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Research Article

SOWING TIME OPTIMIZATION FOR INSECT PEST MANAGEMENT AND ENHANCED CROP YIELD IN COTTON

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Abstract

Sowing time has a significant role in minimizing insect pest damage by disrupting synchronization between host plant and insect life cycle. The effect of different times of sowing viz. April, May and June designated as early, intermediate and late was determined on the ability of four cotton genotypes (NIA-30, NIA-88, NIA-98 and Sadori) to resist sucking insect pests and bollworms. Cotton genotypes were sown on the 15th of each month. The results showed that the planting time had pronounced effect on the infestation of insect pests. April sown cotton had a higher infestation of jassid compared to May and June sown cotton. The occurrence of thrips was recorded highest in the May sowing followed by April. Infestation of whiteflies and spotted bollworm was negligible on all the genotypes and were below the economic threshold levels during the entire period of observation. Furthermore, April sown cotton showed the higher infestation of spotted and pink bollworms. Among the tested genotypes in different sowing times, they exhibited similarity in insect pest abundance, except for jassid population which significantly differed in May sown genotypes. Concerning yield, April sowing yielded the most at 2107.7 kg/ha, followed by May (1917.6 kg/ha) and June (801.7 kg/ha). Notably, NIA-88 followed by Sadori consistently yielded the highest across all sowing times compared to the other two genotypes. This study indicates that sowing of cotton varieties in April is recommended for achieving higher yields.

Keywords: Sowing dates, genotypes, resistance, cotton, insect pests.
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1. INTRODUCTION

Cotton plays a vital role in Pakistan's agriculture-based economy, serving as a significant source of foreign exchange earnings. This versatile crop provides both fiber and edible oil, contributing 0.6% to GDP and 2.4% to value addition. In the 2021-22 period, Pakistan achieved a cotton production of 8.329 million bales from 1937 thousand hectares of cultivation, ranking 5th globally. However, compared to other nations, Pakistan's average cotton yield remains notably low at approximately 731 kg/ha (GOP, 2022). This reduced productivity is influenced by various biotic and abiotic factors, with the most notable being insect pest infestation severity (Arshad and Suhail, 2010).

Cotton pests are broadly classified into two groups: sucking and chewing. The prominent sucking insect pests include jassids, thrips, and whiteflies, while the bollworm complex comprises the american bollworm, pink bollworm, and spotted bollworm (Mohyuddin et al., 1997). These insect pest complexes are responsible for causing around 20-40% of yield losses in Pakistan (Ahmad, 1999). To mitigate these losses, cotton growers commonly rely on synthetic insecticides as the primary control measure (Khan et al., 2010).

However, the indiscriminate use of pesticides has significant consequences on biodiversity and the development of insect resistance (Bashir et al., 2001). In this context, it becomes crucial to explore and adopt alternative methods for pest management. Cultural management is a cornerstone of integrated pest management (IPM) programs (Summy and King, 1992).

Factors such as sowing dates, plant population, irrigation practices, nutrient management, and pest control techniques play pivotal roles in achieving productive yields (Ali et al., 2005). Optimal planting time is particularly important for both controlling insect pests and ensuring favorable crop yields (Showler et al., 2005), underscoring the impact of sowing time on both production and pest infestation.

Manipulating planting time can effectively reduce insect damage by disrupting the synchronization between host plants and insect life cycles. Selecting appropriate sowing dates capitalizes on periods when crops are pest-free or when the vulnerable crop stage aligns with minimal pest infestation (Acharya and Singh, 2007). Staggered sowing can lead to one to two additional pest generations in a season. Adjusting the crop's sowing time can prevent these extra generations (Ali et al., 2009).

Prior research has explored the influence of planting time on various insect pests (Mann et al., 1997; Tomar et al., 2000; Mohamed, 2012). Zheng et al. (2002) observed lower resistance against american bollworm in early-sown cotton and increased resistance in late-planted cotton. However, there are few evidence from Pakistan reporting the control of sucking and chewing pest complexes in cotton, specifically focusing on sowing dates and new varieties. Thus, the current study aims to assess the impact of sowing time on insect pest infestation in different cotton genotypes.

2. Materials and Methods

To assess the impact of sowing time manipulation on sucking insect pests and bollworms, four distinct cotton genotypes—NIA-30, NIA-88, NIA-98, and Sadori were planted on three separate dates: April 15, 2019; May 15, 2019; and June 15, 2019. April was classified as the early sowing, while May and June were considered as intermediate and late sowing, respectively. The study employed a Randomized Complete Block Design with three replications. Each replication consisted of a plot measuring 6 x 3.75 m, with plant-to-plant and row-to-row distances of 0.30 m and 0.75 m, respectively. Standard agronomic practices were implemented for cultivating all genotypes at different sowing times. Synthetic insecticides were not utilized throughout the growing season to control any insect pests. Insect pest abundance data were collected weekly over the cultivation period. For jassids, thrips, and whiteflies, three leaves—representing the upper, lower, and middle sections—were examined on five plants from each plot. To evaluate bollworm infestation, damage symptoms or larvae presence were noted on fruiting structures (buds, flowers, and bolls) of five randomly selected plants. The percentage of infestation was calculated by comparing the total and damaged fruiting structures using the following formula:

$$\text{Infestation } (\%) = \frac{\text{No. of damaged fruiting parts}}{\text{Total no. of fruiting parts}}$$

The recorded data on sucking insects and bollworms from each genotype were analyzed to determine tolerance levels among the assessed genotypes and the correlation between insect pest occurrence and sowing time. Cotton was harvested twice during the cultivation period, and the seed cotton yield of each plot was documented. The data were subjected to analysis using ANOVA through Statistix 8.1. The significance of differences in mean insect pest population and yield was determined at a 5% probability level using the LSD test.

3. Results:

3.1. Insect Pests Infestation on Early Sown (April) Genotypes

The ANOVA table concerning infestation of insect pests in the early-sown genotypes indicates that all insects, both sucking and bollworms, displayed statistically similar levels of infestation across genotypes sown in April (Table 1). However, NIA-98 exhibited the highest jassid population with a mean of 0.87 per leaf, followed by NIA-30 (0.77 per leaf), while NIA-88 demonstrated the most resistance with an average of 0.50 per leaf. Among the early-sown genotypes, Sadori displayed the highest susceptibility to thrips with an average population of 3.33 per leaf, followed by NIA-88 (3.07 per leaf), while NIA-30 and NIA-98 exhibited the lowest population of 2.98 per leaf. Throughout the crop cycle, whitefly infestation remained consistently low. The most significant infestation of spotted bollworm was noted in Sadori (2.64%), while NIA-98 emerged as the most resistant among the tested genotypes, with an infestation rate of 1.51%. Concerning pink bollworm, NIA-98 demonstrated the highest resistance with a 9.35% infestation, whereas Sadori proved the most susceptible, with an average infestation of 11.11% (Table 2). The highest yield of 2511.7 kg/ha was attained from NIA-88, followed by Sadori (2262.2 kg/ha). NIA-30, succeeded by NIA-98, yielded the least, producing 1841.3 and 1851.4 kg/ha, respectively (Table 3).

3.2. Insect Pests Infestation on Intermediate Sown (May) Genotypes

The results indicated significant variation in jassid and whitefly infestations, while infestations of thrips, spotted bollworm, and pink bollworm were statistically similar among the intermediate-sown genotypes (Table 1). Among these genotypes, NIA-88 displayed the lowest jassid count (0.16 per leaf) and was rated as the most tolerant, followed by Sadori (0.19 per leaf). Conversely, NIA-30 proved most susceptible, recording the highest jassid count (0.32 per leaf), which differed significantly from the other tested genotypes. The maximum number of thrips occurred on Sadori with a mean population of 5.06 per leaf, followed by NIA-88 (4.86 per leaf). The lowest thrips infestation was observed on NIA-30 (4.23 per leaf), trailed by NIA-98 (4.75 per leaf). Similar to the early-sown genotypes, whitefly population remained consistently low throughout the season. Among the intermediate-sown genotypes, NIA-98 exhibited the least susceptibility to spotted bollworm, with an infestation rate of 0.90%, followed by NIA-88 (0.92%). Spotted bollworm infestation was highest on NIA-30 and Sadori with infestation rates of 1.78% and 1.33%, respectively. Regarding pink bollworm, there was no significant difference among the tested genotypes. Nonetheless, NIA-98 displayed the highest pink bollworm infestation, with a rate of 9.77%, while the lowest was observed on NIA-30 (8.85%) (Table 2). NIA-88 emerged as the top yielding genotype, producing 2286 kg/ha. In the sequence of early sowing, Sadori, NIA-98, and NIA-30 contributed yields of 2107.5 kg/ha, 1711.9 kg/ha, and 1565.2 kg/ha, respectively (Table 3).

3.3. Insect Pests Infestation on Late Sown (June) Genotypes

The results indicated that only the infestation of spotted bollworm significantly varied, while infestations of jassid, thrips, whiteflies, and pink bollworm were statistically consistent among the tested genotypes (Table 1). The lowest jassid infestation was observed on Sadori, with a mean population of 0.16 per leaf, followed by NIA-88 (0.17 per leaf), while the highest was recorded on NIA-30 (0.28 per leaf). NIA-88 had the minimum thrips population (3.45 per leaf), whereas NIA-98 exhibited the highest infestation at 3.76 per leaf. Similarly, as observed in early and intermediate sowing, whitefly infestation remained consistently low throughout the season. While the infestation of spotted bollworm varied significantly among the tested genotypes, the mean percent infestation remained very low and did not reach the Economic Threshold Level (ETL) during the growing season. The highest mean percent infestation of spotted bollworm was found on NIA-88 (1.06%), followed by Sadori (0.75%), while the lowest was recorded on NIA-30 with a mean percent infestation of 0.52%. Regarding pink bollworm, NIA-88 exhibited the highest susceptibility with the highest mean percent infestation of 7.21%, followed by NIA-98 (6.87%), while the lowest percent infestation was on NIA-30 (5.41%) (Table 2).

Table 1. Analysis of variance of pest infestation and yield of four cotton genotypes grown in three different sowing times

Variables	DF	MS	F value	P
Early Sowing (April)				
Jassid	3	0.08006	2.42	0.163
Thrips	3	0.08414	1.20	0.386
Whitefly	3	0.00405	2.08	0.204
Spotted Bollworm	3	0.70570	1.30	0.356
Pink Bollworm	3	1.61353	0.65	0.608
Seed Cotton Yield (Kg/ha)	3	313928*	5.03	0.044
Intermediate Sowing (May)				
Jassid	3	0.01454*	12.33	0.005
Thrips	3	0.37078	2.06	0.206
Whitefly	3	0.00627*	5.45	0.037
Spotted Bollworm	3	0.52085	1.16	0.400
Pink Bollworm	3	0.55302	0.55	0.666
Seed Cotton Yield (Kg/ha)	3	338295*	9.60	0.010
Late Sowing (June)				
Jassid	3	0.00912	0.10	0.103
Thrips	3	0.0530	0.18	0.905
Whitefly	3	0.0017	0.99	0.459
Spotted Bollworm Infestation	3	0.1574*	6.79	0.023
Pink Bollworm Infestation	3	1.8655	1.29	0.361
Seed Cotton Yield (Kg/ha)	3	11472	1.97	0.220
Combined Analysis of Sowing times				
Jassid	2	0.2326*	165.11	0.000
Thrips	2	2.1120*	29.87	0.003
Whitefly	2	6.152	0.68	0.558
Spotted Bollworm Infestation	2	1.1859*	23.09	0.006
Pink Bollworm Infestation	2	11.179*	295.42	0.000
Seed Cotton Yield (Kg/ha)	2	14935*	77.70	0.000

*= Significant ($p < 0.05$)

Regarding yield, the results indicated that all the tested genotypes sown late (June) had statistically similar yields. Similar to early and intermediate sowing times, NIA-88 yielded the highest, with a significant production of 1052.5 kg/ha, followed by Sadori (830.8 kg/ha). NIA-30 exhibited the lowest performance, yielding 585 kg/ha, followed by NIA-98 with a yield of 738.3 kg/ha (Table 3).

3.4. Combined insect pest infestation and yield in relation to sowing times

The results showed that infestations of all studied insects significantly differed across the various sowing times, except for whiteflies, which remained statistically consistent across all dates. Additionally, the combined yield of all tested genotypes varied significantly among the early, intermediate, and late sowing dates (Table 1). The outcomes indicated that genotypes sown early (April) exhibited the highest jassid infestation, with a percentage infestation of 0.69 per leaf, differing significantly from intermediate (May) and late (June) sown genotypes. Late-sown genotypes (June) displayed the lowest jassid infestation, followed by intermediate

Table 2. Response of cotton genotypes to sucking insects and bollworms grown over different sowing times

Population of sucking insects and bollworms					
Genotypes	**Jassid**	**Thrips**	**Whitefly**	**Spotted bollworm %**	**Pink bollworm %**
Early Sowing (April)					
NIA-30	0.77 ab	2.98 a	0.19 a	2.06 a	9.92 a
NIA-88	0.50 b	3.07 a	0.11 a	1.75 a	10.12 a
NIA-98	0.87 a	2.98 a	0.17 a	1.51 a	9.35 a
Sadori	0.64 ab	3.33 a	0.14 a	2.64 a	11.11 a
LSD 0.05	**0.36**	**0.52**	**0.03**	**1.47**	**3.13**
Intermediate Sowing (May)					
NIA-30	0.32 a	4.23 a	0.19 a	1.78 a	8.85 a
NIA-88	0.16 b	4.86 a	0.08 b	0.92 a	9.54 a
NIA-98	0.22 b	4.75 a	0.14 ab	0.90 a	9.77 a
Sadori	0.19 b	5.06 a	0.12 b	1.33 a	9.05 a
LSD 0.05	**0.06**	**0.84**	**0.06**	**1.34**	**2.00**
Late Sowing (June)					
NIA-30	0.28 a	3.58 a	0.15 a	0.52 b	5.41 a
NIA-88	0.17 b	3.45 a	0.14 a	1.06 a	7.21 a
NIA-98	0.22 ab	3.76 a	0.11 a	0.65 b	6.87 a
Sadori	0.16 b	3.54 a	0.10 a	0.75 b	6.29 a
LSD 0.05	0.10	1.08	0.08	0.30	2.40

Means sharing similar letters within a column are statistically non-significant (p>0.05), LSD = Least significant difference

Table 3. Response of cotton genotypes to yield grown over different sowing times (Early, Intermediate, Late)

Cultivars	**Seed Cotton Yield Kg/ha**		
	Early (April)	**Intermediate (May)**	**Late (June)**
NIA-30	1841.3 b	1565.2 b	585.0 a
NIA-88	2511.7 a	2286.0 a	1052.5 a
NIA-98	1851.4 b	1711.9 b	738.3 a
Sadori	2226.2 ab	2107.5 a	830.8 a
LSD 0.05	**499.31**	**375.14**	**482.63**

Means sharing similar letters within a column are statistically non-significant (p>0.05), LSD = Least significant difference

Table 4 Evaluation of insect pests infestation with respect to sowing times (Early, Intermedi Late)

Sowing Times	**Jassid**	**Thrips**	**Whitefly**	**Spotted Bollworm %**	**Pink Bollworm %**
Early (April)	0.69 a	3.09 b	0.15 a	1.99 a	10.13 a
Intermediate (May)	0.22 b	4.73 a	0.13 a	1.23 b	9.30 b
Late (June)	0.20 b	3.58 b	0.12 a	0.74 b	6.45 c
LSD	**0.08**	**0.60**	**0.06**	**0.51**	**0.44**

Means sharing similar letters within a column are statistically non-significant (p>0.05), LSD = Least signifi difference

(May), with mean infestations of 0.20 and 0.22 per leaf, respectively. In contrast to jassids, thrips infestation peaked on intermediate (May) sown genotypes,

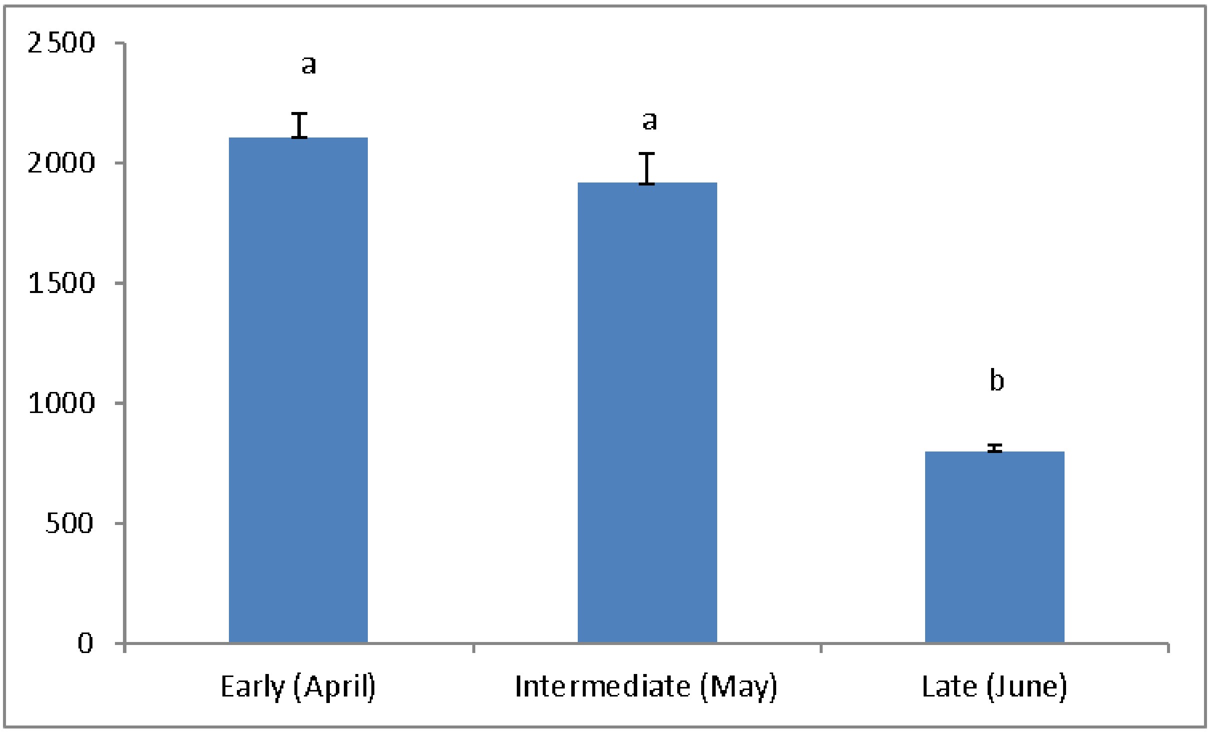

Fig. 1. Combined yield (kg/ha) obtained from early, intermediate and late sown cotton genotypes.

followed by late (June) sown genotypes, with mean infestations of 4.73 and 3.58 per leaf, respectively. The lowest thrips infestation (3.09 per leaf) was noted on early-sown genotypes, which was statistically consistent with the late-sown group but significantly different from the intermediate-sown group. Infestations of whiteflies and spotted bollworms remained minimal and did not reach the Economic Threshold Level (ETL) throughout the growing season. In terms of pink bollworms, the highest infestation was significantly recorded in early (April) sown genotypes, with a percentage infestation of 10.13%, followed by intermediate (May) and late (June) sown genotypes, with infestations of 9.30% and 6.45%, respectively (Table 4).

Considering the combined yield obtained from the three different sowing times, the maximum yield was achieved by genotypes sown early (April), with a yield of 2107.7 kg/ha, followed by intermediate (May) sown genotypes (1917.6 kg/ha), which was statistically consistent with early-sown genotypes. Late (June) sown genotypes significantly differed from the other two sowing dates, yielding the lowest at 801.7 kg/ha (Fig. 1).

4. Discussion

Host plant resistance (HPR) constitutes an important component of Integrated Pest Management (IPM), capitalizing on resistance mechanisms and traits exhibited by plants. Plants manifest traits like tolerance, susceptibility, immunity, and resistance, which significantly influence insect pest behavior and determine whether the pest deems the plant suitable or unsuitable as a host (Javaid et al., 2012). Comparative screening trials involving diverse genotypes are undertaken to assess their tolerance against insect pests across field, greenhouse, and laboratory conditions.

In this study, four cotton genotypes sown at three distinct times were compared for their tolerance to sucking insect pests and bollworms. The abundance of insect pests did not significantly differ among the tested genotypes across all sowing dates. These findings align with the work of Abro et al. (2003) and Ali et al. (2009), who similarly observed nonsignificant variations in mean insect pest populations across tested genotypes. However, other studies such as Salman et al. (2011), Shahid et al. (2012), Sarwar et al. (2013), Atta et al. (2015), Asif et al. (2017), and Saleem et al. (2018) reported differing results, indicating significant variations in pest infestations among genotypes against both sucking and bollworm complexes. The precise comparison of their findings with our present results is challenging due to the differing combinations of insect pests and varieties examined.

Regarding yield, a significant difference was noted among the tested genotypes. NIA-88 and Sadori yielded significantly higher outputs across all sowing times compared to the other two genotypes. Similar findings were reported by Asif et al. (2018), Khan et al. (2019), and Rizwan et al. (2021), indicating significant variations in cotton seed yield among studied genotypes.

The current results indicate substantial variations in the infestations of sucking and bollworm complexes across different sowing times. Jassids, thrips, and pink bollworm emerged as prominent pests across all genotypes, while whitefly and spotted bollworm infestations remained low and failed to reach the Economic Threshold Level (ETL) during the study period. Early-sown genotypes (April) exhibited higher jassid and pink bollworm infestations, whereas intermediate-sown (May) genotypes experienced greater thrips infestation. Prior research conducted in diverse climatic conditions and locations aligns with our findings. Khan et al. (2019) reported high jassid abundance in cotton sown in April, and Shahid et al. (2014) explained increased pest infestation in early-sown cotton varieties. Rasool et al. (2002) similarly reported higher infestation of the American bollworm in early-sown crops. However, contradictory results have been reported by Feng et al. (2003), Karavina et al. (2012), and Ali et al. (2015), indicating higher pest abundance in late-sown cotton. Discrepancies in climatic conditions and tested cotton genotypes could account for these variations.

Despite the higher pest incidence, particularly with jassids and pink bollworm, early-sown (April) genotypes yielded significantly more than intermediate (May) and late (June) sown genotypes. This underscores that, aside from pest infestation, sowing time impacts the climatic conditions necessary for boll opening, influencing yield fluctuations (Ali et al., 2009). Favorable growth conditions lead to increased growth potential, resulting in greater boll numbers and consequently higher cotton yield (Norfleet et al., 1997). Qayum et al. (1990) found that sowing during mid-April led to increased production due to enhanced fruiting branches, a greater number of bolls, and higher per-plant yield. Arshad et al. (2007) recorded elevated flower count (10% increase), more open bolls (23% increase), and improved seed cotton yield (18% increase) and ginning outturn (GOT) (13% increase) in early-sown cotton compared to late-sown. Late sowing resulted in noticeable yield decreases and reduced yield components. Butter et al. (2004) reported higher sympodial branch count, seed weight, and boll number in early sowing. John et al. (2019) concluded that early-sown crops align better with favorable environmental conditions, yielding higher outputs. However, Bange et al. (2008) noted lower cotton yields in early-sown Bollgard II cotton, indicating varietal differences and climatic factors at play.

5. Conclusion

Based on the current findings, it can be concluded that all genotypes sown in April (early) yielded the highest despite the elevated infestation of jassids and pink bollworm in comparison to crops planted in May (intermediate) and June (late). Genotypes sown in June (late) were notably influenced by sowing time, resulting in significantly lower yields. Among the various tested genotypes, NIA-88 followed by Sadori exhibited the highest cotton yields across all sowing times. Consequently, the recommendation is to sow the latter two genotypes in April for attaining superior yields.

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