

RESEARCH ARTICLE

RESPONSE OF PRUNING MANAGEMENT ON GRAIN YIELD, BIOMASS PRODUCTION AND WATER USE EFFICIENCY OF WHEAT CROP IN SEMI-ARID REGION OF PUNJAB

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ABSTRACT

During the year 2023-24, an in-depth field experiment was conducted at the Agricultural Mechanization Research Institute (AMRI) in Multan, Punjab province, to explore comprehensively the effect of pruning level on grain yield, Biomass Production, Water use Efficiency and other characteristics contributing to yield of wheat crop. This experiment involved a careful comparison of the performance of various wheat pruning managements, ranging from light pruning, no pruning, moderate, heavy and very heavy pruning. The results revealed significant data: a maximum plant height reaching 96.42 cm, an impressive number of effective tillers per meter of row, estimated at 95.75, a remarkable spike length of 8.89 cm, as well as an exceptional grain yield of 3456.76 kg/ha. Additionally, straw yield was recorded at a high level of 5114.23 kg/ha. Crucially, water use efficiency was calculated at 0.43 kg/cm³, demonstrating optimized management of this essential resource. Among the different pruning managements tested, ultra-heavy pruning, with an 80% reduction in vegetation, emerged as the most favourable treatment, generating significantly better results than those obtained with light or moderate pruning. These results provide appreciated insights for agronomic practices and increasing production in the wheat sector, including importance of appropriate pruning management for maximum production.

KEYWORDS

Pruning, Wheat crop, Water Use Efficiency, Spike Length, Grain yield, Tillers

1. INTRODUCTION

Pakistan, among the countries most vulnerable to future climate change, already faces significant challenges in water sustainability and food security. Wheat production in Pakistan's Punjab region is of crucial importance to national food security. With about 80% of farmers growing wheat on nearly 9 million hectares, or about 40% of the country's cultivated land, wheat is a vital crop for the country's agricultural economy. As the world's population continues to grow exponentially, demand for food also increases, highlighting the importance of increasing agricultural productivity to meet these growing needs (Islam et al., 2023; Janjua et al., 2014; Usman et al., 2023). Farmers around the world face this challenge, but in many developing countries they are constrained by their limited experience and knowledge, highlighting the need to adopt advanced agricultural technologies such as usage of mechanical pruner to improve productivity. Therefore, it is dire need to increase grain yield, water use efficiency and biomass production by using different pruning levels (Hu et al., 2019; Hu ChangLu et al., 2019; Hussain et al., 2020; Waqas et al., 2021).

Pruning can potentially increase plant growth, straw yield, water use efficiency and grain yield of wheat crop. Pruning practices were used to

manage tree size and optimize the yield of fruits such as apples and citrus (Anthofer et al., 1998; Dreccer et al., 2009; Fereres and Soriano, 2007; Hu et al., 2019; Khan et al., 1998; Ma ShouChen et al., 2008). Biomass production responds differently to pruning depending on the vegetation species and growing conditions (Ashraf and Ashraf, 2014; Zhang et al., 2018). For example, showed that pruning enhanced no. of tillers and numbers of ears, influences the contribution of post-flowering photosynthesis, and promotes the mobilization of carbon reserves to the grains, resulting in increased crop yield (Dhillon and Thakur, 2014; Shi et al., 1999; You et al., 2020). A group researcher showed that pruning could increase yield of rice grain under dry growing conditions, but not under irrigation conditions (Fang et al., 2010; Kisman et al., 2021; Wang et al., 2024).

Experimental studies have also shown varied results. As an illustration, recent study showed that vertical pruning decreased the number of kernels of each ear, kernel mass, and kernel yield of corn (Baitelle et al., 2020; Fang et al., 2010; Pineda et al., 2020; Wang et al., 2024). However, the experiments was conducted showed that wheat pruning can rise ear weight of wheat crop and yield under drought conditions, but in the case of abundant water, it could not increase (Wang et al., 2024).

In the field, mostly researches have confirmed the paybacks of pruning

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practices and its effects on overall grain production and water use efficiency. As an illustration, observed an increase in biomass production, harvest index, grain yield, as well as water use efficiency under traditional growing environments (Baitelle et al., 2020; Fang et al., 2010; Pineda et al., 2020). Additionally, some research found a good interaction between pruning and application of manure, which increased grain production of wheat crop (Fang et al., 2010; Pineda et al., 2020).

The beneficial effect of pruning on grain yield is often associated with increasing efficient tillers, increasing grain number and grain weight, and improving water utilization. Pruning can transfer water use to later stages of growth, improve the rate of photosynthesis of leaves, promote the dry matter accumulation after flowering and its mobilization to grains, which promotes an increase in weight seeds (Fang et al., 2010; Hendriks et al., 2016; Ma et al., 2018; Pineda et al., 2020).

Although, the much-spoken positive impact and observed benefits, there was still uncertainties the to understand the impact of the on the crop production and other traits related to quality and quantity. Previously, most of the studies solely based on the laboratory experiment related to intensities of the pruning height on the crop yield which can have varying results depending on agronomic practices and other factors such as environments of semi-arid field conditions. Following study highlights the impact of pruning height on grain production and production-traits, concentrating on the production, water use efficiency and traits related to crop biomass. From these experimental approaches, this study was aimed to recognize the mechanisms underlying these things and identify effective management approaches to enhance the grain production in the semi-arid environmental conditions of the Southern Punjab.

2. MATERIALS AND METHODS

2.1 Wheat Crop Pruner

Wheat pruning machines was designed and fabricated at the Agriculture Mechanization Research Institute (AMRI), Multan, Punjab, Pakistan. This pruner was especially designed to efficiently and effectively trim the excess foliage and extra parts the of wheat crop in the complete growth cycle of the wheat crop. This machine was applied for lone pruning the unwanted parts of the wheat crop or prune the crop at the specific heights for better air circulation, light penetration, even nutrient distribution and better pest and weeds management. Key features this pruner was farmer friendly usage, such easily attachment and detachment from the tractor, different pruning height adjustment, multi-blade configuration for different wheat varieties and soil conditions. This wheat pruner also equipped with sophisticated safety devices which protect the machine operator and ensure the better working under different field conditions. The prime purpose of the improve the overall crop health and better grain yield by promoting the maximum tillers, reducing the extra nutrients consumption, better light penetration, air circulations and minimizing the risk of the crop diseases and pest attack.

2.2 Study Area

The study was conducted at the Agricultural Mechanization Research Institute (AMRI), Multan, Punjab, Pakistan, which has been steering various agricultural improvement researches in semi-arid environments for 45 years. Five experimental plots were established at the AMRI Farm located at coordinates (30°9'29.27" N, 71°26'52.91"E) for the wheat crop period of November 2023 to April 2024. The size of each plot for the different treatments was selected at 10 m x 10 m. Winter wheat seeds (*Triticum aestivum* L.) were planted in each plot. The experiment comprised five main plot treatments: 0% pruning (base plot), 20% pruning, 40% pruning, 60% pruning, and 80% (Table 1).

The different treatments in the Table 1 refer to different levels of pruning compared to the main plot which has no pruning. The main plot is a reference point that serves as a basis for comparison. Treatments include a wide range of pruning levels, starting from "Light Pruning" at 20%, which means only a small proportion of plants are pruned, to "Extreme Heavy Pruning" at 80%, which means a significant proportion of plant is trimmed. These pruning levels directly affect the plant growth and yield contributing characteristics of the wheat crop. "Light pruning" can have a moderate impact, while "extremely heavy pruning" can result in significantly altered growth and yield characteristics. Pruning affects the structure and growth of plants, which can also change the quantity and quality of the harvest. Studying these different treatments provides valuable insight into how pruning affects wheat crop performance and allows optimal pruning strategies to be developed for maximum harvest. This research endeavor aligns with AMRI's longstanding commitment to agricultural innovation and seeks to investigate the effects of varying

degrees of pruning on winter wheat cultivation in the region. By systematically examining different levels of pruning, the study aims to provide valuable insights into optimizing wheat production under semi-arid conditions.

Table 1: Effect of pruning intensities on yield, yield contributing parameters, water use efficiency and biomass production

Treatments	Pruning Managements
T0	Main Plot (Zero pruning)
T1	Light Pruning (20%)
T2	Moderately Light Pruning (40 %)
T3	Heavy Pruning (60%)
T4	Ultra Heavy Pruning (80%)

2.3 Experimental Treatments

The parameters selected for the different experimental treatments were as follows:

2.3.1 Plant Height (cm)

plant height was calculated in centimeters by using given equation.

$$Hpc = \frac{Hpc1 + Hpc2 + Hpc3 + Hpc4 \dots \dots Hpc10}{10}$$

Where,

Hpc=Plant Height of crop from soil level to base of fully opened leaf (cm)

Hpc1, Hpc2, Hpc3, Hpc4, Hpc5, Hpc6, Hpc7, Hpc8, Hpc9, Hpc10= Random plant Height of crop

2.3.2 Number of Effective Tillers per meter of Row Length

The tillers producing ears are called efficient tillers. At Harvest stage, Five Rows were marked in one-meter length for each plot. After that, the total number of effective tillers was counted. Number of effective tillers was calculated by using given equation:

$$Te = \frac{Te1 + Te2 + Te3 + Te4 + Te5}{5}$$

Where,

Te= Effective Tillers (No.)

Te1, Te2, Te3, Te4, Te5= Random Effective Tillers

2.3.3 Ear Length (cm)

Ear length was measured by using given equation.

$$Le = \frac{Le1 + Le2 + Le3 + \dots \dots Le10}{10}$$

Where,

Le=Ear Length from base to tip of ear (cm)

Le1, Le2, ..., Le10= Random ear length (cm)

2.3.4 Grain Yield (Kg/ha)

The net grain yield of each plot was estimated by using given equation:

$$Yg = \frac{Wg}{An} * 10,000$$

Where,

Yg= Grain yield((Kg/ha)

Wg= weighing the grains after proper winnowing and cleaning (Kg)

An= Net area (Ha)

2.3.5 Straw Yield (Kg/ha)

The straw yield was calculated by using given equation:

Where,

Y_s = Straw Yield((Kg/ha)

W_{cb} = weight crop bundle of each plot (Kg)

Y_g =Grain Yield each plot (Kg)

A_n =Net Area

2.3.6 Water Use Efficiency (Kg/Cm³)

Water application in each plot was the same. It was observed that grain yield increased with increasing water use efficiency (WUE) respectively.

Application of water in one hectare= 8000 cm³/ha

Water use efficiency was determined by using the below equation:

$$Wue = \frac{Yg}{Va}$$

Were,

Wue =Water use efficiency((Kg/Cm³)

Yg = Grain yield (Kg/Ha)

Va =Total water applied in each plot(cm³/ha)

3. RESULTS

In the results section, among the different treatments of the main plots, all parameters contributing to yield, such as grain yield, straw yield and biomass production, increased with effective pruning, as shown in Figure 1 to 6. For example, the maximum plant height (96.42 cm) was observed under ultra-intensive pruning, as shown in Figure 1. Similarly, Figure 2 shows that the number of effective tillers per meter of row length was maximum with 96. Ear length was maximum at 8.89 cm under ultra-intensive pruning as shown in Figure 3. Grain yields (3456.76 kg /ha) and straw (5114.23 kg/ha) were also maximum under ultra-intensive pruning, as shown in Figure 4 and 5. Furthermore, Figure 6 shows that the water use efficiency was recorded at the maximum (0.43 kg/cm³) under ultra-intensive pruning (80%) and significantly higher than the other treatments (basic treatment, light or moderate pruning).

However, among the different pruning intensity treatments, similar results are observed. For example, maximum plant height (94.6 cm), number of effective tillers per meter of row length (90), ear length (8.54 cm), grain yield (2875, 34 kg/ha) and straw (4465.45 kg/ha), as well as water use efficiency (0.36 kg/cm³), were recorded under intensive pruning (60%)., as shown in Figures 1 to 5. Comparable results were observed under light to moderate pruning (40%), with a plant height of 90.2 cm, number of effective tillers per meter of row length of 88, an ear length of 7.98 cm, a grain yield of 2588.45 kg/ha and straw yield of 4234.34 kg/ha, as well as a water use efficiency of 0.32 kg/cm³, as shown in Figures 1 to 5. Similar trends were observed under light size (20%), with slightly lower values, as shown in Figures 1 to 5.

Finally, under a zero-size treatment (0%), the results showed the lowest yields, with a minimum plant height (81.9 cm), a number of effective tillers per meter of row distance of 80, an ear length of 6.74 cm, a grain yield of 2097.98 kg/ha and straw yield of 3678.78 kg/ha, as well as a water use efficiency of 0.26 kg/cm³, as shown in Figures 1 to 5.

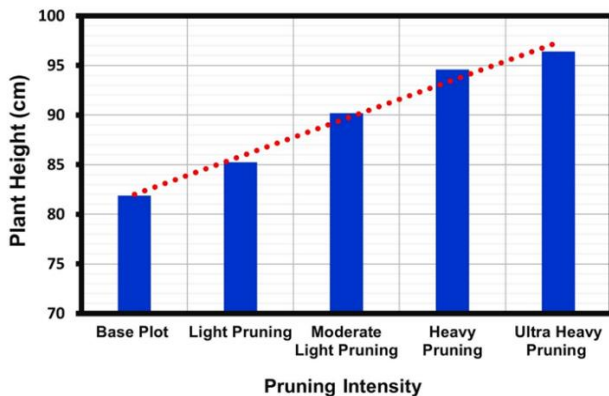


Figure 1: Response of Different Pruning Patterns on Plant Height at harvest (cm)

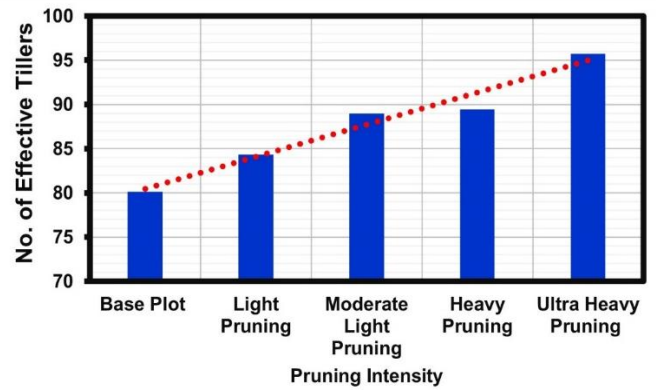


Figure 2: Response of Different Pruning Patterns on No. of effective tillers

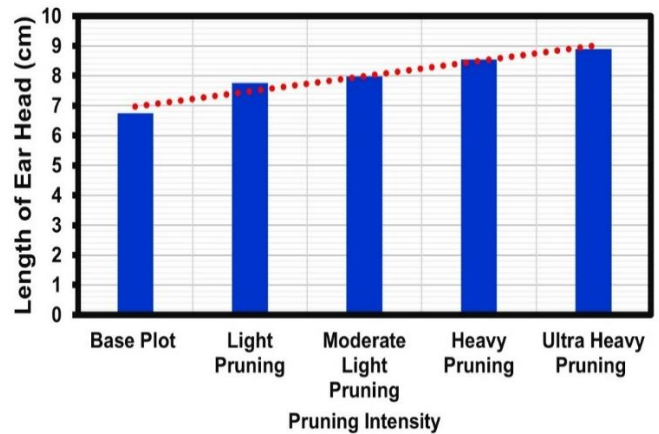


Figure 3: Response of Different Pruning Patterns on Length of Ear Head (cm)

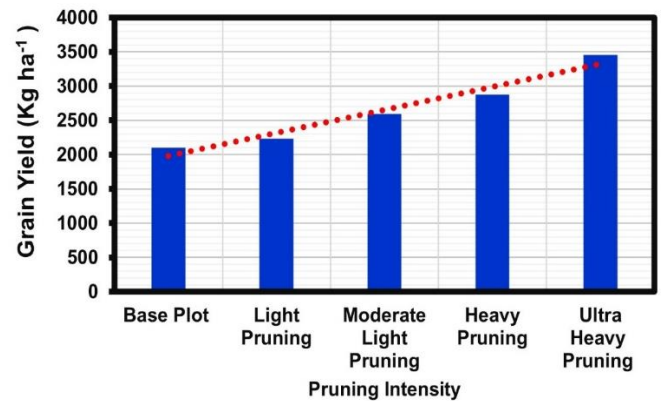


Figure 4: Response of Different Pruning Patterns on Grain Yield (kg ha⁻¹)

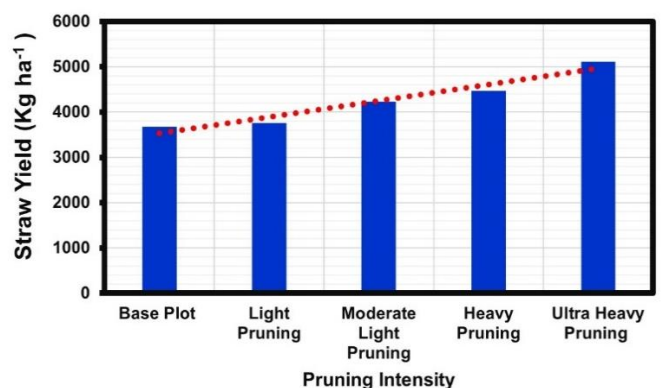


Figure 5: Response of Different Pruning Patterns on Straw Yield (kg ha⁻¹)

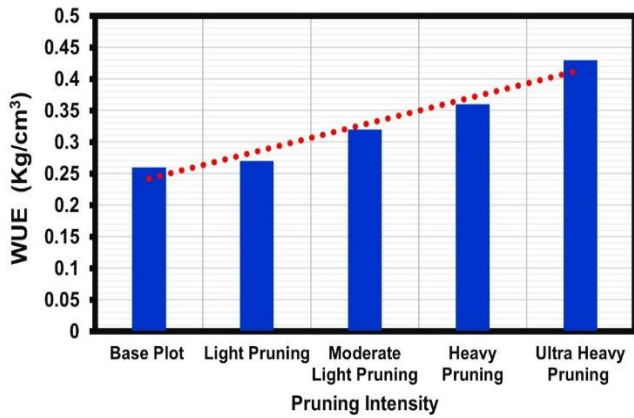


Figure 6: Response of Different Pruning Patterns on Water Use Efficiency (Kg/cm³)

4. DISCUSSION

The current research aimed to examine the response of different pruning levels on wheat production, biomass production and yield contributing traits, alongside water use efficiency. This study compared pruning intensity with grain yield (kg/ha), other yield contributing traits, water use efficiency and straw yield (kg/ha) at different pruning heights. Yield and factors contributing to yield and water use efficiency were higher when the pruning heights was 80%. The most likely reason is that pruning promotes uniform ripening of wheat grains by ensuring that all parts of the plant receive sufficient sunlight and nutrients. It promotes good sun penetration, improves air circulation and helps fight pests and diseases.

Many previous researches obtained similar findings, however, yield and factors contributing to yield increased as pruning intensity promote higher number of tillers production with uniform tillers height which further improve uniform sun light exposure (Uniform photosynthesis). Heavy and moderate pruning treatments produced comparable or even significantly higher yields than no-pruning and light treatments (Bertomeu and Roshetko, 2007; Bertomeu et al., 2011; Dai et al., 2017; Hu et al., 2015; Kisman et al., 2021; Ma et al., 2010; Siriri et al., 2010). Recent study observed that pruning favored intercrop production in trees and crops compared to unpruned trees in a comparable experiment (Bayala, 2002; Kisman et al., 2021; Siriri et al., 2010). In some study, researchers found that ultra-high pruning significantly increased the growth and yield contributing traits of better agriculture productivity compared to different levels of pruning and treatment without pruning (Akume et al., 2015; Dai et al., 2017; Lauri et al., 2018; Newaj et al., 2012; Singh et al., 2020).

This study fits perfectly in line with various previous research which has not only been carried out exclusively for wheat production, but also for other agricultural production and the biomass of beans, shrubs, vegetables, fruits and trees (Agus et al., 1998; Budiarto et al., 2019; Castillo-Ruiz et al., 2017; Dias et al., 2020; Fang et al., 2010; Gatti et al., 2011; Hu et al., 2019; Mehta et al., 2012; Menzel and Le Lagadec, 2017; Schupp et al., 1992; van Oirschot et al., 2000; Yang et al., 2010).

Pruning managements can rise grain yield of crop and water use efficiency under the semi-arid region prevailing in our treatments. The machines allowing this practice to be implemented on a large scale currently give results consistent with some study, but it is necessary to promote the pruning of wheat crops in developing countries to improve the production of wheat, which is a food crop of this region (Fang et al., 2010; Hu et al., 2019; Lü et al., 2009).

5. CONCLUSION

Research results show the encouraging effects of pruning on yield and yield-promoting properties, as well as water-use-efficiency (WUE). Outcomes show that higher levels of pruning are associated with higher yields, with ultra-intensive pruning providing best results in terms of grain yield, straw yield, and WUE. These findings suggest that pruning plays an important role in optimizing wheat production, especially in semi-arid environments. Moreover, the study results also signify the importance of the use of large-scale wheat pruners to improve wheat crop production in developing countries. This research provides a deeper look for better understanding the advantages of mechanized farming especially in the context of the grain crop pruning. This kind of mechanization not only enhance the food and water security of the developing country but also leads towards the agriculture sustainability.

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