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Suvarna Shubhra (AKH-09-5): A Promising American Cotton Variety for Sustainable Cotton Production under Rainfed Situation for Central Zone of India

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ABSTRACT: Rapid increase in human population and reduction in arable land due to urbanization and other soil problems, the demand for promoting cotton yield is increasing continuously. The major limiting factors for increasing yield are biotic and abiotic stresses, global climate change, genotype x environment interactions, limited germplasm resources, and negative association between yield and fiber quality. To meet the demands of rainfed cotton growers of Central Zone of India, concentrated breeding efforts at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola resulted in development and release of high yielding variety Suvarna Shubhra (AKH-09-5) having medium duration and desirable fibre properties. It was continuously evaluated in University Trials, State Multi Location Trials and All India Coordinated Research Project on Cotton (AICRP) trials from 2011-12 to 2018-19 before its release. It was tested on farmer's field through adaptive trials also. This variety has recorded higher yield compared to the check varieties in all the trials. It is tolerant to leaf hoppers and important cotton diseases. In addition, it has good fibre qualities and acceptable boll size. Due to these desirable features, farmers have shown acceptability to this variety in adaptive trials and because of high lint yield potential and good fibre qualities, ginning industry and mill owners can satisfy their demands.

Keywords: American cotton, seed cotton yield, lint yield, fibre quality, AICRP trials, diseases and pests.

INTRODUCTION

Cotton is one of the most important crops in the world due to its universal use in the textile industry (Ashokkumar *et al.*, 2014). Around 71% of the world cotton production comes from China, India, USA and Brazil from 64% of the world cotton area. India is the leading country in terms of area under cotton, cultivates cotton on around 130 lakh hectares. At global level, though India occupies 40% of the cotton area, but able to produce just 21% of the global cotton production. The average productivity of India is around 440 kg/ha which is much less than world's average productivity (Anonymous, 2023). Cotton production faces many challenges in the 21st century. The rapid increase in human population and the loss of arable land due to soil erosion, soil salinization, harsher climate conditions, and urbanization, the demand for promoting cotton yield is increasing dramatically. Various factors like biotic and abiotic stresses, global climate change, genotype × environmental interactions, limited germplasm resources and the negative association between yield and fiber quality limit the yielding potential of the genotypes (Zeng *et al.*, 2022). To enhance the cotton productivity in the country, there is need to identify the robust elite varieties having broad genetic base with tolerance to biotic and abiotic stresses and should have good fiber quality for the demand of the textile industries.

After introduction of Bt cotton in India in 2002, the area under traditional non Bt cotton cultivars declined rapidly and now more than 90 per cent cotton growing area is occupied by Bt cotton F_1 hybrids (Mayee, 2012; Mayee and Choudhary 2013). The main advantage of growing Bt cotton was claimed that there is no need of insecticidal sprays for controlling boll worms with added advantage of yield superiority over traditional non Bt cotton varieties/hybrids (Kranthi and Stone 2020). Farmers were benefited with Bt technology with reduced sprayings for controlling bollworms but at the same time the problem of sucking pests remained unsolved. Unfortunately, most of the prevailing Bt cotton hybrids are susceptible to sucking pests which is a major issue in Central Zone. Farmers need to undertake frequent sprayings of costly insecticides to control these pests which has increased by 158% within

the decade of Bt cotton spread in India (Kranthi and Stone 2020). The incidence of pink bollworm on large scale in Gujarat and Maharashtra in last decade also threatened the farmers and also there are several reports claiming that bollworm has developed resistance against Bt toxins (Dhurua and Gujar 2011; Zhang *et al.*, 2012; Fand *et al.*, 2019; Mohan, 2017; Naik *et al*., 2018). Generally, Bt cotton hybrids are high input responsive, requires higher doses of fertilizers and other inputs. Secondly, farmers have to purchase Bt cotton seed every year which is very expensive. All these factors increase the cost of cultivation (Kranthi and Stone 2020). So, cultivation of Bt cotton has become risky under changing climatic situation.

Farmers need early to medium duration, high yielding, low input responsive cotton varieties with good fibre qualities and which can withstand to biotic and abiotic stresses. This will minimize the risk of failure and monitory losses to the farmers. Over the years efforts were made to develop cost effective varietal lines in different breeding program. In this study newly developed promising cotton genotype AKH-09-5 was compared with previously released cotton varieties *viz*., PKV Rajat, AKH-9916, AKH-8828, NH-615, NH-545 and Phule-688 in different trials at University, State and national level for its suitability in rainfed condition.

MATERIAL AND METHODS

Development of high yielding varieties with good fibre qualities and tolerant to biotic and abiotic stresses are the primary objectives of cotton breeding program. At Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, the work on genetic enhancement of American cotton is being carried out since last five decades which resulted in development and release of several high yielding cotton varieties. Concentrated efforts were continued to develop medium duration high yielding variety with desirable fibre properties. In this context, a cross was made between high yielding line AKH-9913 and AKH-8801, line with good fibre qualities followed by selections for symmetrical good plant type with fibre qualities and tolerance to various diseases and pests. Desirable tolerant plants were selected in F_2 generation and plant to row selections were made in F_3 toF_6 generations. Uniform promising lines were evaluated for yield potential and finally a most promising one was evaluated by the code AKH-09-5 in University, State, national and on farmers' field during 2011-12 to 2018-19 before its release. Based on the yield performance, fibre quality and tolerance to major pest and diseases, Variety Release Committee for Field Crops recommended this variety for cultivation under rainfed situation in Maharashtra State during 47th Joint Agresco Meet at Mahatma Phule Krishi Vidyapeeth, Rahuri during May, 2019 and subsequently during May, 2020, it was recommended by Varietal Identification Committee, All India Coordinated Research Project on Cotton (AICRP on Cotton) for Central Zone States of India including Maharashtra, Madhya Pradesh, Gujarat, South Rajasthan and Odisha under rainfed condition.

RESULTS AND DISCUSSION

The variety Suvarna Shubhra (AKH-09-5) was evaluated for seed cotton yield and lint yield in Station trial, University Multi location Trials (MLT), State Multi location Trials (SMVT), All India Coordinated Research Project on Cotton (AICRP) trials and adaptive trials on farmers' field during 2011-12 to 2018-19. It was compared with earlier released cotton varieties *viz*., PKV Rajat and AKH-8828 in station trial during 2011-12. The results indicated that the variety Suvarna Shubhra (AKH-09-5) recorded 37.2 and 26.4 per cent higher seed cotton yield over the checks PKV Rajat and AKH-8828 (Table 1).

Similarly, the genotype Suvarna Shubhra (AKH-09-5) was evaluated in University Multi location Trials (MLT) in comparison with PKV Rajat, AKH-8828 and AKH-9916 during 2012-13 to 2018-19. On the basis of average of 25 MLTs, it has recorded 25.0, 25.6 and 24.6 per cent higher seed cotton yield over the checks PKV Rajat, AKH-8828 and AKH-9916, respectively (Table 1). Similarly, for lint yield in 21 MLTs, it has recorded 21.7, 19.7 and 19.2 per cent higher lint yield over PKV Rajat, AKH-8828 and AKH-9916, respectively (Table 2). Bhatade and Ansingkar (2003) reported on an average 22.5 and 19.3 per cent increased seed cotton yield and lint yield of NH-545 over the check NH-452 in Regional Multi location Trials. Similar trend of increased seed cotton yield over checks was observed by Bhatade *et al.* (2008).

During the period of 2012-13 to 2018-19, the variety Suvarna Shubhra (AKH-09-5) was evaluated with five checks in State Multi Location Trials (61 trials) conducted in three different regions of Maharashtra *viz.*, Vidarbha, Marathwada and Western Maharashtra. The results showed that the variety Suvarna Shubhra (AKH-09-5) exhibited higher seed cotton yield to the extent of 27.0 per cent over PKV Rajat, 34.7 per cent over AKH-8828, 28.8 per cent over AKH-9916, 23.0 per cent over NH-615, 19.8 per cent over NH-545 and 27.5 per cent over Phule 688, respectively (Table 1). The genotype Suvarna Shubhra (AKH-09-5) has recorded 18.9, 27.1, 25.2, 20.5, 11.8 and 25.1 per cent higher lint yield over the checks PKV Rajat, AKH-8828, AKH-9916, NH-615, NH-545 and Phule 688, respectively (Table 2).

As regards the performance of Suvarna Shubhra (AKH-09-5) in All India Coordinated Research Project (AICRP) on Cotton trials, it was evaluated during 2015-16 to 2018-19. Based on average of 18 trials, it has recorded 14.8 and 9.4 per cent increased seed cotton yield and lint yield over the Zonal check NH-615, there by indicating its wider adaptability and stability for seed cotton yield (Table 1 and 2). Meshram *et al.* (2003) reported 18.52 per cent increased seed cotton yield of PKV Hy-4 in coordinated trials conducted over the years. Vindhiyavarman *et al.* (2021) reported 40.4 per cent increased seed cotton yield of variety CO-18 over the check Suvin in coordinated trials and Vishnuvardhan *et al*. (2022) also reported similar trend of increased seed cotton yield of NDLH-2035-5 over zonal check NH-615 in coordinated trials.

Fibre length and fibre strength properties have influenced textile processing (Kohel, 1999; Amjad, 1999). Current modernized spinning mills fibre standards sets mainly based on greater fibre quality, especially strength (Arioli, 2005). Strong fibres survive the rigours of ginning, cleaning, opening, carding, combing and drafting (Guo *et al.*, 2003). Ahuja (2003) also suggested that developing high fibre length and strength cultivars or hybrids is required for current modernized spinning mills. The fibre quality of Suvarna Shubhra (AKH-09-5) fulfill the requirement of current modern spinning machines. The fibre quality of Suvarna Shubhra (AKH-09-5) was evaluated in 6 University and State Multi Location Trials and 15 AICRP trials (Table 3) and results indicated that it has recorded good fibre qualities, superior for Upper Half Mean Length, Fibre Strength, Micronaire value and Uniformity Index as compared to the check varieties and suitable for current modern spinning machines.

As regards the field reaction to the diseases and pest (Table 4 and 5), the genotype Suvarna Shubhra (AKH-09-5) found tolerant to jassids, *Myrothecium* leaf spot, grey mildew and Bacterial Leaf Blight disease.

The Salient features of Cotton Variety Suvarna Shubhra (AKH-09-5)

- Seed cotton yield (Rainfed)- 1200-1600 kg/ha
- Lint yield- 450-525 kg/ha
- Ginning Out turn- 34-36 %
- Boll weight – 3.8-4.0 g.
- Lint Index- 5-5.5
- Staple Length (UHML)- 28-30 mm
- Fibre Strength- 27-29 g/tex
- Fibre Fineness (Micronaire value)-3.8-4.5 ug/inch
- Uniformity Index - 82-84
- Maturity duration - 150-160 days
- Tolerant to Jassids, *Myrothecium* leaf spot, grey mildew and Bacterial Leaf Blight diseases.

Table 1: Summary of Seed Cotton Yield data of Suvarna Shubhra (AKH-09-5) in University trials, State Multilocation trials and AICRP trials.

Sr. No.	Trial/ Year of testing	No. of Locations	Seed Cotton Yield (kg/ha)						
			Suvarna Shubhra (AKH-09-5)	PKV Rajat (Ch)	AKH-8828 (Ch)	AKH-9916 (Ch)	NH-615 (Ch)	NH-545 (Ch)	Phule 688 (Ch)
A	**Station Trial**								
	2011-12	1	1340	977	1060				
	Percent increase/ decrease over the checks			**37.2**	**26.4**				
B	**University Multilocation Trials**								
	2012-13	3	1741	1548	1392	1305			
	2013-14	4	1158	933	885	1201			
	2015-16	4	1532	1212	1129	1047			
	2016-17	4	1660	1093	1280	1189			
	2017-18	4	1284	1030	1028	1008			
	2018-19	6	1627	1386	1403	1402			
	Weighted Mean	**25**	**1501**	**1201**	**1195**	**1204**			
	Percent increase/ decrease over the checks			**25.0**	**25.6**	**24.6**			
C	**State Multilocation Trials**								
	2012-13	9	1328	957	868		1062		973
	2013-14	11	1236	928	900		1075		1039
	2014-15	8	1170	928	772		862	949	825
	2015-16	10	969	816	795	708	699	764	821
	2016-17	8	1250	920	933	1057	1033	1005	936
	2017-18	6	1102	980	912	816	888	1048	950
	2018-19	9	1294	1080	1038	1003	1150	1104	983
	Weighted Mean	**61**	**1194**	**941**	**889**	**893**	**971**	**963**	**937**
	Percent increase/decrease over the checks			**27.0**	**34.7**	**28.8**	**23.0**	**19.8**	**27.5**
D	**AICRP on Cotton Trials**								
	2015-16	6	1551				1242		
	2016-17	4	1851				1623		
	2017-18	4	791				721		
	2018-19	4	1685				1590		
	Weighted Mean	**18**	**1478**				**1288**		
	Percent increase/decrease over the checks						**14.8**		
E	**Adaptive trials on Farmers' fields**								
	2018-19								
	General Mean	**25**	**1591**			**1332**	**1324**		
	Percent increase/ decrease over the checks					**19.4**	**20.1**		

Table 2: Summary of lint yield data of Suvarna Shubhra (AKH-09-5) in University trials, State Multi Location Varietal Trials and AICRP trials.

Sr. No.	Trial/ Year of testing	No. of Locations	Lint Yield (kg/ha)						
			Suvarna Shubhra (AKH-09-5)	PKV Rajat (Ch)	AKH-8828 (Ch)	AKH-9916 (Ch)	NH-615 (Ch)	NH-545 (Ch)	Phule 688 (Ch)
A	**Station Trial**								
	2011-12	**1**	496	369	437				
	Percent increase/ decrease over the checks			**34.4**	**13.5**				
B	**University Multilocation Trials**								
	2012-13	3	485	469	499	452			
	2013-14	3	416	354	332	463			
	2015-16	4	545	481	449	401			
	2016-17	4	629	405	456	465			
	2017-18	3	409	335	339	326			
	2018-19	4	602	512	522	518			
	Weighted Mean	**21**	**525**	**432**	**439**	**441**			
	Percent increase/ decrease over the checks			**21.7**	**19.7**	**19.2**			
C	**State Multilocation Trials**								
	2012-13	7	483	391	329		392		341
	2013-14	5	420	317	290		315		348
	2014-15	4	423	341	359		337	409	328
	2015-16	6	457	399	394	337	345	383	381
	2016-17	5	480	400	379	420	436	418	379
	2017-18	5	412	389	326	316	332	385	338
	2018-19	4	658	546	564	538	590	591	456
	Weighted Mean	**36**	**468**	**394**	**371**	**393**	**389**	**430**	**374**
	Percent increase/ decrease over the checks			**18.9**	**27.1**	**25.2**	**20.5**	**11.8**	**25.1**
D	**AICRP on Cotton Trials**								
	2015-16	6	498				428		
	2016-17	4	627				570		
	2017-18	4	346				334		
	2018-19	3	618				598		
	Weighted Mean	**17**	**514**				**469**		
	Percent increase/ decrease over the checks						**9.4**		

Table 3: Fibre quality data of Suvarna Shubhra (AKH-09-5) in in various trials (HVI Mode).

Fibre trait	Suvarna Shubhra (AKH-09-5)	PKV Rajat (Ch)	AKH-8828 (Ch)	AKH-9916 (Ch)	NH-615 (Ch)	NH-545 (Ch)	Phule 688 (Ch)
University and State Multilocation trials							
Upper Half Mean Length (mm)	29.7	25.7	27.6	27.1	28.5	26.0	26.3
Micronaire value (ug/inch)	4.1	4.8	4.3	4.5	3.8	4.4	4.2
Bundle strength (g/tex)	29.1	26.0	27.0	26.9	26.4	27.2	28.7
Uniformity index	83	80	81	81	82	80	80
Fibre elongation (%)	5.7	5.8	5.7	6.0	5.5	5.7	5.9
AICRP trials (15)							
Upper Half Mean Length (mm)	29.2				28.6		
Micronaire value (ug/inch)	4.1				3.9		
Bundle strength (g/tex)	26.6				27.4		

Table 4: Reaction of Suvarna Shubhra (AKH-09-5) to various diseases Coordinated varietal trials (AICRP).

Year/Disease	Location	Proposed variety AKH-09-5	NH-615 (ZC)	LRA-5166
Bacterial Leaf Blight (Grade)				
2016-17	Akola	1	2	3
	Nanded	2	2	3
	Bharuch	1	2	2
2017-18	Akola	3	4	
	Nanded	1	2	3
2018-19	Nanded	1	1	2
	Bharuch	1	1	2
	Akola	1	2	4
Myrothecium Leaf spot (Grade)				
2016-17	Akola	1	1	1
2017-18	Akola	1	1	1
2018-19	Akola	1	1	2
Alternaria Leaf Spot				
2016-17	Nanded	2	3	3
	Bharuch	1	0	3
2017-18	Nanded	1	2	3
2018-19	Nanded	1	2	3
	Bharuch	1	1	2
Grey mildew				
2016-17	Akola	1	1	1
	Nanded	0	0	1
2017-18	Akola	1	1	
	Nanded	0	1	2
2018-19	Nanded	0	0	1
	Akola	1	1	2

Scale for grading various diseases in cotton

Bacterial blight		Grey Mildew		*Myrothecium* leaf spot	
Grade	**Disease reaction**	**Grade**	**Disease reaction**	**Grade**	**Disease reaction**
0	Immune (I)	0	Immune (I)	0	Immune (I)
1	Resistant (R)	1	Resistant (R)	1	Resistant (R)
2	Moderately Resistant (MR)	2	Moderately Resistant (MR)	2	Moderately Resistant (MR)
3	Moderately susceptible (MS)	3	Moderately susceptible (MS)	3	Moderately susceptible (MS)
4	susceptible (S)	4	susceptible (S)	4	susceptible (S)

Table 5: Reaction of Suvarna Shubhra (AKH-09-5) to Leaf hoppers in Coordinated varietal trials.

Year	Loc.	Proposed Variety AKH-09-5		NH-615 (ZC)		DCH-32 (SC)		DHY-286 (RC)	
		Grade	Count	Grade	Count	Grade	Count	Grade	Count
Leaf hopper/3 leaves									
2016-17	AK	I	3.70 (1.92)	I	6.00 (2.43)	III	24.00 (4.90)	I	3.00 (1.68)
	NA	III	8.10 (2.93)	III	9.90 (3.21)	III	8.60 (3.01)	II	11.75 (3.49)
	BH	I	4.0 (2.12)	I	3.80 (2.07)	IV	22.40 (4.78)	I	3.60 (2.02)
	BA	II	9.33 (3.05)	II	6.33 (2.51)	IV	13.67 (3.70)	I	4.33 (2.08)
2017-18	BA	II	8.00 (2.82)	II	8.33 (2.88)	IV	15.67 (3.96)	I	4.33 (2.04)
	AK	I	3.50 (1.86)	II	4.50 (2.11)	III	9.60 (3.09)	I	2.60 (1.61)
	NA	II	16.00 (4.06)	II	16.00 (4.06)	IV	25.80 (5.12)	III	19.00 (4.41)
2018-19	BA	II	8.0	II	7.7	IV	16.0	I	4.7
	AK	I	1.3	I	2.1	III	6.9	I	3.5
	NA	II	17.3	I	15.8		22.4	III	18.9
No. of White flies/3 leaves									
2016-17	AK		9.80 (3.09)		8.70 (2.87)		3.80 (1.91)		13.70 (3.68)
	NA		10.90 (3.37)		14.90 (3.92)		13.30 (3.69)		11.20 (3.41)
	BH		20.90 (4.57)		18.00 (4.28)		9.60 (3.17)		35.40 (5.98)
	BA		15.00(3.86)		13.00 (3.60)		18.67 (4.32)		6.0 (2.44)
2017-18	BA		11.67 (3.41)		12.00 (3.46)		24.00 (4.89)		5.00 (2.23)
	AK		5.40 (2.32)		9.20 (3.03)		11.90 (3.44)		6.10 (2.46)
	NA		20.70 (4.60)		15.90 (4.04)		21.00 (4.63)		27.00 (5.24)
2018-19	BA		9.3		9.0		22.3		5.7
	AK		1.4		2.9		1.9		4.3
	NA		15.9		23.4		18.4		16.0
No. of Thrip/3 Leaves									
2016-17	BH		32.10(5.69)		84.30(9.20)		30.90(5.60)		48.20(6.95)
2017-18	NA		31.20 (5.63)		30.60 (5.57)		35.90 (6.03)		48.10 (6.97)
2018-19	NA		102.5		87.2		113.3		115.4

Open Boll damage (%) Boll basis									
2016-17	AK		26.81(31.13		25.95(30.62)		6.75(14.88)		39.67(38.94)
	NA		11.60(19.89)		11.45(19.77)		20.80(27.12)		14.95(22.74)
	BH		18.20(25.25)		16.64(24.05)		28.87(32.46)		23.54(28.95)
2017-18	AK		61.23(51.49)		76.92(61.29)		75.0(60.32)		88.89(71.14)
	NA		15.10(22.86)		15.80(23.41)		20.40(26.84)		16.90(24.27)
2018-19	AK		18.6		49.7		33.3		63.1
	NA		25.7		27.1		46.2		35.5
Average loculi damage at harvest (%)									
2016-17	AK		9.54 (17.96)		9.68 (18.12)		2.09 (8.20)		13.55 (21.53)
	NA		6.30 (14.51)		5.50 (13.56)		8.20 (16.63)		8.70 (17.15)
	BH		10.86(19.20)		13.46 (21.48)		23.29(28.79)		17.06 (24.33)
2017-18	AK		55.38(48.11)		44.23 (41.69)		50.64(45.37)		59.47 (50.47)
	NA		8.25 (16.69)		8.35 (16.78)		10.30(18.71)		9.70(18.14)
2018-19	AK		6.7		18.0		15.2		29.0
	NA		5.6		6.7		8.7		7.3
Open boll damage by PBW (%)									
2016-17	BH		9.49(17.93)		11.82(20.07)		20.38(26.77)		14.47(22.25)
2018-19	NA		23.6		24.5		42.7		31.3
Locule damage by PBW (%)									
2016-17	BH		6.5(14.72)		8.26(16.52)		16.82(24.16)		12.74(20.81)

Where, AK- Akola; NA- Nanded; BH- Bharuch and BA-Banswara,

Leaf hoppers injury grade scale for resistance/susceptibility against Leaf hoppers:

Grade –I : Resistant (1 to 1.5 average grade point).
Grade- II : Tolerant (1.6 to 2.5 average grade point).
Grade –III : Susceptible (2.6 to 3.5 average grade point)
Grade–IV : Highly susceptible (3.6 to 4.0 average grade point)

Table 6: Data on other important characters in various trials.

Character	No. of Location	Suvarna Shubhra (AKH-09-5)	PKV Rajat (Ch)	AKH-8828 (Ch)	AKH-9916 (Ch)	NH-615 (Zonal ch)
Number of bolls per plant						
University trials	19	21.4	18.5	18.9	19.5	
AICRP trials	18	21.0				20.6
Boll weight (g)						
University trials	16	3.8	3.0	3.1	3.1	
AICRP trials	18	3.8				3.2
Ginning Out turn (%)						
University trials	21	36.3	37.3	37.6	37.6	
AICRP trials	16	33.9				36.4

CONCLUSIONS

Concentrated breeding efforts at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola resulted in development of American cotton variety Suvarna Shubhra (AKH-09-5). It has been tested continuously over seven years in different University, State and AICRP on Cotton trials and found promising for seed cotton yield, lint yield, fibre qualities and pest and disease tolerance. It has shown promising performance on farmer's field in adoptive trials also. Considering its performance, it has been released and notified for Central Zone States of India including Maharashtra, Madhya Pradesh, Gujarat, South Rajasthan and Odisha for rainfed cultivation.

FUTURE SCOPE

The medium duration variety Suvarna Shubhra (AKH-09-5) is having high yield potential, tolerant to major sucking pests and diseases. In addition, it has good fibre qualities suitable for current modern spinning machines and farmers have shown acceptability to this variety in adaptive trials and they may get higher economic return and hence, this variety has good scope in rainfed cotton growing region of Central Zone of India.

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