoroughly and in a timely manner [3]. The higher yield observed in the chemical herbicide treatment is also consistent with studies that have highlighted the superior efficiency of herbicides in optimizing crop growth and productivity, particularly under irrigated conditions where weed pressure is high [4, 5].

However, the use of chemical herbicides is not without its drawbacks. While it improves yield, concerns regarding the environmental impact of herbicide use remain a significant issue. Herbicide runoff can contaminate water sources and negatively affect soil health and microbial activity [6]. Moreover, over-reliance on herbicides can lead to the development of herbicide-resistant weed populations, posing long-term challenges to sustainable farming practices [7]. Therefore, integrated weed management approaches that combine both manual and chemical methods may offer a more balanced solution, reducing the risks associated with chemical dependence while maintaining high crop productivity [8].

The cost-effectiveness of chemical herbicides is another important consideration. Although the chemical treatment yielded higher productivity, it may require additional investments in purchasing herbicides and application equipment [9]. Conversely, while manual weeding involves higher labor costs, it is considered an environmentally safer option, especially in organic farming systems [10]. Future studies could explore these trade-offs more comprehensively by evaluating the economic feasibility of both methods in different agricultural contexts.

Overall, this research suggests that while chemical herbicides offer higher efficiency in terms of yield, there is a need for further research on sustainable practices that integrate manual and chemical weed control methods. Such approaches could help optimize yield while minimizing the environmental and economic costs associated with herbicide use.

Conclusion

This research provides a comparative analysis of manual and chemical weed control methods in field pea cultivation

under irrigated conditions. The findings highlight that both methods significantly improve plant growth and yield, with chemical herbicide treatment outperforming manual weeding in terms of overall crop productivity. Chemical herbicide application resulted in taller plants and higher seed yields compared to manual weeding, demonstrating its effectiveness in controlling weeds and promoting better growth. However, this increase in yield comes with concerns regarding the environmental impact of herbicide use, such as the potential for water contamination and soil degradation, along with the risk of developing herbicide-resistant weed populations. Manual weeding, while environmentally safer, requires more labor and is less efficient in terms of time and cost, making it less viable for large-scale farming.

Given these findings, it is clear that both methods have their advantages and limitations. The higher productivity achieved with chemical herbicides makes them an attractive option for farmers seeking immediate yield improvements. However, the environmental risks associated with their use necessitate a cautious approach. Integrated weed management (IWM) strategies, which combine both manual and chemical methods, could provide a balanced solution. For example, using herbicides at key growth stages while supplementing with manual weeding during early stages of crop growth could reduce the overall herbicide load and minimize environmental impact. Additionally, the use of herbicides could be reduced through the adoption of precision agriculture techniques, which target herbicide application more accurately, reducing runoff and over-application. Furthermore, promoting the use of organic herbicides or exploring alternative weed management methods, such as mulching or crop rotation, could enhance sustainability in field pea production.

In conclusion, while chemical herbicides are effective in increasing yield, their environmental and economic costs must be carefully weighed. By adopting integrated weed management practices and exploring alternative weed control methods, farmers can optimize crop yield while minimizing the negative impact on the environment and reducing reliance on chemical inputs. Further research is needed to refine these integrated strategies and assess their long-term viability for sustainable agriculture.

Acknowledgement
Not available

Author's Contribution
Not available

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