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Research Note

Variability among north carolina designs in okra (*Abelmoschus esculentus* (L.) Moench)

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Abstract
The progenies developed through North Carolina Designs (NCD I, II and III) in F_2 populations of okra *viz.*, HRB-55 x Kamini (cross-1) and BO-13 x Parbhani Kranti (cross-2) were used to study the variability. The results of yield, plant height, number of nodes per plant, fruit girth and average number of fruits per plant was observed higher in NCD II for both the crosses. The value of CV was also higher in NCD II for yield, average number of fruits per plant and fruit weight in two cross. The test of significance between the means of progenies developed through North Carolina designs I, II and III for yield per plant, plant height, number of nodes per plant and intermodal length was observed significant in both cross. The average fruit length indicated significant difference in all the designs for both the crosses barring NCD I and NCD II in cross 1. The fruit girth was significantly higher in NCD II over NCD I in cross 1. The mean fruit weight was found more in NCD I for the cross 1 and NCD III for the cross 2. Early flowering was observed in NCD II for the cross 1 and it was significant with NCD I. The higher value of CV was observed in NCD II for the cross 1 and NCD III for the cross 2 for flowering.

Key words
NCD I, NCDII, NCD III and Okra

The genetic improvement of any crop relies mainly on the presence of substantial magnitude of variability in the population. Plant breeders are always engaged with various breeding procedures for crop improvement, out of which, till now, is to hybridize diverse genotypes possessing complementary desirable characters, followed by selection in F_2 and subsequent generations, combining these characteristics from both the parents. The mating design refers to a system of mating employed to develop progenies of certain kinds. Therefore, the present study on comparison among various NC designs was planned to select proper design for the study of variability obtained in okra.

The seeds of F_1 generation of two crosses of okra *viz.*, HRB-55 x Kamini (Cross 1) and BO-13 x Parbhani Kranti (Cross 2) were obtained from the Vegetable Research Station, Junagadh Agricultural University, Juanagdh and F_2 generation was obtained by selfing the F_1 generation at the same place during the *kharif* 2006. The plants of F_2 population of the crosses were utilized for generating the experimental materials for NCD I, II and III during the summer 2007.

North Carolina Design I: Crosses for NCD I (Comstock and Robinson, 1952) were made in F_2 populations of HRB-55 x Kamini (Cross 1) and BO-13 x Parbhani Kranti (Cross 2) using randomly selected plants each for male and female. Each male was mated to five different randomly selected plants as females. Thus, 25 crosses were obtained for NCD I for each cross during summer 2007. The selected plants as male (five plants) and female (twenty five plants) were also selfed by bagging the flower with white butter paper and the seeds were collected at the time of maturity. Thus, the experimental materials for each cross in this design consisted of 25 crosses and 30 selfed progenies (F_3) making a total of 110 progenies from the two crosses for NCD I.

North Carolina Design II: From each F_2 base population (Cross 1 and Cross 2) five plants each as male and female were selected at random and were mated in all possible combinations. Thus, 25 crosses were made in each base population. The plants selected as males and females were also selfed. Thus, the experimental material for each cross in this design consisted 25 crosses and 10 selfed progenies (F_3) totally 70 progenies from two crosses for NCD II.

North Carolina Design III: The experimental material for North Carolina Design III was generated using the parents of each base population i.e. HRB-55 and Kamini for Cross 1 and BO-13 and Parbhani Kranti for Cross 2 as females and were crossed with five randomly selected plants as male from their respective F_2. Thus, 10 crosses were made from each base population. The selected male and female plants were also selfed. Thus, the experimental material obtained from each

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cross in this design consisted 10 crosses and 7 selfed progenies with sum of 34 progenies from the two crosses for NCD-III.

Experimental designs: The experimental progenies developed in NCD I, II and III were evaluated alongwith their selfed progenies of parent plants in a compact family block design with two replications for designs I & II and three replications to maintain error degrees of freedom for design III. Each entry was sown in a single row having 20 plants, with a spacing of 60 x 30 cm. Thus, the plot size was 6.0 x 0.6 m. All the recommended agronomic practices were followed to raise the good crop.

The observations were recorded for days to flowering, number of nodes per plant, internodal length (cm), plant height (cm), fruit length (cm) , fruit girth (cm), number of fruits per plant, yield per plant (g) and average fruit weight (g) from 10 randomly selected plants from each progeny.

Mean, range and coefficient of variation: The overall mean, range and coefficient of variation for nine character of okra under study for North Carolina Designs I, II, III are given in Table 1.

North Carolina Designs (NCD): The differences among the mean values obtained in the various NC designs for nine character within crosses were tested by student 't' test (Snedecor and Cocharan, 1994). The results (Table 1) indicated that the highest overall yield was observed in NCD II (150.68 gm/plant and 163.02 gm/plant) followed by NCD III (147.75 gm/plant and 155.50 gm/plant) and in NCD-I i.e. 141.06 gm/plant and 149.95 gm/plant for both the crosses *viz.*, HRB-55 x Kamini and BO-13 x Parbhani Kranti). The results (Table 2) indicated that the yield of NCD II was statistically significant over NCD I and NCD III. The value of CV varied from 9.39 to 12.49% in different NC designs for two cross. Similar trend was also reported by Bains *et al*. (1982) while comparing three NC design alongwith the generation mean analysis in inter-varietal cross of cotton. Higher mean values in NCD II might be due to higher number of progenies belonging to the upper-side of the range in both the crosses. Similar results were also obtained by Patel (1997) in tobacco.

Mean plant height was the highest in NCD II (106.75 cm and 116.60 cm) followed by NCD I (102.68 cm and 112.51 cm) and NCD III (97.95 cm and 96.03 cm) for both the crosses, respectively. Plant height was significantly higher in NCD II over NCD I and NCD III in both the crosses. The higher variability (15.78% and 15.27%) was observed in NCD III for both the crosses whereas more or less similar variability was observed for both the crosses in NCD I and NCD II. These results are in close agreement with those reported by Patel (1997) in cross 2 of tobacco.

The average number of nods per plant were higher in NCD II (16.31 and 18.20) for both the crosses. It was significant over NCD I and NCD III for both the crosses. The percentage variability was more in cross 1, when it was compared with cross 2 in NCD I and NCD II, whereas it was more in cross 2 (12.80%) than cross 1(12.39%) in NCD III.

The mean value of middle inter nodal length of plant was the highest in NCD III (6.73 cm and 7.43 cm) followed by NCD II (5.71 cm and 6.43 cm) and NCD I (5.44 cm and 6.19 cm) for both the crosses. The inter-nodal length was significantly higher in NCD III over NCD I and NCD II in both the crosses. The higher variability (21.24 to 23.53%) was observed in cross 1 as compared to cross 2 (17.01 to 20.91%) for all three NC designs.

The average fruit length indicated significant difference in all the designs for both the crosses barring NCD I and NCD II in cross 1. Higher value (12.75 cm) of fruit length was observed in NCD II for the cross 1 and NCD I for the cross 2 (12.90 cm). The higher variability (15.99% and 18.08%) was observed in NCD I for both the crosses.

The mean of fruit girth (5.14 cm and 5.19 cm) was observed high in NCD II for both the crosses. The CV values varied from 11.38 to 12.21% in different NC designs in both the crosses. The fruit girth was significantly higher in NCD II over NCD I in cross 1.

The average number of fruits per plant varied from 11.60 to 12.99 with the variability of 19.17% and 22.69% which were higher in NCD II and was significant over NCD I for both the crosses. Similar trend was also reported by Bains *et al*. (1982) in case of number of bolls/plant in cotton, while comparing three NC designs alongwith the generation mean analysis in inter-varietal cross of cotton. Higher mean values in NCD II might be due to higher number of progenies belonging to the upper-side of the range in both the crosses.

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The mean fruit weight (13.26 gm/pod) was found more in NCD I for the cross 1 and NCD III for the cross 2 (12.84 gm/pod). The CV (16.96% and 20.98%) was the highest in NCD II for both the crosses. Bains *et al*. (1982) observed higher boll weight in NCD I, while comparing three NC designs alongwith the generation mean analysis in inter-varietal cross of cotton indicating close agreement of this finding.

Early flowering (50.81 day) was observed in NCD II for the cross 1 and it was significant with NCD I. While in cross 2, early flowering (48.09 day) was observed in NCD III and was significant over NCD I and NCD II. Early flowering of tobacco was noted in NCD III for the cross 2 by Patel (1997). The higher value of CV (7.66%) was observed in NCD II for the cross 1 and NCD III for the cross 2 (7.34%).

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Table 1. Mean, range and coefficient of variation for different characters of the progenies developed through North Carolina designs I, II and III.

Sl. No.	Characters		Cross 1 (HRB-55 x Kamini)			Cross 2 (BO-13 x Parbhani Kranti)		
			North Carolina designs			North Carolina designs		
			I	II	III	I	II	III
1	Yield / plant (g)	Mean	141.06	150.68	147.75	149.95	163.02	155.50
		Range	105.00-190.00	120.00-180.00	105.34-199.15	109.00-204.00	128.00-197.00	102.00-192.00
		CV %	10.31	11.49	10.69	9.39	12.49	11.21
2	Plant height (cm)	Mean	102.68	106.75	97.95	112.51	116.60	96.03
		Range	73.00-141.00	76.00-141.00	70.00-130.00	78.00-152.00	85.00-156.00	65.00-138.00
		CV %	11.03	11.07	15.78	9.45	9.81	15.27
3	No. of Nodes / plant	Mean	15.55	16.31	14.80	17.56	18.20	13.16
		Range	10-22	11-21	10-19	12-22	12-21	10-18
		CV %	11.97	11.71	12.39	9.92	8.65	12.80
4	Internodal length (cm)	Mean	5.44	5.71	6.73	6.19	6.43	7.43
		Range	3.00-9.80	3.09-9.36	4.12-11.64	3.33-11.88	3.50-9.98	4.69-13.50
		CV %	23.53	22.34	21.24	19.03	17.01	20.91
5	Fruit length (cm)	Mean	12.70	12.75	11.78	12.90	11.58	11.93
		Range	6.00-18.00	9.00-16.00	6.41-17.22	6.00-21.00	6.00-16.50	7.21-16.87
		CV %	15.99	13.18	14.59	18.08	11.14	15.48
6	Fruit girth (cm)	Mean	5.06	5.14	5.13	5.13	5.19	5.18
		Range	3.50-6.50	3.64-6.83	3.37-6.96	3.50-6.80	3.68-7.07	3.50-6.94
		CV %	11.38	11.90	11.63	11.91	12.10	12.21
7	No. of fruits / plant	Mean	10.86	11.60	11.36	12.31	12.99	12.39
		Range	6-16	6-17	8-15	6-21	6-22	8-15
		CV %	17.92	19.17	13.05	21.41	22.69	14.67
8	Average fruit weight (g)	Mean	13.26	12.47	13.23	12.62	12.43	12.84
		Range	8.75-23.33	7.06-19.67	8.10-19.37	8.00-21.00	6.69-20.00	7.54-20.57
		CV %	14.15	16.96	16.34	19.04	20.98	19.23
9	Days to flowering	Mean	53.67	50.81	50.87	54.00	51.77	48.09
		Range	41-61	45-57	40-63	42-62	46-57	41-58
		CV %	6.45	7.66	7.43	6.73	6.63	7.34

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Table 2. Test of significance between the means of progenies developed through North Carolina designs I, II and III

Sl. No.	Character	Cross 1 (HRB-55 x Kamini)			Cross 2 (BO-13 x Parbhani Kranti)		
		North Carolina designs					
		I/II	I/III	II/III	I/II	I/III	II/III
1	Yield / plant (g)	*	*	*	*	*	*
2	Plant height (cm)	*	*	*	*	*	*
3	No. of Nodes / plant	*	*	*	*	*	*
4	Internodal length (cm)	*	*	*	*	*	*
5	Fruit length (cm)	ns	*	*	*	*	*
6	Fruit girth (cm)	*	ns	ns	ns	ns	ns
7	No. of fruits / plant	*	*	ns	*	ns	*
8	Average fruit weight (g)	*	ns	*	ns	ns	*
9	Days to flowering	*	*	ns	*	*	*

* Significant at P = < 0.05 ns : non-significant