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Screening and Identification of Germplasm Resources for Early-maturing Machine-picked Cotton in Northern Xinjiang

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Abstract The early-maturing cotton planting area in northern Xinjiang is a significant high-quality cotton production region in China. The screening and identification of early-maturing cotton germplasm resources are essential for the selection and breeding of early-maturing machine-picked cotton varieties, thereby facilitating the development of high-quality early-maturing machine-picked cotton materials. In this study, 19 self-fertilized early-maturing materials were screened and identified. Among these, the varieties G15 and G9 were selected based on their superior overall traits. Notably, the G9 variety exhibited exceptional early-maturing characteristics, with a reproductive period of 116 d.

Key words Cotton, Early-maturing cotton area in northern Xinjiang, Early-maturing upland cotton, Variety screening

1 Introduction

Xinjiang is the largest cotton production area in China. In 2022, the national cotton sowing area was recorded at 3.003 million hm^2, with Xinjiang contributing 2.497 million hm^2, thereby accounting for 83.2% of the total cotton sowing area in the country. The lint cotton production in Xinjiang reached 5.391 million t, which constitutes 90.2% of the national lint production. Consequently, the cotton industry has emerged as a significant pillar of Xinjiang's economy and serves as a primary source of income for local farmers[1]. The North Xinjiang early-maturing cotton planting area is the second largest cotton cultivation region in Xinjiang, comprising 38.2% of the total cotton field area in the region. Furthermore, this area contributes to over 40% of the total cotton output in Xinjiang. Northern Xinjiang cotton planting area experiences a cumulative temperature of 3 200 to 3 500 ℃ at or above 10 ℃, a frost-free period ranging from 175 to 220 d, and annual precipitation between 150 and 200 mm. This area represents the highest latitude for cotton production in China and is characterized as a typical inland cotton region. Furthermore, it serves as a significant high-quality cotton production zone within Xinjiang. The determination of high yield and quality in cotton production is primarily influenced by the inherent potential of the cotton variety itself[2].

In the cotton planting area of Northern Xinjiang, a shorter frost-free period is a critical factor for achieving high yield, quality, and efficiency in early-maturing machine-picked cotton varieties[3]. These early-maturing varieties not only contribute to stable and high yields but also reduce the planting cycle duration, thereby effectively mitigating the competition between grain and cotton for land resources[4]. Consequently, the cultivation and selection of early-maturing cotton varieties play a crucial role in the selection of machine-picked cotton[5]. By screening and identifying 19 self-breeding early-maturing cotton germplasm materials, suitable early-maturing cotton varieties for cultivation in Northern Xinjiang have been identified. This process will also contribute to the establishment of superior backbone parents for the selection and breeding of early-maturing machine-picked cotton varieties.

2 Materials and methods

2.1 Materials The cotton varieties selected for testing included early-maturing line materials that were self-bred by the Cotton Institute at the Shihezi Agricultural Science Research Institute. The control variety utilized in this study was Xinshi K24.

2.2 Overview of the test site The experiment was carried out at the Cotton Institute within the Shihezi Agricultural Science Research Institute. The preceding crop was cotton, and the soil was identified as irrigated grey desert soil. The organic matter content of the soil within the 0 – 20 cm tillage layer was 15.13 g/kg. Additionally, the levels of available nitrogen, phosphorus, and potassium were 61.23, 13.32, and 174.32 mg/kg, respectively. The pH of the soil was determined to be 7.81, and the irrigation method employed was well water drip irrigation.

2.3 Experimental design and methods Nineteen early-maturing self-breeding lines were selected as test materials, with Xinshi K21 serving as the control variety. All lines were arranged in a randomized block design with three replications. The film was mechanically spread and perforated, and the seeds were manually placed onto the film. The length of the mulched rows was 8.8 m, with an average row spacing of 38 cm. The plot comprised six rows, resulting in a total area of 20 m^2. The spacing between plants was 10.5 cm, leading to a density of 15 874 plants/666.7 m^2. The total net area of the experiment was 900 m^2.

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2.4 Survey methods The experiment examined the growth and morphological characteristics of cotton plants within each plot. A representative point was selected for each plot, from which 10 plants were chosen from the side rows, inner rows, and middle rows to assess the growth characteristics of the cotton plant. Each plot was harvested, and the yield was measured on October 5.

3 Results and analysis

3.1 Investigation of agronomic traits in early-maturing machine-picked cotton As illustrated in Table 1, the reproductive period, defined as the duration from seedling emergence to flocculation, for the tested varieties varied between 111 and 123 d, indicating a significant difference up to 12 d among the varieties. The control variety, Xinshi K24, exhibited a reproductive period of 118 d. Additionally, 13 varieties demonstrated a reproductive period of 120 d or less, with G7 recording the shortest reproductive period at 111 d. The average number of bolls produced per plant was 6.5, with a minimum recorded value of 5.8. The average weight of a single boll was approximately 5.3 g, with G7, G12, and G15 exhibiting the highest single boll weight of 6.4 g, while the CK (Shinshi K24) recorded a weight of 5.6 g.

3.2 Yield level and analysis of variance

3.2.1 Yield performance. The yields of each variety are presented in Table 2. The G15 variety exhibited the highest seed cotton yield, measuring 494.5 kg/667 m^2, while the G4 variety recorded the lowest seed cotton yield at 437.66 kg/667 m^2. Additionally, G15 also achieved the highest lint yield, amounting to 216.49 kg/667 m^2, which represents an increase of 7.46% compared to CK (Xinshi K24). The lowest yield was recorded for G17, which produced 169.87 kg/667 m^2, representing a decrease of 15.68% compared to CK (Xinshi K24). Overall, the lint percentage was relatively high, with an average value of approximately 44.4%. Specifically, the lint percentage for CK (Xinshi K24) was 45.2%, while G14 exhibited a lint percentage of 45.7%, and G17 recorded a lint percentage of 41.5%. Notably, the pre-frost flowering rates for all varieties were consistently 100%.

Table 1 Survey of agronomic traits in cotton

Variety	Reproductive period//d	Plant height//cm	Height of initial fruit knot//cm	Number of bolls per plant//boll	Boll weight//g
G1	114	73.0	22.7	6.0	5.3
G2	114	74.5	23.6	6.3	5.3
G3	116	79.6	29.5	6.7	6.0
G4	120	73.9	25.8	5.8	5.2
G5	114	88.0	33.7	6.2	5.5
G6	115	76.2	25.0	7.2	5.6
G7	111	84.5	33.6	5.7	6.4
G8	121	80.5	29.6	6.7	6.2
G9	116	77.2	27.6	6.7	5.7
G10	118	76.3	23.9	7.5	5.5
G11	120	86.2	29.2	7.4	5.9
G12	123	79.5	29.4	5.8	6.4
G13	122	76.0	30.2	6.8	6.2
G14	121	80.1	27.9	7.3	5.4
G15	122	78.3	27.1	6.5	6.4
CK	118	71.4	25.1	6.7	5.6
G17	117	89.3	32.2	5.9	5.4
G18	119	72.8	22.9	6.1	5.6
G19	121	80.0	24.0	6.9	5.4
G20	122	85.7	31.7	6.2	6.3

Table 2 Yield performance of early-maturing machine-picked cotton varieties

Variety	Actual density	Seed cotton yield			Cotton lint yield			Lint	Pre-frost
	plant/667 m^2	kg/667 m^2	CK	Rank	kg/667 m^2	CK	Rank	percent//%	flowering rate//%
G1	13 877	406.17	91.25	19	180.26	89.48	17	44.5	100
G2	14 205	441.47	99.18	12	194.15	96.37	14	44.0	100
G3	13 218	396.35	89.04	20	179.70	89.20	18	45.3	100
G4	14 919	437.66	98.32	14	197.02	97.80	13	45.1	100
G5	14 057	428.94	96.36	16	189.43	94.03	16	43.5	100
G6	14 164	457.46	102.77	4	206.54	102.52	3	45.3	100
G7	13 351	419.18	94.17	17	175.51	87.12	19	41.9	100
G8	13 802	449.53	100.99	7	201.18	99.86	10	44.9	100
G9	14 485	475.63	106.85	2	206.59	102.55	2	43.5	100
G10	13 553	441.25	99.13	13	199.33	98.94	12	45.2	100
G11	13 397	435.82	97.91	15	193.35	95.97	15	44.4	100
G12	13 690	458.67	103.04	3	203.62	101.07	6	44.4	100
G13	13 626	446.38	100.28	8	201.79	100.16	8	45.3	100
G14	13 889	451.51	101.43	6	206.21	102.36	4	45.7	100
G15	13 690	494.50	111.09	1	216.49	107.46	1	43.7	100
CK	14 474	445.13	100.00	10	201.46	100.00	9	45.2	100
G17	13 486	409.87	92.08	18	169.87	84.32	20	41.5	100
G18	14 041	443.57	99.65	11	202.18	100.36	7	45.5	100
G19	13 314	445.42	100.07	9	199.39	98.97	11	44.8	100
G20	13 627	452.47	101.65	5	203.75	101.14	5	45.1	100

3.2.2 Analysis of variance (lint yield). The analysis of variance (ANOVA) was conducted utilizing the least significant difference (LSD) method for multiple comparisons. The collected data were processed using DPS 9.5, and the ANOVA results for each variety are presented in Tables 3 and 4. Significant differences were observed between the treatments of each variety; however, the differences between groups were not significant. Varieties G15, G9, G6, and G14 exhibited significant differences when compared to the control group, with G15 demonstrating a highly significant increase in yield relative to CK (Xinshi K24). Conversely, the yield reduction observed in G17 was also highly significant when compared to CK (Xinshi K24).

Table 3 ANOVA results

Source of variation	Sum of squares	Degree of freedom	Mean square	F	P
Group	503.336 3	2	251.668 1	1.844	0.172 1
Treatment	8 052.433 1	19	423.812 3	3.105	0.001 4
Error	5 187.160 4	38	136.504 2		
Total variance	13 742.929 8	59			

NOTE Coefficient of variation CV (%) = 5.074.

3.3 Fiber quality Each variety was surveyed and sampled, and subsequently tested by the former Cotton Quality Supervision, Inspection, and Testing Centre of the Ministry of Agriculture, utilizing HVI calibration cotton standards. The test results are presented in Table 5. Overall, the fiber quality of the examined varieties was found to be average, characterized by elevated macronaire values. G1, G7, G9, G15, and CK (Xinshi K24) exhibited superior performance in terms of fiber quality, with the average length of the upper half measuring approximately 30.0 mm or greater, and the average specific strength at break reaching or exceeding 30.0 cN/tex. In contrast, G18, G19, and G20 demonstrated comparatively inferior performance.

Table 4 Significant difference analysis results

Treatment	Mean	5% Significant level	1% Significant level
G15	216.490 0	a	A
G9	206.593 3	ab	AB
G6	206.543 3	ab	AB
G14	206.210 0	ab	AB
G20	203.753 3	abc	AB
G12	203.616 7	abc	AB
G18	202.180 0	abc	AB
G13	201.790 0	abc	AB
CK	201.463 3	abc	AB
G8	201.183 3	abc	AB
G19	199.390 0	abc	AB
G10	199.333 3	abc	AB
G4	197.023 3	abc	AB
G2	194.153 3	abc	AB
G11	193.346 7	abc	AB
G5	189.426 7	abc	AB
G1	180.263 3	abc	AB
G3	179.696 7	bc	AB
G7	175.510 0	bc	AB
G17	169.873 3	c	B

Table 5 Fiber quality test results of early-maturing machine-picked cotton

Variety	Average length of the upper half//mm	Neatness index//%	Specific strength at break//cN/tex	Micronaire	Elongation//%	Reflectivity//%	Yellowness index	Spinning consistency index
G1	30.0	83.9	30.0	4.9	6.4	79.3	8.0	136.7
G2	29.0	84.1	28.7	4.8	6.5	79.2	7.7	134.7
G3	29.2	86.4	32.7	5.0	6.9	77.7	8.1	154.3
G4	28.9	84.6	31.3	4.8	6.1	78.9	8.2	144.0
G5	29.6	85.6	31.7	4.3	5.4	79.0	7.9	156.7
G6	29.2	86.1	30.2	4.7	6.1	80.6	7.8	151.3
G7	30.8	86.2	35.6	4.5	6.9	80.5	7.7	169.7
G8	28.2	85.5	31.3	5.1	7.3	78.6	8.2	143.7
G9	30.4	85.8	30.3	4.6	6.6	79.5	7.5	146.7
G10	29.1	84.5	28.7	4.7	6.0	79.9	8.0	138.0
G11	29.4	84.6	28.8	4.6	6.7	81.0	7.6	141.0
G12	28.8	85.9	30.7	5.0	6.6	79.1	8.5	146.3
G13	28.3	84.4	28.4	4.7	6.8	79.7	8.3	136.0
G14	28.1	84.8	28.4	4.5	6.0	80.7	7.5	138.7
G15	30.7	86.2	32.2	4.8	7.0	79.2	8.3	156.3
CK	30.5	84.7	30.9	4.9	6.2	79.9	7.7	142.3
G17	29.6	85.0	33.1	4.4	5.4	78.0	8.1	156.3
G18	28.7	84.4	27.5	5.0	6.5	79.6	7.6	131.0
G19	29.2	85.1	27.7	5.0	6.2	79.7	7.5	135.3
G20	27.6	85.3	28.7	4.9	7.7	78.4	8.6	136.0

4 Conclusions and discussion

Lint yield is the primary objective of screening and serves as the most significant goal in cotton variety breeding[6]. Concurrently, fiber quality is a critical indicator of cotton lines. Therefore, enhancing cotton yield while simultaneously improving fiber quality has emerged as a vital direction for breeding efforts in China[7]. In this experiment, the participating lines were analyzed with respect to their reproductive period, agronomic traits, yield, fiber quality, and other relevant aspects, in comparison to the primary varieties[8]. The lines demonstrating superior overall performance were subsequently selected. Among the 19 participating varieties, G9 and G15 exhibited the most favorable overall performance.

The G15 variety demonstrates the following characteristics: a reproductive period of approximately 122 d, an average of 6.5 bolls per plant, a single boll weight of 6.4 g, a lint percentage of 43.7%, a pre-frost flowering rate of 100%, an average length of the upper half of the HVICC measuring 30.7 mm, a neatness index of 86.2%, a specific strength at break of 32.2 cN/tex, a micronaire value of 4.8, an elongation percentage of 7%, a reflectivity of 79.2%, a yellowness index of 8.3, and a spinning consistency index of 156.3. The seed cotton and lint yields of this variety were 494.5 and 216.49 kg/667 m^2, representing 111.09% and 107.46% of the control variety G16 (Huiyuan 720). This variety ranked first in both categories.

The G9 variety exhibits the following characteristics: a reproductive period of approximately 116 d, an average of 6.7 bolls per plant, a single boll weight of 5.7 g, a lint percentage of 43.5%, a pre-frost flowering rate of 100%, an average length of the upper part of the HVICC measuring 30.4 mm, a neatness index of 85.8%, a specific strength at break of 30.3 cN/tex, a micronaire value of 4.6, an elongation percentage of 6.6%, a reflectivity of 79.5%, a yellowness index of 7.5, and a spinning consistency index of 146.7. The seed cotton and lint yields of this variety were 475.63 and 206.59 kg/667 m^2, representing 106.85% and 102.55% of the control variety G16 (Huiyuan 720), thereby ranking second in both categories.

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ongoing monitoring and protective measures are essential to ensure the long-term stability and survival of these species.

6.3 Enhancement of ecosystem services Mangrove restoration is crucial for enhancing the ecological services provided by coastal ecosystems. Mangrove forests offer a range of ecological benefits, including coastal protection, carbon storage, and water purification. Research has demonstrated that restored mangrove ecosystems actively contribute to these services, which is vital for mitigating the impacts of climate change and safeguarding coastlines from erosion.

6.4 Challenges and future directions Despite the achievements of ecological restoration projects, several challenges persist. For instance, the long-term stability of mangrove forests must be addressed in light of both natural and anthropogenic pressures, which include climate change, rising sea levels, pollution, and overexploitation. Consequently, future research and management efforts should prioritize the following areas: continuous monitoring, which entails the long-term assessment of the growth status, biodiversity, and ecosystem service functions of mangrove forests to evaluate the sustainability and stability of restoration outcomes; adaptive management, wherein management strategies are adjusted based on monitoring results to address environmental changes and emerging threats; community participation, aimed at enhancing local communities' awareness and involvement in mangrove conservation, as well as educating them on the significance of ecological restoration; and policy support, which involves strengthening regulatory frameworks and policy initiatives to safeguard mangrove forests from illegal logging and degradation.

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