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Review

Cotton Canopy Management: A Review of Topping and Pruning Techniques to Enhance Yield and Quality

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Abstract

Cotton is a significant cash crop globally, so optimizing the yield and quality of fibre is crucial for its sustainability. Managing canopy architecture and planting density in cotton is important because it affects light interception, humidity and temperature that are crucial for boll development and yield. Improper management adversely affects boll numbers, weight and boll setting rates. The present review highlights canopy management and planting density as the critical factors in enhancing productivity and optimizing the microenvironment in the cotton canopy. High density planting maximizes light interception and lint yield by increasing bolls per unit area. However, excessive density can lead to reduced yield due to increased competition within plants. Furthermore, by managing canopy structure with pruning, chemical topping and manual topping, plant canopy can maintain a beneficial microclimate that is essential for higher yield. It also explains the importance of canopy microclimate, including air temperature, relative humidity and light interception in the development of bolls and fibre quality. By optimizing canopy architecture and planting density farmers can achieve higher yields and maintain fibre quality hence contributing to the global significance of cotton as a cash crop.

Keywords: agronomic practices; fibre quality; light interception; microclimate; canopy architecture

1. Introduction

Cotton holds significant importance, contributing to many aspects of economies around the world. It is essential for global textiles and numerous industrial applications. Global production of cotton is projected to stand at 28.1 million metric tons by 2032, at a growth rate of 1.81% per annum and land expansion will contribute by 1.4% and 0.4% per annum, respectively (OECD-FAO, 2023). Cotton farming supports livelihood of 100 million farmers and almost 350 million people around the globe including ginning, labor, storage and baling (Fairtrade Foundation, 2022). Cotton is one of the main sources of income for millions of farmers around the world (Khan et al., 2020). In the textile industry, cotton is one of the most important raw materials used in production. The most used fabrics are the ones derived from cotton and are used in all fashion industries accounting for 70% of the apparel-making industries (Khanzada et al., 2020). This shows a strong demand for cotton and its by-products, hence promoting economic activities ranging from the cultivation by farmers, manufacturers and sellers. Cotton farming community faces significant challenges including rising production cost, market price volatility, declining yield and climate change which hinder their ability

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to maintain sustainable operations and provide fair wages (Li et al., 2021). These problems can be solved by applying optimal management practices in managing the crops to increase light penetration, modify microclimate and increase boll retention, thus increasing productivity and sustainable farming of cotton (Nadiruzzaman et al., 2021; Chabi Simin Najib et al., 2022). Some of the important management practices that can be implemented by the farmers include canopy management and the planting density in a particular agro-ecological condition.

Cotton shows different leaf types primarily as normal, okra and sub okra leaves. Normal leaves look board with multiple lobes gives more area for photosynthesis. Okra is lobed and narrower type which enhances light penetration also reduces pest infestation and sub okra leaves have reduced leaf area enhancing light distribution within the plant (Andres et al., 2016). Leaf area index was decrease in sub okra leaves by 11.24 to 22.84% and yield increased up to 5.72% as compared to normal leaves hence these morphological differences of leaves provide visual distinction as well as enhance cotton production efficiency (Jiang et al., 2024). These morphological differences influence yield hence playing important role in canopy management strategies. The key drivers in the demand for cotton and other eco-friendly fibres include the cost of production, accessibility of raw materials, technology and sustainable initiatives in the textile industry that involve the use of fibres such as organic cotton, hemp and jute among others. The present study emphasizes optimal planting density and canopy architecture for quality cotton production considering the above scenario. Recent developments and improvements in cotton agronomic practices and their impact on cotton quality and yield are thoroughly discussed in the present review.

2. Canopy Management Techniques

Canopy management is the major determinants of cotton yield and fibre quality. Canopy architecture and spatial distribution of cotton plants greatly influence light penetration, microclimate and resource use efficiency (Chapepa et al., 2020; Zhang et al., 2021). Radiation use efficiency (RUE) is an important agronomical factor that is affected by canopy management and planting density in the case of cotton cultivation (Ko et al., 2009). The size, shape and orientation of the shoot affect the rate of light interception in the cotton canopy (Bhattarai and Midmore, 2009). The response of cotton plants to different management practices allows the researchers to make conclusions about the efficiency of the specific interventions in increasing the yield of cotton and the quality of the fibres produced (Jiang et al., 2018). Different canopy management techniques such as chemical topping, pruning and manual topping as shown in Figure 1.

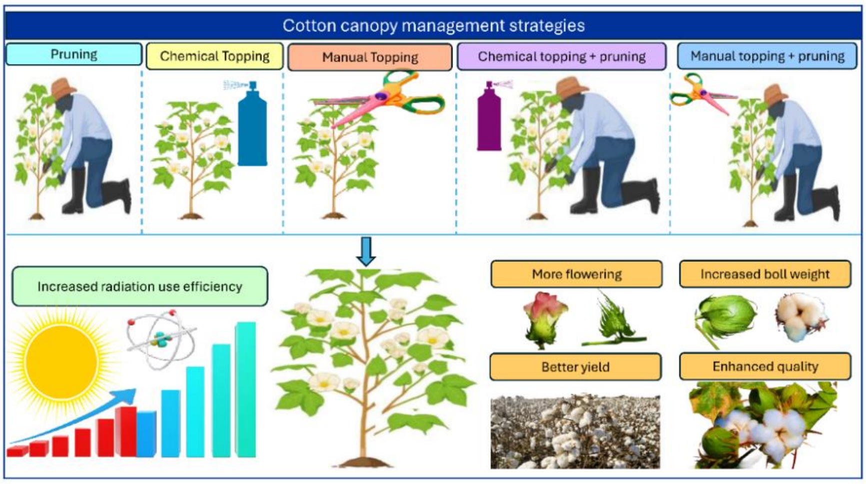

Figure 1. Different canopy management techniques.

2.1. Pruning

Pruning of cotton is a management practice involving manually removing vegetative branches and unproductive plant parts to improve canopy architecture (Dai et al., 2014). By increasing light penetration, it helps to redistribute nutrients to the fruiting part. It is useful to prune the side branches of the plant to ensure compact canopy architecture and enhance plant height. It improves light penetration and increases air exchange, allowing crops to utilize light resources more efficiently. Pruning is a process of redistribution of the nutrients from the vegetative parts to the fruiting structures, thus enhancing the yield and fibre quality (Wang et al., 2021). Pruning is normally done 40-45 days after sowing when the plants have grown up to 40-45 centimeters in height (Dai et al., 2014; Ramkrushna G.I., 2023). Monopodial branches are pruned manually using secateurs, pruning shears, hand pruners, or knives depending on the size of the branch to be pruned. Therefore, pruning is one of the canopy management practices in cotton production that is used to control the outward growth of plants, improve light interception and distribution as well as optimize nutrients given to the fruiting structures (Nie et al., 2023). Thus, it was found that the use of pruning as a management practice at the right growth stage and in conjunction with other practices can significantly increase the cotton yield.

2.2. Chemical Topping

Mepiquat chloride is a plant growth regulator that is applied to control the height of the plant and provide a more compact structure of the canopy in cotton plants (Tung et al., 2020). It is applied at the rate of 1.0 ml/liter of water for the first spray and 1.2 ml/liter of water for the second and third sprays. The use of Mepiquat chloride decreases the plant height through the inhibition of cell division and promoting the cell division hence a dense canopy structure (Shekar, 2011). This leads to increased light penetration and nutrient distribution in the canopy layer leading to higher rates of photosynthesis and plant productivity (Liang et al., 2020). PGR's such as Mepiquat chloride are used 2-3 times within a crop season with the first spray 40-45 days after sowing, when the plants are approximately 40-45 cm tall. Subsequent sprays are based on the length of the top five internodes; a spray is required when the average of these is more than 4 cm. Koudahe et al., (2021) also pointed out that MC is helpful in enhancing the canopy structure and boll retention. It also has the potential to increase the fibre quality through increasing the fibre length, strength and micronaire. Compared to other PGRs, Mepiquat chloride is more effective in reducing the height of plants and increasing the compactness of the canopy structure (Tung et al., 2020). The optimal time to apply Mepiquat chloride is at the early stages of plant growth especially at 40-45 days after sowing. When PGRs are used at the right growth stages together with the right decision criteria, farmers can optimize a desirable canopy architecture that will enhance light penetration, nutrient distribution and subsequently high yields of cotton with improved fibre quality (Ramkrushna G. I., 2023).

2.3. Manual Topping

Manual topping is one of the canopy management practices that is traditional in China (Wu et al., 2023) and has been used in cotton production whereby the terminal growing point of the cotton plant is removed to limit the growth of the plant height and promote lateral growth of the branches (Awan et al., 2022). Manual topping helps minimize the vegetative growth and enhances the yield and early production of cotton. It also reduces the use of insecticides, sucking insects and improves cotton yield (Brévault et al., 2024). Manual topping also involves the use of secateurs, pruning shears, hand pruners and a knife blade to remove the terminal bud. The crop height is managed to a height of about 90-100 cm through de-topping (Renou et al., 2011). Topping is done manually and this is labor-intensive and time-consuming hence making it a significant impediment to the full mechanization of cotton production. There is also a problem with the quality of the manual topping since skilled labor may be scarce and may also not be able to meet the production requirements. Mechanical topping has not been implemented frequently because it negatively impacts the cotton plants and their bolls (Renou et al., 2011; Tian et al., 2022). Manual topping is one of the promising and efficient methods of canopy management in cotton cultivation that is used to regulate vegetative growth, optimize the structure of the canopy and, thus, increase yield and fibre quality. Though it has been a labor-consuming method and has not been easily mechanized, it has paved the way for other techniques such as chemical topping using plant growth regulators. Wang et al. (2014) suggested that delaying the timing of shoot topping has been found to decrease fibre quality affecting the physiological age and development of individual cotton bolls.

2.4. Combing Chemical Topping with Pruning

To entrap more radiation canopy was reduced by observing chemical topping and removing side branches of cotton (Maiti et al., 2020). The major aim of this technique is to have a dense canopy structure to capture maximum light and nutrient distribution for fruit development. The combined strategy of pruning and chemical topping is a way to reduce boll rot, improve boll retention and increase green pigment in leaves as compared to control (Thind and Mahal, 2021). This consolidated approach tends to improve fibre quality and high cotton seed yields by manipulating the canopy cover and resource distribution within plant parts (Yang et al., 2008). For the chemical topping, when the crop is in the field apply the chemical 2-3 times, first application is done after sowing when the plant attains a height of 40-45 cm within 40 days. When the length of the top internodes exceed 4cm plant is ready for the next plant growth regulator spray. Manual pruning of vegetative parts is accomplished simultaneously or soon after the application of chemicals to develop a strong canopy further. The crop height is stopped by de-topping either chemically by using PGRs or manually at 90-100 cm (Yang et al., 2008).

The efficiency of this integrated management may vary and depends on many factors including nutrient availability, moisture content of the soil and the plant ecology (Bargaz et al., 2018). Thus, controlling plant growth and applying PGRs at the right time can help to increase the yield of cotton and improve the architecture of the canopy. The combined application of chemical topping and pruning is anchored on resource availability and other growth factors that define cotton cultivation (Eagan and Dhandayuthapani, 2018). Indeed, this strategy of chemical topping using PGRs with manual pruning is a significant technique for the achievement of the desired yield of cotton and a crucial method of preserving the dense canopy. Combined treatment can effectively reduce branch elongation to increasing yield chemical should be sprayed after 5 days of pruning which can enhance yield up to 15.28% (Cui et al., 2020). Different methods can be tailored to achieve targeted outcomes in cotton production system. Table 1 shows the application periods and field application methods and how it effects cotton performance. Among all Mepiquat chloride applied during flowering and squaring stage enhanced yield while limiting plant height making it leading choice for cotton improving.

Table 1. Comparison of PGR active ingredients and effects on cotton.

PGR (Plant Growth Regulator)	Active Ingredient	Application Period	Effects on cotton	Reference
Miantaijin (MTJ)	Mepiquat chloride + DA-6	Foliar applied during flowering and squaring	Recover efficiency of Potassium uptake	(Yang et al., 2014)
Mepiquat Chloride (MC)	Mepiquat chloride	Foliar applied during flowering and squaring periods	Increase lint yield and agronomic efficiency of K	(Yang et al., 2014)

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Gibberellic Acid (GA3)	Gibberellic acid	Foliar spray at squaring stage or by soaking seed	Yield enhancement up to 7.5% and also enhance carbohydrate content.	(Fang et al., 2019)
N6 benzyadenine (6-BA)	N6-benzyadenine	Foliar spray at squaring stage or by soaking seed	Increase square numbers, boll retention especially with seed soaking	(Fang et al., 2019)
Cytokinin's	zeatin	Apply at flowering and boll formation stage at 200 ppm rate	Reduce CLCuV incidence and enhance fibre fineness	(Ahmed et al., 2015)

2.5. Combing Manual Topping with Pruning

Manual topping promotes a compact canopy by removing the top growing points and helps control plant height. When vegetative parts are manually pruned, it increases light penetration and photosynthates assimilation in plants that store the nutrients in the fruiting structure of cotton (Sehrawat Dhankhar and Pannu, 2014). When combined the manual topping with pruning an increase observed in boll number due to a reduction in abscised fruiting site (Yang et al., 2008). Manual topping and pruning is another approach in cotton cultivation and are helpful for optimizing yield (Dai et al., 2014). Manual topping and pruning have increased the greenness of the leaf which is essential to enhance photosynthesis in the leaf for better growth and development of fruit. For manual pruning usually one-leaf secateurs is used (Yang et al., 2008; Renou et al., 2011). Manual pruning is either done with manual topping or shortly after topping operation to further process the canopy structure. Both these practices are laborious and demand highly skillful workers for proper implementation and to minimize the risk of damaging cotton crops. Integrated canopy management strategies effectively optimized light interception and resource distribution as shown in Figure 2.

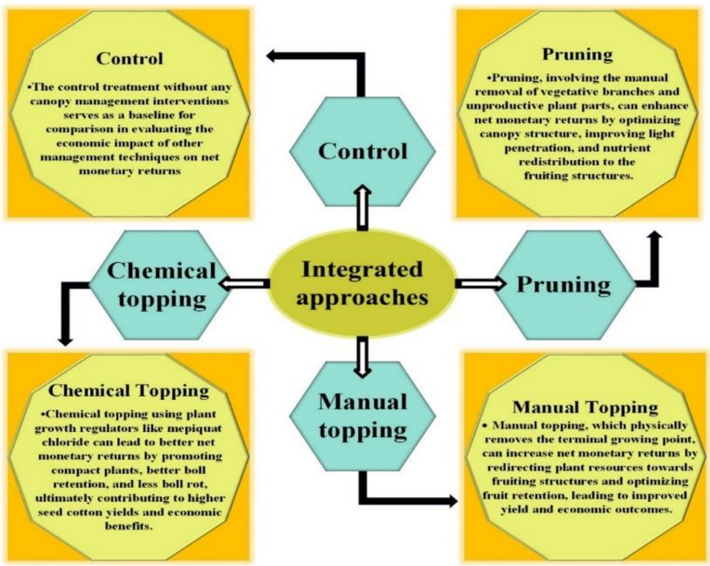

Figure 2. Integrated approaches for canopy management techniques are mentioned; like manual topping, chemical topping and pruning show difference through control.

The handling of manual practices may vary due to the large-scale production of cotton and may lead to inconsistency in manual operation and leads to damage to the cotton plant and bolls. Many factors are contributing to this manual strategy of increasing cotton production such as plant overall ecology, soil humidity, nutrient availability and translocation (Lopez Llandres et al., 2017). Though this is traditional management technique but it's still very helpful in maintaining crop equal growth and development by maintaining canopy architecture for proper light penetration to increase overall cotton production.

3. Impact of Canopy Management on Cotton Radiation Use Efficiency, Yield and Quality

By altering the canopy structure of the plant. The light penetration can be modified which somehow to affect the quality parameters of cotton.

3.1. Cotton Radiation Use Efficiency

Many factors can affect the radiation use efficiency (RUE) of cotton like pruning and shoot topping which can ultimately enhance the light-capturing capacity and resource storage in the fruiting part of the plant (Liang et al., 2020). Pruning has improved cotton seed yield by up to 34% through the accumulation of photosynthates within the plant and increased the light interception rate of the plant (Reta-Sánchez and Fowler, 2002). This practice leads light to penetrate lower leaves and boosts the overall photosynthesis rate for better development of the boll. Many studies have shown that seed cotton yield is high by pruning as the number and weight of bolls increased due to nutrient allocation as compared to control. Shoot topping is another helpful technique for canopy management as it removes the terminal bud and promotes growth in the lateral bud to maintain a uniform structure of the canopy (Khalil et al., 2023). These changes increase the boll retention of plants as the photosynthesis rate is high due to more light penetration. Research has indicated that these management practices are important to maintain a favorable microclimate for efficient light interception and nutrient distribution in cotton for optimal boll development. For sustainable cotton cultivation such integrated techniques contribute to boll development and increase in number of cotton seeds (An et al., 2023).

3.2. Seed Cotton Yield Enhancement

Cotton defoliants can help in the early shedding of leaves and opening of bolls and hence affect the quality of the bolls by influencing the time of boll maturity and harvesting (Ubaydullaev et al., 2021). Cotton leaf abscission and boll opening are processes that influence the physiological parameters of the cotton plants, including boll formation and maturation. Defoliation can alter the height of the canopy which may impact the microclimate of the canopy, in turn affecting boll characteristics and yield formation (Wu et al., 2022). The spatial position of bolls within the canopy may also be affected by canopy management practices such as defoliation and pruning about factors such as boll-setting rate and boll weight at various positions of fruiting branches. The position of bolls in the canopy also affects the quality and quantity of the cotton bolls, the weight of the bolls and the boll setting percentage. Zhang et al. (2021) study reveals that canopy management practices like pruning and planting density influence the quality of the cotton bolls in terms of boll maturation, spatial distribution, microclimate conditions and boll characteristics.

3.3. Fibre Quality Improvement

Parameters like temperature and relative humidity affect the fibre development and quality of the cotton (Yang et al., 2014). This means that with higher plant density, the canopy microclimate of the field is changed and it influences some of the parameters such as the fibre length, fibre strength and micronaire (Altundag and Karademir, 2021). Thus, the findings in the literature are that canopy management techniques, particularly shoot topping, which is the removal of the main stem and branch tips, can influence cotton fibre quality. In particular, the plant density and the canopy microclimate which is formed can also influence the fibre quality parameters such as the fibre length, strength and the micronaire (Altundag and Karademir, 2021).

4. Planting Density Management in Cotton Cultivation

Planting density is also a crucial factor in the management of cotton production since it affects the plants' growth, light interception (Khan et al., 2017). It means that the planting density can affect boll development, nutrient distribution and general health of the plant. Plant with densities greater than 40,000 plants per hectare may lead to competition for light, water and nutrients among the plants (Kavya et al., 2023). This competition sometimes results in smaller boll sizes since a plant will allocate resources to the development of fewer bolls which in this case will be smaller and lighter. Higher planting density indicates better opportunities to maximize the interception of radiation by the crop canopy with more light intercepted in different parts of the canopy (Shakarami and Rafiee, 2009). However, the vertical penetration of light into the canopy layer is not equal and uniform. The lower canopy layer receives maximum amount of light while the upper canopy layer receives minimum amount of light because of the dense structure of the canopy. A suitable planting density ensures increased light penetration and gaseous exchange to enhance the utilization of light resources for high crop yields (Zhang et al., 2021). The planting density changes the distribution of the leaf azimuthal and the sizes of the plants and therefore, the light interception. Plant density is one of the important crop management practices that affect canopy light distribution and canopy photosynthetic capacity in cotton and the increase in plant density generally increases the value of leaf area index (LAI) to an optimum population density is reached, beyond which it has no significant effect on yield (Chapepa et al., 2020). Furthermore, denser canopy offers high humid microclimate and this is likely to encourage diseases such as fungal and pest infestations (Monteiro et al., 2006). Shading at high densities can also lower the photosynthetic rates and thus reduce light penetration and negatively influence the yield. Plants with planting density below 30,000 plants per hectare have some advantages such as higher light interception and better air circulation (Yada, 2011). Since it reduces the number of plants, the light can reach the lower leaves and promote better photosynthesis and thus the bolls are larger and heavier due to better distribution of nutrients. Due to increased airflow in a less dense canopy helps in the reduction of the humidity and the risk of disease is also lower. However, very low densities may lower the total yield due to a reduced number of plants as well as enhance the competition with weeds, which in turn influences the availability of resources (Sylla et al., 2013). Moderate planting density ranging from 30,000-40,000 plants per hectare may be considered optimal because they are between the extremes of higher and lower densities (Kgasago, 2006). This density range ensures that the plants intercept light to the greatest degree and capture light while minimizing competition between the plants. It favors an appropriate number of bolls with the right size and weight and a standard microclimate, better airflow and disease control. In this regard, medium planting densities enable the development of good bolls and general productivity (Zhou et al., 2021).

Optimizing planting densities enables the plants to effectively capture light in the canopy leading to improved photosynthetic capacity, thus increasing the yields (Li et al., 2021b). Other microclimates of the canopy also affect boll number per unit area (Zhang et al., 2021). The type of growing environment and the cultivar affect the optimal density of planting for boll characteristics. Planting densities that result in higher plant populations intercept more light, humidity and temperature which in turn influence boll number, weight and boll-setting rate (Yang et al., 2014). Optimal planting densities are crucial in determining high boll yield and fibre quality (Feng et al., 2014).

5. Effects of Planting Density on Cotton Agronomic Parameters

Many factors affect the agronomic characteristics of the crop while growing cotton and among these are the planting density. Stress factors such as light, water and nutrients become limited at high planting densities and this results in a higher boll per hectare (Zhi et al., 2016). However, increase competition can compromise the formation of individual bolls, as they may be formed in smaller sizes and with lower weights. On the other hand, low planting density usually produces fewer bolls per plant, but the bolls are large and heavy because of lower competition and efficient partitioning of nutrients. Moderate planting density can balance the number of bolls produced with the balanced size of the bolls hence increasing the yield quality.

5.1. Boll Weight

Boll weight is important factor influenced by the planting density (Zhang et al., 2021). Higher planting density also reduces the size of the boll produced due to competition for the plant's resources which are detrimental to the yield. Lower planting density, on the other hand, results in larger bolls as the plants get to compete less on the available nutrients hence each boll gets bigger and heavier. Medium planting densities generally favor the optimal boll weight, which is a result of the advantages of both large and small planting densities and helps to increase seed cotton yield by making bolls of the desirable size and weight.

5.2. Boll-Setting Rate

Another factor that is also affected by planting density is the boll-setting rate which is the ratio of flower buds that fully develop into mature bolls. Higher population densities may reduce the boll setting rate because plants are stressed and competition among plants; hence, fewer boll formations are likely to occur (Khan et al., 2017). Lower planting densities usually have a better boll-setting rate since plants have more resources to support each boll's growth. Moderate planting densities are usually associated with a high rate of boll setting because of proper resource distribution and competition, which optimize the number of bolls as well as their quality (Khan et al., 2019). Planting density management is crucial for the achievement of high yield and quality of cotton crops. It is possible to make better decisions that increase yields and efficiency of growing cotton through the knowledge of the impacts of higher, lower and medium planting densities on boll number, weight and setting rates.

5.3. Cotton Yield

The higher planting density provides the best light interception and canopy architecture (Li et al., 2023). The shaded ground in high plant densities and higher evapotranspiration contribute to cooling and humidifying effect. All these factors should therefore be well managed to achieve a sustainable and efficient production of cotton. The planting density that will help to get the highest yield and better fibre quality which varies among different varieties and geographical locations. Cotton yield normally increases with the increase in plant density to a certain level after which it starts to decline (Vaughan, 2005). For example, in the research on hybrid cotton, the yield of cotton raised with plant density up to the level of 3.0 plants m^{-2} (Yang, et al., 2014). The relationship between plant density and yield in cotton crops is a multifaceted one depending on factors such as the type of cotton, the regional conditions and yield parameters. Optimal planting density must be established depending on the conditions of the cotton crop to increase the yield and quality of the fibres (Ul-Allah et al., 2021). It is established that appropriate planting density that will help increase the yield and quality of the fibre depends on the type of cotton and the area in which it will be planted. Canopy management and planting density are the important factors that influenced the yield of cotton and its fibre quality. Canopy architecture and spatial arrangement of the cotton plants affect light penetration, microclimatic conditions and efficiency with which resources are used. Some of the planting patterns like high density and wide-narrow row spacing have been observed to increase the yield stability and fibre quality of cotton. Higher planting density such as 100,000 plants ha^{-1} increased 70 percent yeid in venzuela. Growth regulators also demonstrated high yield when DPC dimethylpiperidinium chloride increased yield by 4.7%. The importance of selecting plant per hectare and use of PGR in yield improvements as compared to control is shown in Table 2.

Table 2. Effect of different canopy management techniques impact on yield of cotton.

Canopy management	Treatment	Country	Variety	Yield	Citation
Planting Density	100000 pl ha-1	Venezuela	SN-290	70% increase	(Guzman et al., 2019)
	83333 pl ha-1	Venezuela	Delta Pine 16	58.33% increase	
	51000 pl ha-1	China	CR175	161.3 % increase	(Zhi et al., 2016)
	87000 pl ha-1	China	CR175	165.3 % increase	
	6x104 pl ha-1	China	J-4B	28.9% increase	(Khan et al., 2019a)
	9x104 pl ha-1	China	J-4B	24.1% increase	
Application of Plant growth regulator	DPC (1,1 dimethylpiperidinium chloride)	China	Xinluzao 60 (L60)	4.7% increase	(Ji et al., 2023)
	DPC (1,1 dimethylpiperidinium chloride)	China	Jinken 1402 (JK1402)	11.8% increase	
	CSILs (Chlormequat chloride salicylic acid iconic liquids))	China	Xinluzhong 75	11% increase	(Shi et al., 2022)

6. Challenges and Discussion

Despite owning several benefits of canopy management, it also faces challenges like labor intensive work, labor can only prune limited number of plants per day which can delay over all farming schedule (Yue and Sun, 2019). Manual toping heavily relies on labor skill to top at same height and same timing inconsistency can result in plant hormone irregulating (TIAN et al., 2022) Hinderance that farmer faces while topping with chemical includes sourcing these chemical and proper training to get efficient results. Soil moisture and weather condition also cause drift in ineffectiveness (Dai et al., 2022). With time plant can become resistant to these chemicals, that's why it's crucial to monitor and adopt sustainable practice to mitigate the risk. Improper pruning can increase risk stress in plants. Pruning during wet conditions can increase risk of wilting or disease due to fresh cut exposure to humidity (Iqbal et al., 2024). To sustain cotton production different future directions can be explored to enhance effectiveness of these methods including remote sensing that can be used to monitor the crops optimal time for topping pruning, proper workshops m extension service can help bridging gap to latest method and in implementing innovative methods to enhance yield as shown in Figure 3. The cotton industry can increase productivity and sustainability by adopting these improved strategies while reducing labor costs and environmental impact.

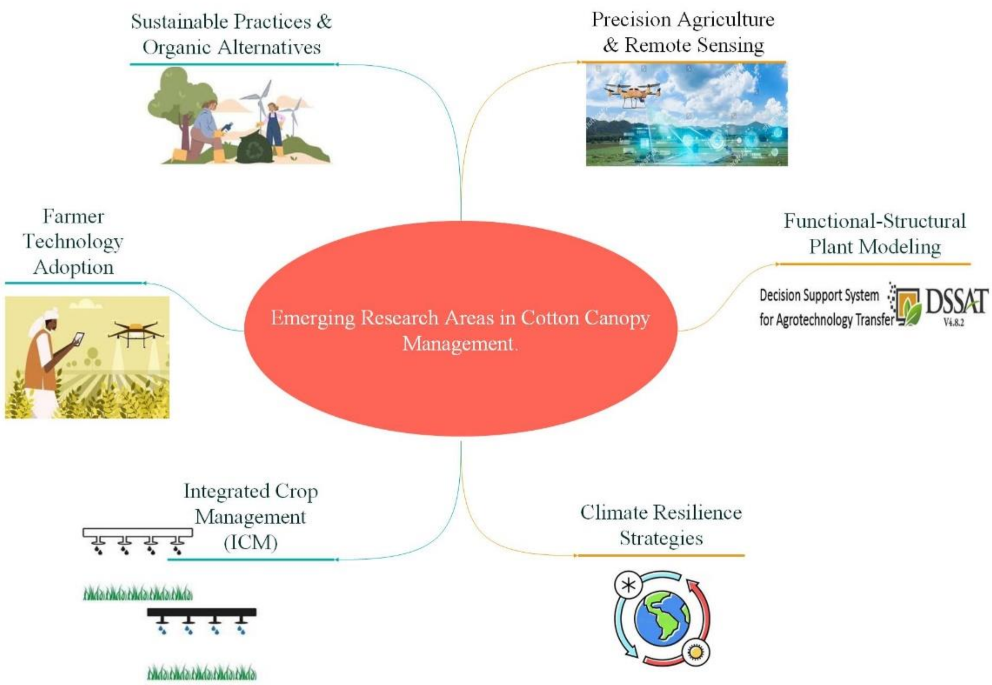

Figure 3. Emerging research areas in cotton canopy management.

By focusing on innovative canopy management methods like integrating remote sensing and plant modelling promising yield can be obtained. Cotton plays a crucial role in the world's economy, a means of earning for millions of families. Future prospect of cotton production increasingly relies on advanced canopy management techniques such as advance canopy management such as planting density, applying topping, pruning strategies. Demand for achieving higher yield while maintaining fibre quality is increasing while area for cotton production is decreasing due to floods and inheritance fragmentation. Optimizing plant density will play a crucial role in maximizing yield per unit area while balancing the number of plants within available resources like water and nutrients. Efficient canopy management is also vital to control unwanted growth of cotton plant. Topping control plant height and encourage lateral branches promoting air circulation within canopy. Pruning selective single or double will help in balancing vegetative and reproductive growth for optimal plant structure. This technique will become important as farmer seeks to enhance productivity by ensuring sustainable agriculture practices and maintain fibre quality in an increasingly demanding global market.

7. Conclusions

Cotton contributes to many aspects of economies around the world. Light interception in cotton crops is highly influenced by plant density and spatial arrangement of the plants. Present review indicated that proper plant density can improve the distribution of light within the canopy as well as the photosynthetic ability of the plant. Canopy management and planting density are the influential factors for the enhancement of cotton yield and fibre quality. The recommended planting density for obtaining higher yields and better quality of the fibres depends on the type of the cotton and the region crop is growing. It is crucial to establish the correlations between canopy management, planting density, cotton yield and fibre quality to improve the cotton production system

8. Patents

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