J. Cotton Res. Dev. **32** (2) 177-187 (July, 2018) **ISSN No. 0972-8619**

Identification of best GMS lines having maximum cross boll setting in *desi* cotton (*Gossypium arboreum* L.)

S. A. PATIL*, I. S. HALAKUDE AND J. C. RAJPUT
Nirmal Seeds Pvt. Ltd., Pachora- 424201, Jalgaon
**E-mail : sandippatil@nirmalseedsindia.com*

ABSTRACT : *Desi* cotton (*Gossypium arboreum* L.) is very well adapted to the fluctuating rainfall and adverse climatic conditions. Desi cotton is still under cultivation because of their inherent ability to tolerate major pests and diseases. After the introduction of *Bt* cotton, there was significant decrease in area of *desi* cotton because of their smaller boll size and low yield potential but now there is a big demand of short staple cotton for denim and surgical cotton. Cotton is highly amenable for heterosis breeding. Hand emasculation and pollination was generally adopted practice in hybridization programme but crossed boll setting in hand emasculation and pollination in *desi* cotton is very low. Thus, Genetic Male Sterility (GMS) is commercially utilized for hybrid seed production in *desi* cotton. When compared to *G. hirsutum* cross combinations by conventional method and *G. arboreum* cross combinations in GMS lines boll setting was low due to vulnerable to fluctuating environmental conditions and receptivity of stigma in GMS lines. Due to low cross boll setting in GMS lines of *G. arboreum* as compared to *G. hirsutum*, the present investigation was carried out at Nirmal Seeds Pvt. Ltd., Pachora, Distt. Jalgaon to identify superior GMS lines having maximum cross boll setting for commercially utilization in hybrid seed production of *G. arboreum* cotton. The study revealed that cross boll setting in early sown crop during *kharif,* 2015 ranged from 7.7 (NCAGA 22 x NSA 306) to 67.5 per cent (NCAGA 13 x NSA 318) in different GMS based cross combinations. Whereas, in late sown crop during *kharif* 2016 it ranged from 5.9 (NCAGA 22 x NSA 318) to 52.2 (NCAGA 13 x NSA 502). Maximum crossed boll setting (49.2 and 36.2%) was observed in crosses having NCAGA 13 as a common female parent with different testers followed by NCAGA 46 (33.6 and 23.3 %) and NCAGA 5 (31.2 and 24.4 %) in both growing season.

Key words : Cross boll setting, *Gossypium arboreum*, GMS

The *desi* cotton (*G. arboreum*) being highly tolerant to abiotic and biotic stresses gets well adapted to the climatic aberrations and also well suited in resource limited environments and therefore are still preferred in the low rainfall areas because of suitability under rainfed conditions with low cost management. In addition they are highly tolerant to major pests and diseases especially cotton leaf curl disease, a dreaded disease of upland cotton in the North India (Pathak and Gill, 2011). In spite of above merits, the diploid cottons (20 lakh ha) and their hybrids (0.5 lakh ha) are cultivated on very less area. Hybrid cotton in India covers 90 per cent of total cotton area and contribute about 99 per cent of the country's production, in which *desi* cotton hybrid contributes only 1 per cent (Sekhar and Khadi, 2012). Asiatic cotton (*G. arboreum*) are locally known as *desi* were grown on about 98 per cent area around 1947 and the American cotton (*G. hirsutum*) on just around 2 per cent. Presently, the situation is exactly the reverse.

However, now a days even short staple cotton is in great demand, particularly in fabrics like denim and upholstery. Also, it fetches price *at par* with the long-staple one. These aroused the interest for developing superior hybrids in Asiatic cotton. The competitive demand for fibre warrants to improving the productivity of cotton crop in such situation which is difficult to achieve through conventional hybridization and selection. Heterosis breeding seems to be good approach in these directions (Pathak and Gill, 2011).

The first ever success story of heterosis breeding in tetraploid cotton encouraged cotton breeders to explore the possibility of similar attempts in diploid cotton, that resulted in released hybrids *viz.*, G.Cot.DH7 and G.Cot.DH9, which have not covered sizable area, due to the problem of seed production, the high cost of conventional hybrid seed, which are limiting factors for poor/ marginal farmers to grow hybrids. Hence, the system of male sterilities are of great significance in practical, as it avoids laborious process of emasculation and it can add in production of hybrid seed. However, with the availability of genetic male sterility (GMS), in *G. arboreum* seed production cost can be reduced with increased purity. Therefore, this system seems to be the best, economical and alternative method for hybrid seed production in diploid cotton (Mehetre, 2015). But due to less cross boll setting, small boll size, poor boll bursting and locule retention, the hybrid seed production in *G. arboreum* is not feasible or economical for farmers. So, their is need to improve GMS lines having stable performance in term of boll retention, boll size and boll bursting. hence the present investigation was carried out to identify GMS lines having maximum cross boll setting with big boll size, excellent boll bursting and retention for hybrid seed production of *G. arboreum*.

MATERIALS AND METHODS

The experiment was conducted during *kharif* 2015 and 2016. The experimental material involve 10 promising diverse GMS lines as female parent and 9 diverse lines as male parent having agronomically superior and with good yield contributing traits. The crosses were attempted in line × tester *desi*gn using GMS as female and pure lines as male parents. The experiment was carried out at different dates of sowing in both the seasons. During *kharif*, 2015 it was sown on 30/05/2015 as early and in *kharif*, 2016 as late sown crop on 28/06/2016. The experimental material was sown in four rows with 6.0 m length at Research and Development Division, Nirmal Seed Pvt. Ltd,. Bhadgaon, Jalgaon with the spacing 120 x 90 cm. The GMS female parents were sown with 5 seeds / hill and male parents with 2 seeds/ hill. Recommended agronomic and plant protection measures were taken during the crop season.

Before crossing programme initiated, from the GMS female lines fertile plants were removed at the time of flowering, keeping only sterile plants for the crossing programme. The crossing programme was initiated during second week of August and continue till last week of October in *kharif,* 2015, while crossing was carried out from September first week to Novemeber second week in *kharif,* 2016. The flower buds in GMS lines expected to open on next day morning were covered with the butter paper bag on previous day in between 3.0 to 5.0 pm. On the next day morning the butter paper bags were removed and flower buds were pollinated with the flower of male lines used as tester. The pollination work was done in between 8.0 am to 12.0 noon. Single male flower was used to pollinate 2-3 female flowers. On each day, number of pollinated flowers buds in each GMS lines were counted and labelled with jewel tags with dates. The number of flower bud pollinated count was also recorded. At the time of boll bursting stage, crossed bolls were harvested with count. The per cent boll setting was calculated by dividing the number of opened crossed bolls to the total numbers of crossed flowers/buds × 100 (Sawan *et al.,* 2005).

RESULTS AND DISCUSSION

In diploid cotton GMS lines the setting of crossed bolls is affected by various factors like season, location, genotype, sowing dates, skill of labour and climatic conditions. Genotypic differences seems to play an important role in crossed boll setting. The perusal of data in Table 1 reveals that the cross boll setting in early sown crop during *kharif* 2015 ranged from 7.7 (NCAGA 22 x NSA 306) to 67.5 per cent (NCAGA 13 x NSA 318) in different GMS based cross combinations. Whereas, in late sown crop during *kharif* 2016 it ranged from 4.5 (NCAGA 6 x NSA 319) to 52.2 (NCAGA 13 x NSA 502). Maximum crossed boll setting (49.2 and 36.2%) was observed in crosses having NCAGA 13 as a common female parent with different testers followed by NCAGA 46 (33.6 and 23.3 %) and NCAGA 5 (31.2 and 24.4 %) in both growing season. The least crossed boll setting was observed in crosses NCAGA 22 (17.5 and 17.0 %) as a female parent for both the seasons. The highest per cent of crossed boll setting was observed in crosses having NSA 502 (37.0 and 29.5 %) as testers followed by NSA 256 (32.9 and 27.0 %) and NSA 236 (32 and 23.9 %) in both the seasons. The least crossed boll setting was observed in crosses having NSA 319 (13.5 and 11.8 %) and NSA 322 (15.9 and 13.5) as common testers (Table 2). The two year study revealed that during *kharif* 2015 early sown crop having maximum cross boll setting as compared to late sown crop of *kharif* 2016. It indicated that the early sown crop also benefits for cross boll setting in diploid cotton. These results indicated that genotypic differences played a vital role in crossed boll setting, although the variation could be partly due to the difference in environmental conditions. The probable reasons for differences in per cent crossed boll setting may be the difference in receptivity of stigma in GMS lines and cross compatibility. Similar result were found by Sangwan *et al.,* (2010) in hand emasculation and pollination in *G. arboruem.*

During the crossing programme the minimum temperature was up to 23 °C and minimum relative humidity upto 45 per cent. The average cross boll setting in GMS lines was ranged in between 45-60 per cent. Where as the minimum temperature (less than 20 °C) and relative humidity (less than 40 %) decreased cross boll setting in GMS lines. The rainfall during the crossing period also affected the crossed boll setting. It indicated that there is positive correlation between cross boll setting and enviromental factors such as rainfall, minimum temperature and relative humidity. (Table 3). Similar results were found by Balakrishna *et al.,*(2015) in inter-specific

Table 1. Genotypic effect of female parent (GMS line) on per cent cross boll setting in *desi* cotton

Season	*Kharif,* 2015			*Kharif,* 2016		
Sowing date	30/05/2015			28/06/2016		
Cross	Cross attempted	Crossed boll set	Boll setting (%)	Cross attempted	Crossed boll set	Boll setting (%)
NCAGA 4						
NCAGA 4 x NSA 29	137	42	30.7	76	20	26.3
NCAGA 4 x NSA 236	146	48	32.9	80	15	18.8
NCAGA 4 x NSA 256	206	56	27.2	78	16	20.5
NCAGA 4 x NSA 306	237	82	34.6	74	11	14.9
NCAGA 4 x NSA 312	143	20	14.0	69	13	18.8
NCAGA 4 x NSA 318	134	46	34.3	72	14	19.4
NCAGA 4 x NSA 319	137	21	15.3	92	10	10.9
NCAGA 4 x NSA 322	144	13	9.0	88	10	11.4
NCAGA 4 x NSA 502	153	63	41.2	80	24	30.0
Mean	**160**	**43**	**26.6**	**79**	**15**	**19.0**
NCAGA 5						
NCAGA 5 x NSA 29	174	58	33.3	113	24	21.2
NCAGA 5 x NSA 236	157	60	38.2	80	23	28.8
NCAGA 5 x NSA 256	131	41	31.3	88	22	25.0
NCAGA 5 x NSA 306	138	52	37.7	78	19	24.4
NCAGA 5 x NSA 312	135	44	32.6	96	19	19.8
NCAGA 5 x NSA 318	136	40	29.4	106	34	32.1
NCAGA 5 x NSA 319	159	18	11.3	94	10	10.6
NCAGA 5 x NSA 322	143	32	22.4	69	14	20.3
NCAGA 5 x NSA 502	112	50	44.6	93	35	37.6
Mean	**143**	**44**	**31.2**	**91**	**22**	**24.4**
NCAGA 6						
NCAGA 6 x NSA 29	119	30	25.2	70	18	25.7
NCAGA 6 x NSA 236	118	40	33.9	55	12	21.8
NCAGA 6 x NSA 256	133	37	27.8	59	13	22.0
NCAGA 6 x NSA 306	155	60	38.7	65	16	24.6
NCAGA 6 x NSA 312	113	25	22.1	90	7	7.8
NCAGA 6 x NSA 318	135	42	31.1	65	18	27.7
NCAGA 6 x NSA 319	134	17	12.7	67	3	4.5
NCAGA 6 x NSA 322	167	23	13.8	83	5	6.0
NCAGA-6 x NSA 502	149	48	32.2	78	16	20.5
Mean	**136**	**36**	**26.4**	**70**	**12**	**17.9**
NCAGA 13						
NCAGA 13 x NSA 29	91	40	44.0	120	40	33.3
NCAGA 13 x NSA 236	114	68	59.6	123	46	37.4
NCAGA 13 x NSA 256	93	51	54.8	76	34	44.7
NCAGA 13 x NSA 306	133	60	45.1	77	33	42.9
NCAGA 13 x NSA 312	105	58	55.2	82	22	26.8
NCAGA 13 x NSA 318	126	85	67.5	102	47	46.1

Table 1 contd...

Table 1. contd...

NCAGA 13 x NSA 319	109	34	31.2	104	26	25.0
NCAGA 13 x NSA 322	132	40	30.3	126	22	17.5
NCAGA 13 x NSA 502	126	69	54.8	69	36	52.2
Mean	**114**	**56**	**49.2**	**98**	**34**	**36.2**
NCAGA 22						
NCAGA 22 x NSA 29	78	9	11.5	49	12	24.5
NCAGA 22 x NSA 236	78	14	17.9	68	8	11.8
NCAGA 22 x NSA 256	105	31	29.5	72	21	29.2
NCAGA 22 x NSA 306	65	5	7.7	79	17	21.5
NCAGA 22 x NSA 312	91	19	20.9	46	8	17.4
NCAGA 22 x NSA 318	66	10	15.2	65	9	13.8
NCAGA 22 x NSA 319	52	7	13.5	68	4	5.9
NCAGA 22 x NSA 322	95	10	10.5	72	5	6.9
NCAGA 22 x NSA-502	58	18	31.0	63	14	22.2
Mean	**76**	**14**	**17.5**	**65**	**11**	**17.0**
NCAGA 30						
NCAGA 30 x NSA 29	56	18	32.1	54	14	25.9
NCAGA 30 x NSA 236	89	23	25.8	45	9	20.0
NCAGA 30 x NSA 256	82	20	24.4	67	14	20.9
NCAGA 30 x NSA 306	48	14	29.2	64	17	26.6
NCAGA 30 x NSA 312	68	26	38.2	48	5	10.4
NCAGA 30 x NSA 318	56	21	37.5	63	9	14.3
NCAGA 30 x NSA 319	70	15	21.4	60	6	10.0
NCAGA 30 x NSA 322	60	15	25.0	56	7	12.5
NCAGA 30 x NSA 502	77	23	29.9	79	22	27.8
Mean	**67**	**19**	**29.3**	**60**	**11**	**18.7**
NCAGA 31						
NCAGA 31 x NSA-29	95	31	32.6	67	12	17.9
NCAGA 31 x NSA-236	95	34	35.8	60	9	15.0
NCAGA 31 x NSA-256	105	37	35.2	64	18	28.1
NCAGA 31 x NSA-306	88	16	18.2	52	12	23.1
NCAGA 31 x NSA-312	53	12	22.6	85	10	11.8
NCAGA 31 x NSA-318	69	7	10.1	88	19	21.6
NCAGA 31 x NSA-319	68	8	11.8	68	9	13.2
NCAGA 31 x NSA-322	104	12	11.5	70	8	11.4
NCAGA 31 x NSA-502	105	32	30.5	61	14	23.0
Mean	**87**	**21**	**23.2**	**68**	**12**	**18.3**
NCAGA 32						
NCAGA 32 x NSA-29	99	14	14.1	89	16	18.0
NCAGA 32 x NSA-236	141	40	28.4	50	13	26.0
NCAGA 32 x NSA-256	98	34	34.7	69	15	21.7
NCAGA 32 x NSA-306	107	21	19.6	48	12	25.0
NCAGA 32 x NSA-312	182	45	24.7	90	14	15.6
NCAGA 32 x NSA-318	103	17	16.5	93	22	23.7

Table 1 contd...

Table 1. contd...

NCAGA 32 x NSA-319	63	9	14.3	105	11	10.5
NCAGA 32 x NSA-322	103	19	18.4	60	7	11.7
NCAGA 32 x NSA-502	79	15	19.0	82	23	28.0
Mean	**108**	**24**	**21.1**	**76**	**15**	**20.0**
NCAGA 37						
NCAGA 37 x NSA 29	123	49	39.8	65	21	32.3
NCAGA 37 x NSA 236	124	27	21.8	64	20	31.3
NCAGA 37 x NSA 256	86	20	23.3	65	12	18.5
NCAGA 37 x NSA 306	122	56	45.9	97	23	23.7
NCAGA 37 x NSA 312	116	37	31.9	85	9	10.6
NCAGA 37 x NSA 318	104	29	27.9	63	10	15.9
NCAGA 37 x NSA 319	129	16	12.4	97	16	16.5
NCAGA 37 x NSA 322	106	18	17.0	53	11	20.8
NCAGA-37 x NSA 502	116	39	33.6	89	28	31.5
Mean	**114**	**32**	**28.2**	**75**	**17**	**22.3**
NCAGA 46						
NCAGA 46 x NSA 29	67	25	37.3	54	14	25.9
NCAGA 46 x NSA 236	107	29	27.1	40	11	27.5
NCAGA 46 x NSA 256	52	21	40.4	49	13	26.5
NCAGA 46 x NSA 306	74	21	28.4	46	14	30.4
NCAGA 46 x NSA 312	64	37	57.8	59	8	13.6
NCAGA 46 x NSA 318	123	37	30.1	58	12	20.7
NCAGA 46 x NSA 319	72	6	8.3	52	6	11.5
NCAGA 46 x NSA 322	61	12	19.7	68	14	20.6
NCAGA 46 x NSA 502	56	30	53.6	72	24	33.3
Mean	**75**	**24**	**33.6**	**55**	**13**	**23.3**

crosses of *G. hirsutum* x *G. barbadense.*

The promising 10 GMS lines and 9 pure male parental lines were evaluated for morphological characters and fibre quality parameters during *kharif* 2016 (Table 4). The lint samples of these promising lines were send to CIRCOT, Mumbai. Among GMS lines NCHGA 32 recorded 3.5 g boll weight followed by NCAGA 22 (3.4 g) and NCAGA 46 (3.3 g) and in male parental lines NSA 318 and NSA 502 were found 4.3 g boll weight. In terms of staple lenght, the GMS lines, NCAGA 6 (28.8 mm), NCAGA 5 (27.7 mm), NCAGA 31 (27.7 mm) and male parents NSA 306 (29.7 mm), NSA 236 (28.7 mm) , NSA 29 (27.8 mm), NSA 256 (27.3 mm) were found promising.

As compared to *G. hirsutum* cross combinations by conventional method the cross boll setting in *G. arboreum* cross combinations in GMS lines was low due to vulnerable to fluctuating environmental condition and receptivity of stigma in GMS lines. The results reveal that the minimum temperature coupled with minimum relative humidity plays a crucial role in deciding amount of per cent crossed boll setting in GMS lines of diploid cotton . Success of hybrid seed production in diploid cotton depends upon selecting compatible (GMS line) parents having maximum cross boll setting, but also depends upon environmental conditions prevailing

Table 2. Genotypic effect of male parent on per cent cross boll setting in *desi* cotton

Season	*Kharif,* 2015			*Kharif,* 2016		
Sowing date	30/05/2015			28/06/2016		
Cross	Cross attempted	Crossed boll set	Boll setting (%)	Cross attempted	Crossed boll set	Boll setting (%)
NSA 29						
NCAGA 4 x NSA 29	137	42	**30.7**	76	20	**26.3**
NCAGA 5 x NSA 29	174	58	**33.3**	113	24	**21.2**
NCAGA 6 x NSA 29	119	30	**25.2**	70	18	**25.7**
NCAGA 13 x NSA 29	91	40	**44.0**	120	40	**33.3**
NCAGA 22 x NSA 29	78	9	**11.5**	49	12	**24.5**
NCAG 30 x NSA 29	56	18	**32.1**	54	14	**25.9**
NCAGA 31 x NSA 29	95	31	**32.6**	67	12	**17.9**
NCAGA 32 x NSA 29	116	12	**10.3**	89	16	**18.0**
NCAGA 37 x NSA 29	123	49	**39.8**	89	28	**31.5**
NCAGA 46 x NSA 29	67	25	**37.3**	54	14	**25.9**
Mean	**106**	**32**	**29.7**	**78**	**20**	**25.0**
NSA 236						
NCAGA 4 x NSA 236	146	48	**32.9**	80	15	**18.8**
NCAGA 5 x NSA 236	157	60	**38.2**	80	23	**28.8**
NCAGA 6 x NSA 236	118	40	**33.9**	55	12	**21.8**
NCAGA 13 x NSA 236	114	68	**59.6**	123	46	**37.4**
NCAGA 22 x NSA 236	78	14	**17.9**	68	8	**11.8**
NCAGA 30 x NSA 236	89	23	**25.8**	45	9	**20.0**
NCAGA 31 x NSA 236	95	34	**35.8**	60	9	**15.0**
NCAGA 32 x NSA 236	141	40	**28.4**	50	13	**26.0**
NCAGA 37 x NSA 236	124	27	**21.8**	65	21	**32.3**
NCAGA 46 x NSA 236	107	29	**27.1**	40	11	**27.5**
Mean	**117**	**39**	**32.1**	**67**	**17**	**23.9**
NSA-256						
NCAGA 4 x NSA 256	206	56	**27.2**	78	16	**20.5**
NCAGA 5 x NSA 256	131	41	**31.3**	88	22	**25.0**
NCAGA 6 x NSA 256	133	37	**27.8**	59	13	**22.0**
NCAGA 13 x NSA 256	93	51	**54.8**	76	34	**44.7**
NCAGA 22 x NSA 256	105	31	**29.5**	72	21	**29.2**
NCAGA 30 x NSA 256	82	20	**24.4**	67	14	**20.9**
NCAGA 31 x NSA 256	105	37	**35.2**	64	18	**28.1**
NCAGA 32 x NSA 256	98	34	**34.7**	69	15	**21.7**
NCAGA 37 x NSA 256	86	20	**23.3**	64	20	**31.3**
NCAGA 46 x NSA 256	52	21	**40.4**	49	13	**26.5**
Mean	**109**	**36**	**32.9**	**69**	**19**	**27.0**
NSA 306						
NCAGA 4 x NSA 306	237	82	**34.6**	74	11	**14.9**
NCAGA 5 x NSA 306	138	52	**37.7**	78	19	**24.4**
NCAGA 6 x NSA 306	155	74	**47.7**	65	16	**24.6**
NCAGA 13 x NSA 306	133	60	**45.1**	77	33	**42.9**

Table 2 contd...

Table 2 contd...

NCAGA 22 x NSA 306	65	5	**7.7**	79	17	**21.5**
NCAGA 30 x NSA 306	48	14	**29.2**	64	17	**26.6**
NCAGA 31 x NSA 306	88	16	**18.2**	52	12	**23.1**
NCAGA 32 x NSA 306	107	21	**19.6**	48	12	**25.0**
NCAGA 37 x NSA 306	122	56	**45.9**	65	12	**18.5**
NCAGA 46 x NSA 306	74	21	**28.4**	46	14	**30.4**
Mean	**117**	**42**	**31.4**	**65**	**17**	**25.2**
NSA 312						
NCAGA 4 x NSA 312	143	20	**14.0**	69	13	**18.8**
NCAGA 5 x NSA 312	135	44	**32.6**	96	19	**19.8**
NCAGA 6 x NSA 312	113	25	**22.1**	90	7	**7.8**
NCAGA 13 x NSA 312	105	58	**55.2**	82	22	**26.8**
NCAGA 22 x NSA 312	91	19	**20.9**	46	8	**17.4**
NCAGA 30 x NSA 312	68	26	**38.2**	48	5	**10.4**
NCAGA 31 x NSA 312	53	12	**22.6**	85	10	**11.8**
NCAGA 32 x NSA 312	182	45	**24.7**	90	14	**15.6**
NCAGA 37 x NSA 312	116	37	**31.9**	85	9	**10.6**
NCAGA 46 x NSA 312	64	37	**57.8**	59	8	**13.6**
Mean	**107**	**32**	**32.0**	**75**	**12**	**15.3**
NSA 318						
NCAGA 4 x NSA 318	134	46	**34.3**	72	14	**19.4**
NCAGA 5 x NSA 318	136	40	**29.4**	106	34	**32.1**
NCAGA 6 x NSA 318	135	42	**31.1**	65	18	**27.7**
NCAGA 13 x NSA 318	126	85	**67.5**	102	47	**46.1**
NCAGA 22 x NSA 318	66	10	**15.2**	65	9	**13.8**
NCAGA 30 x NSA 318	56	21	**37.5**	63	9	**14.3**
NCAGA 31 x NSA 318	69	7	**10.1**	88	19	**21.6**
NCAGA 32 x NSA 318	103	17	**16.5**	93	22	**23.7**
NCAGA 37 x NSA 318	104	29	**27.9**	97	23	**23.7**
NCAGA 46 x NSA 318	123	37	**30.1**	58	12	**20.7**
Mean	**105**	**33**	**30.0**	**81**	**22**	**24.3**
NSA 319						
NCAGA 4 x NSA 319	137	21	**15.3**	92	10	**10.9**
NCAGA 5 x NSA 319	159	18	**11.3**	94	10	**10.6**
NCAGA 6 x NSA 319	134	17	**12.7**	67	3	**4.5**
NCAGA 13 x NSA 319	109	34	**31.2**	104	26	**25.0**
NCAGA 22 x NSA 319	52	0	**0.0**	68	4	**5.9**
NCAGA 30 x NSA 319	70	10	**14.3**	60	6	**10.0**
NCAGA 31 x NSA 319	68	10	**14.7**	68	9	**13.2**
NCAGA 32 x NSA 319	63	9	**14.3**	105	11	**10.5**
NCAGA 37 x NSA 319	129	16	**12.4**	63	10	**15.9**
NCAGA 46 x NSA 319	72	6	**8.3**	52	6	**11.5**
Mean	**99**	**15**	**13.5**	**77**	**10**	**11.8**
NSA 322						
NCAGA 4 x NSA 322	144	13	**9.0**	88	10	**11.4**

Table 2 contd...

Table 2 contd...

NCAGA 5 x NSA 322	143	32	**22.4**	69	14	**20.3**
NCAGA 6 x NSA 322	167	23	**13.8**	83	5	**6.0**
NCAGA 13 x NSA 322	132	40	**30.3**	126	22	**17.5**
NCAGA 22 x NSA 322	95	10	**10.5**	72	5	**6.9**
NCAGA 30 x NSA 322	60	7	**11.7**	56	7	**12.5**
NCAGA 31 x NSA 322	104	6	**5.8**	70	8	**11.4**
NCAGA 32 x NSA 322	103	19	**18.4**	60	7	**11.7**
NCAGA 37 x NSA 322	106	18	**17.0**	97	16	**16.5**
NCAGA-46 x NSA 322	61	12	**19.7**	68	14	**20.6**
Mean	**112**	**19**	**15.9**	**79**	**10**	**13.5**
NSA 502						
NCAGA 4 x NSA 502	153	63	**41.2**	80	24	**30.0**
NCAGA 5 x NSA 502	112	50	**44.6**	93	35	**37.6**
NCAGA 6 x NSA 502	149	48	**32.2**	78	16	**20.5**
NCAGA 13 x NSA502	126	69	**54.8**	69	36	**52.2**
NCAGA 22 x NSA 502	58	18	**31.0**	63	14	**22.2**
NCAGA 30 x NSA 502	77	23	**29.9**	79	22	**27.8**
NCAGA 31 x NSA 502	105	32	**30.5**	61	14	**23.0**
NCAGA 32 x NSA 502	79	15	**19.0**	82	23	**28.0**
NCAGA 37 x NSA 502	116	39	**33.6**	53	11	**20.8**
NCAGA 46 x NSA 502	56	30	**53.6**	72	24	**33.3**
Mean	**103**	**40**	**37.0**	**73**	**22**	**29.5**

during crossing programme. So, while planning the crossing programme in diploid cotton one should know the most compatible GMS lines having excellent boll setting. According the sowing window in North Maharshtra is to be adjusted between 25 May to 15 June have to get maximum yield in hybrid seed production of *desi* cotton. In present investigation, the GMS lines *viz.*, NCAGA 13, NCAGA 46 and NCAGA 5 were found to be promising for maximum cross boll setting. These lines may be exploited for commercial hybrid seed production in *desi* cotton after identification of best cross combination for yield and its contributing characters.

REFERENCES

Balakrishna B., Chenga Reddy V. and Siva Reddy K. V. 2015. Factors affecting crossed boll setting in inter specific crosses of cotton (*G. hirsutum* × *G. barbadense*). *Int. J. Pl. Animal and Env. Scie.* **5** : 80-85.

Mehetre, S., 2015. Constraints of hybrid seed production in upland and cultivated diploid cottons : Will different male sterility systems rescue? A review. *J. Cotton Res. Dev.* **29** 181-211.

Table 3. Effect of environmental factors on per cent cross boll setting of GMS lines in *G. arboreum* Location:- Bhadgaon

Month	Metro.	*Kharif,* 2015						*Kharif,* 2016					
	Standard Week	Cross boll set (%)	Temp (max) ^{0}C	Temp (min) ^{0}C	RH (max) (%)	RH (min) (%)	Rainfall (mm)	Cross boll set (%)	Temp (max) ^{0}C	Temp (min) ^{0}C	RH (max) (%)	RH (min) (%)	Rainfall (mm)
August	32	58	33	23	100	53	14	-	32	23	99	76	40
	33	52	34	23	100	54	15	-	34	22	97	45	0
	34	69	34	21	100	49	5	-	33	22	99	54	32
	35	64	34	21	99	50	6	-	33	23	100	58	130
September	36	48	35	23	100	44	36	47	32	21	99	53	3
	37	57	36	23	100	44	2	38	33	22	100	53	62
	38	36	33	22	100	53	117	34	31	23	100	68	87
	39	52	35	19	100	40	0	43	33	22	100	61	9
October	40	30	37	19	100	26	0	28	31	22	100	22	23
	41	32	38	19	95	19	0	20	33	18	100	29	0
	42	26	37	18	95	21	0	27	34	17	100	23	0
	43	28	37	20	94	29	0	23	33	17	96	27	0
November	44	14	36	16	97	27	0	16	31	11	100	12	0
	45	-	36	16	91	25		12	32	10	98	21	0
	46	-	34	14	91	27		-	31	10	100	27	0

Pathak, D. and Gill, M. S. 2011. Genes conditioning male sterility in *desi* cotton lines GAK 423 and DS 5 are non allelic. *Crop Improv.*, **38** : 97-98.

Sangwan, R. S., Siwach, S. S. and Punia, D. P. 2010. Factor affecting crossed boll setting in hand emasculation and pollination techniques in *Gossypium arboreum. J. Cotton Res. Dev.* **24** :138-40**.**

Sawan, Z. M., Hanna, L. I and McCuistion, W. L. 2005. Response of flower and boll development to climatic factors before and after anthesis in Egyptian cotton. *Climate Research.***29**: 167-79.

Sekhar, L. and Khadi, B.M. 2012. Genetic, biochemical, histological and molecular analysis of thermo sensitive genetic male sterility (TGMS) in cotton (*Gossypium arboreum* L.). In Book of papers Silver Jubilee International Symposium "*Global Cotton Production Technologies vis-à-vis Climate Change*" held at HAU, Hisar during 10-12 October,2012, pp. 169-77.

Received for publication : December 6, 2017
Accepted for publication : March 2, 2018