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A Statistical Review on the Timing of Sowing Seed Cotton

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Abstract

One of the ten countries in the world most quickly affected by climate change is Pakistan. Temperature variability, irregular monsoon rain patterns, and other climatic constraints are becoming major threats to agricultural productivity, particularly cotton. This review study aims to highlight the importance of seed cotton sowing time and yield improvement. Four databases (Google Scholar, Springer, Elsevier, and MDPI) were used for this review up to 2020 for the identification of relevant original published and peer-reviewed studies about the impact of seed cotton sowing time on yield with the keywords "seed cotton sowing time" and "optimum seed cotton sowing time" in combination with yield. The final analysis includes data from five surveys. The sowing time of seed cotton varies in different ecological zones of Pakistan and has been found to be an important factor in increasing the yield. Furthermore, the study also highlights that sowing time and cultivars of seed cotton should be prioritized for better yield.

Keywords

Climate change, Cultivars, Ecological zones, Pakistan, Seed cotton, Sowing time.

1. Introduction

Over the past decades, global cotton production has remained consistently high. It plays an important role in the textile industry. Pakistan is one of the largest cotton producers in the world. It benefits from a rich agricultural landscape and climatic conditions favorable to cotton cultivation. In this context, the cotton industry plays an important role in its economy, providing employment opportunities and contributing to export activities. More precisely, it contributes 0.8% to the overall gross domestic product and a further 4.5% to agricultural value added (Rehman et al. 2019). Thus, Pakistan is one of the best cotton producing countries. However, it lags far behind in terms of yields per hectare compared to other competitive countries, ranking 10th in terms of average yield (Shahbaz et al. 2019). Pakistan's low average yield per hectare is due to various factors; see Wei et al. (2020) and GOP (2020–21). Among them, there are the climate change (Blanc et al. 2008; Ozkan; Akcaoz 2002) and insufficient seed cotton sowing time (Arshad et al. 2007; Bilal

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et al. 2019; Gormus; Yucel 2002; Khan et al. 2017; Sankaranarayanan et al. 2020; Shah et al. 2017; Tuttolomondo et al. 2020).

Regarding climate change, Pakistan is one of the ten countries that is the most rapidly affected (Eckstein et al., 2021). In fact, climate change has become a major threat around the world. The negative consequences for agriculture-based economies are certain, particularly in cotton-producing countries. Increased and variable temperatures, as well as other climatic constraints, have reduced agricultural productivity (Chaudhry 2017). Unlike other crops, cotton has a limited margin of ecological adaptation. It is strongly influenced by both climatic conditions and planting periods. The effects of climate change on cotton production and growth in Pakistan and China are known facts; they were examined by Arshad et al. (2021). As a conclusion, due to climate change, growth duration, boll opening, and sowing harvest were reduced by 2.30 and 5.66 days per decade in China and Pakistan, respectively. According to Wang et al. (2017), climate change also affects several aspects, including the advances the sowing period by about 0.24 days per decade, the emergence date by about 1.29 days per decade, the squaring date by about 0.91 days per decade, the flowering date by approximately 2.71 days per decade, and the capsule opening date by approximately 0.82 days per decade, while cotton harvest dates were delayed by approximately 0.28 days per decade between 1981 and 2012.

Sowing time is important for yield (Bilal et al., 2019; Khan et al., 2017). Clearly, sowing too early or too late has a negative impact on boll shed and yield performance (Gormus; Yucel, 2002; Jatt et al., 2007). Due to maturity issues and a shortened fruiting period, late sowing of seed cotton reduces production (Bange et al., 2008; Brown et al., 2004; Shah et al., 2017). In Pakistan, the timing of seed cotton sowing varies across different agro-ecological zones. However, the lack of awareness about agronomic practices is real, and the optimal timing of seed cotton sowing in particular. This is correlated with the variation in yield. The timing of seed cotton has proved to be a crucial management strategy for increasing production. In fact, many researchers have contributed through scientific studies to determine the optimal sowing periods for better yield. For example, Bilal et al. (2019) conducted a two-year study to find the best sowing time of seed cotton under different climatic conditions in Punjab using three different BT varieties (BH-184, CIM-598, and MNH-886) sown on different dates and sites in Bahawalpur, Faisalabad, and Multan. It is concluded that BT sown on April 15 produced a higher yield with better fiber. Arshad et al. (2007) showed that for better yield, cotton should be sown until May 20 in the Faisalabad region. Furthermore, the SLH-284 variety was found to be the best for higher yield. On the other hand, Shah et al. (2017) conducted a study under arid and semi-arid conditions in southern Punjab. It is revealed that March 16 was the best sowing date for a better yield. Since the rapid increase in temperature affected the seed cotton sowing period, seed cotton production was low. The objective of this review study is to highlight the variations in sowing times caused by climate change in various ecological zones as well as the yield performance at different sowing times.

2. Methods and material

In our work, four databases were used to identify published articles regarding seed cotton sowing time and yield performance in Pakistan up to 2020. There are Google Scholar, Springer, Elsevier, and MDPI. To identify related studies published and peer-reviewed original papers on the impact of seed cotton sowing time as a function of yield with specific keywords, such as "seed cotton sowing time" and "optimum seed cotton sowing time" in combination with "yield". The PRISMA (preferred reporting items for systematic reviews and meta-analyses) methodology has been widely supported and advocated by researchers to improve the quality of the review process (Page et al., 2021). This is a visual demonstration of how data progresses through the different stages of a systematic review, as follows searching the databases, counting the total number of articles in each, and discarding all duplicate items. After removing duplicates, we note the number of articles to review and filter. Next, review the titles and abstracts of articles that match the search. Subtract the number of files reviewed from the total number of files; this will give the number of items that are unable to be rated. Count the number of articles that have undergone eligibility screening and full-text reporting review. After reviewing each item, make a list of how many items need to be excluded. Finally, make a list of each item that can be reviewed.

Figure 1 represents the PRISMA flowchart and can be obtained using the PRISMA2020 R package (Haddaway et al., 2022). It lists the quantity of documents that were identified, included, and excluded, as well as the justifications for these exclusions. From initial identification to database searching, 26 articles were evaluated. Relevant articles were screened by reviewing the record and excluding duplicate and irrelevant articles (which were not included in the ISI Thomson router list). A total of five potentially eligible articles were included in the final analysis. Two of the final five studies are randomized complete block designs, two are split plot designs, and one is completely randomized. All the studies were conducted in various regions of Punjab, namely Bahawalpur, Faisalabad, and Multan. Information from five shortlisted articles was recorded in a predefined data extraction form. The detailed description of related studies is given in Table 1.

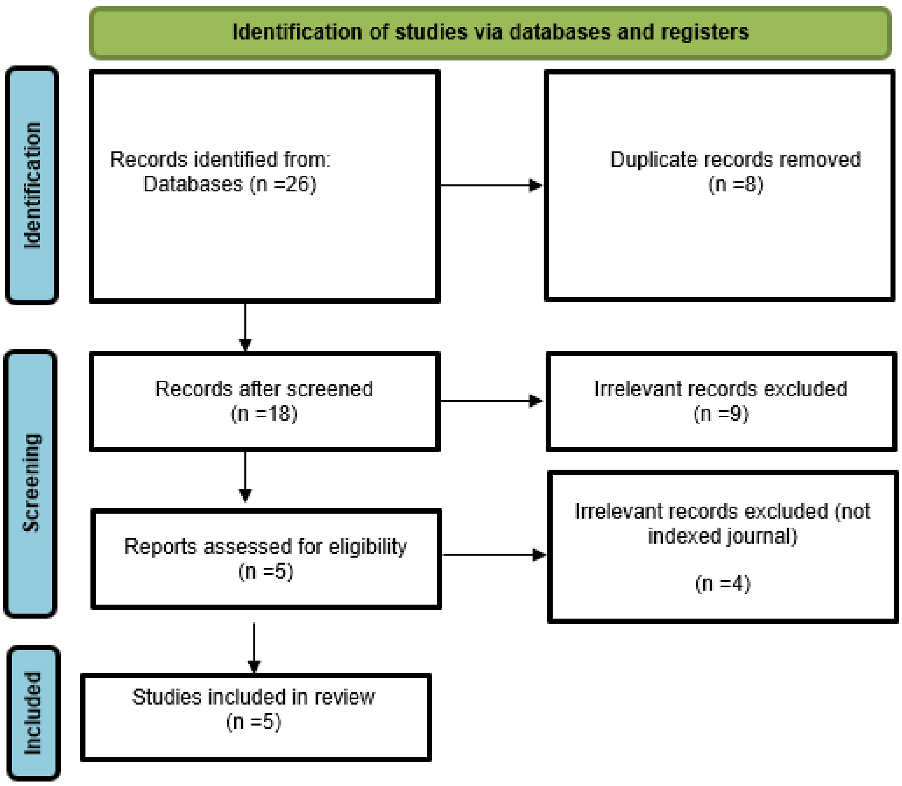

Figure 1" PRISMA flow diagrams for the selection of studies and material for the systematic review.

3. Results

Table 1 illustrates the summary of the five studies, namely the authors' names, study designs, study places, used varieties, and main findings.

Arshad et al. (2007) conducted an experimental-based study in 2005 at the Post Graduate Agriculture Research Station (PGARS), Department of Agronomy, University of Faisalabad, in order to assess the sowing date effects on yield and growth of seed cotton. The experiment had three replications. They have a plot size of 3*10 m, and the treatments were May 20 and June 10 sowing dates with varieties CIM-496, CIM-506, NIAB-111, and SLH-284. Using a single row and drill, the crop was sown 75 cm apart in rows with a seed rate of 25 kg ha-1. The results of the experiment showed that the sowing date of May 20 resulted in an increase in flowering by about 10%, opening of bolls of around 23%, seed cotton yield of around 18%, and ginning out turn of about 13% as compared to the sowing date of June 10. The seed cotton variety SLH-284 was found to be a higher-yielding variety.

Shah et al. (2017) conducted a completely randomized design study at the Wire House of the Agronomy Department (AD), Bahauddin Zakariya University Multan, in 2013 to highlight the sowing time of opium seed cotton in semi-arid climatic conditions. The BT seed MNH-886 was purchased from Punjab Seed Corporation's salespoint. The analysis of the data showed that seed cotton sown on the 16th of March tends to have a higher yield, total number of sympodial branches, number of bolls per plant, and boll weight, as well as better quality of fibre than all other sowing dates under arid and semi-arid climate conditions. A positive association between phenological events and fibber yield of BT cotton was also revealed.

The third study by Ahmad et al. (2018) used a randomized complete block design to evaluate whether sowing time could improve the productivity of cotton crops. To this aim, two sowing dates (March and May) and two sowing methods (direct seeding and transplanting of seeds) were adopted. It was shown that method of transplanting of seed was more likely to increase the productivity of cotton by 14.2% compared to the direct sowing method. Furthermore, it was revealed that March sowing increased cotton productivity by about 34.8% as compared to May sowing.

The fourth study by Bilal et al. (2019) was based on a randomized complete block design tested in three different locations of Punjab (Bahawalpur, Multan, and Faisalabad) during 2013–2014. The objective was to evaluate the best cotton sowing time. More precisely, the study focused on three BT cotton cultivars (BH-184, CIM-598, and MNH-886), which were sown on different dates (March 1, March 15, April 1, April 15, May 1, and May 15) and in three different locations (Bahawalpur, Multan, and Faisalabad). As a result, planting on April 15 seems to be the best option to increase seed cotton yields in the arid and semi-arid conditions of Punjab. Furthermore, MNH-886 produced a higher yield for Multan.

The fifth study took place at the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad, during the 2013–2014 cotton growing season (Rahman et al. 2019). In particular, some graphical works were performed. In the main plots, the sowing dates of March 10, March 30, April 1, and June 21 were randomly chosen. In addition, the cultivars, namely NIAB-112, NIAB-9811, and NIAB-886, were kept in a subplot. The analysis revealed that, for the best seed cotton yield, the cultivars should be planted from April 1 to

May 10. The cultivars NIAB-886, NIAB-9811, and NIAB-112 outperformed with higher seed cotton yields.

Table1: Summary of five mentioned studies.

Author's	Year	Study design	Place	Used variety	Main finding
Arshad et al. (2007)	2005	Split Plot Design	Post Graduate Agriculture Research Station, Department of Agronomy, University of Faisalabad.	CIM-496, CIM-506, NIAB-111, SLH-284	For better yield, cotton should be sown up to May 20 in the Faisalabad region, while SLH-284 was found to be the highest yielding variety
Shah et al. (2017)	2013	Completely Randomized Design	Wire House of Agronomy Department, Bahauddin Zakariya University Multan	MNH-886	Higher yield can be obtained for arid and semi-arid conditions by planting MNH-886 on March 16 in South Punjab.
Ahmad et al. (2018)	2011-2012	Randomized Complete Block Design	Cotton Research Station, Multan	MNH-886	About 14% of cotton's productivity can be increased through transplanting method. However, planting in March rather than May can increase productivity by around 35%.
Bilal et al. (2019)	2013-2014	Randomized Complete Block Design	Bahawalpur, Faisalabad, and Multan	BH-184, CIM-598 and MNH-886	In the arid and semi-arid conditions of Punjab, the April 15 is the best option to increase the seed cotton yield. MNH-886 produced higher yield for Multan.
Rahman et al. (2019)	2013-2014	Split Plot Design	Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad	NIAB-886, NIAB-9811, NIAB-112	Plant cultivars from April 1 to May 10 for the best seed cotton yield. With higher seed cotton yield, the cultivars NIAB-886, NIAB-9811, and NIAB-112 outperformed.

4. Discussion

In summary, this review showed that seed cotton sowing time is a determinant factor for yield. Without surprise, climate change leads to low yields. Furthermore, the sowing time and the cultivar of seed cotton vary in different geographical zones of Pakistan. For a better yield, cotton should be sown up to May 20 in the Faisalabad region, while SLH-284 was found to be the highest yield variety (Arshad et al., 2007).

For arid and semi-arid areas of south Punjab, plant MNH-886 on March 16 for higher seed cotton and lint yields (Shah et al. 2017). About 14% of cotton's productivity can be increased through the transplanting method. However, productivity can be further improved by about 35% by planting in March rather than May in Multan (Ahmad et al. 2018). The best time to plant seed cotton in Punjab's arid and semi-arid regions is April 15. MNH-886 produced a higher yield for Multan (Bilal et al. 2019). Plant the cultivars from April 1 to May 10 for a higher seed cotton yield. The cultivars NIAB-886, NIAB-9811, and NIAB-112 outperformed with higher seed cotton yields in the Faisalabad region (Rahman et al. 2019).

The agricultural sector plays a vital role in Pakistan's economy, and more than 65–70% of the population is directly or indirectly connected to this sector (GOP 2020–21). According to the Pakistan Economic Survey 2020–21, Pakistan contributes 19.2% to the gross domestic product and employs around 38.5% of the workforce (GOP 2020–21). However, this sector is neglected and facing several challenges, mainly climate change, temperature variations, water shortages, and increasing prices of inputs (GOP 2020–21). Cotton is an important cash crop for farmers and an economically valuable component of the total national economy. However, a sufficient reduction was observed in average yield, sown area, and production. There are several reasons for this decline, mainly climate change, heavy monsoon rains, and pest attacks (GOP 2020–21). Weak economic incentives have had a significant impact on the decline in cotton-sown areas, as a large proportion (81%) of cotton producers in Pakistan are small-scale farmers with vulnerable economic conditions and with land holdings of less than 5.7 hectares (USDA 2019). Wei et al. (2020) documented the main reason for low yield considering the economic viability of cotton farmers in the main province of Punjab and came to the following conclusions low level of education of farmers, insufficient or limited access to extension services, cost-effective agricultural-related inputs, and complicated agricultural-related credit and subsidy facilities for the farmers. According to the Pakistan Economic Survey 2020–21, cotton production declined by 22.8% to 7.064 million bales from 9.148 million bales last year (GOP 2020–21). Recently, the government has prioritized monitoring and developing timely policies and interventions to increase agricultural productivity and exports (GOP 2020–21). Government subsidies and agriculture-related initiatives have significantly improved the Rabi and Kharif harvests, with major crops growing by 2.77% against the target of 2.8% (GOP 2020–21).

Cotton occupies 2.45 million hectares in Pakistan; Punjab has the largest cotton area, followed by Sindh, KPK, and Baluchistan. Over the past two decades, the area sown and the average yield have continued to decline. The government and other stockholders can play an important role in the revival of cotton by controlling the seed and pesticide mafia. Unapproved, adulterated seed is the major cause of low germination and low yield. Pesticide mafias, on the other hand, approach villages through untrained and uncertified individuals and mislead farmers into overusing pesticides, resulting in low yields. Smart and effective policies are needed to improve farmers' management skills, provide low-cost inputs, and focus on biological pest control. On the other hand, warehouses should be opened at least at the Markaz level in each tehsil to supply certified seed and pesticides to the farmers. All other uncertified or unapproved seed sellers should be banned. The government and NGOs can play a vital role in promoting awareness programs among farmers regarding the sowing period of seed cotton, the use of quality seeds of approved varieties, and effective and timely intervention to control pesticide attacks through integrated pesticide management practices, to ultimately obtain better results.

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