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PERFORMANCE OF DOUBLE CROSS HYBRIDS IN MAIZE
(*Zea mays* L.)

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ABSTRACT

The present study was conducted with the objectives to asses the possibility of the extent of heterosis for yield and yield contributing characters and to identify superior double hybrids. In *kharif* 2017, forty five double crosses (DC) along with five parents and one check (Rajarshi) were evaluated in two replications and data were recorded on grain yield and yield contributing traits. Among 45 double crosses, only 5 double crosses *viz.,* DC [NMI-3 × NAUM-8] × [NMI-3 × NAUM-26], DC [NMI-3 × NAUM-14] × [NAUM-26 × NAUM-14], DC [NAUM-8 × NAUM-14] × (NAUM-8 × NAUM-21], DC [NMI-3 × NAUM-8] × [NMI-3 × NAUM-21] and DC [NMI-3 × NAUM-14] × [NAUM-14 × NAUM-21] were identified as best double crosses on the basis of high *per se* performance and useful heterosis in desirable direction. Hence, it is suggested that these five double crosses could be used directly for heterosis breeding in maize after proper evaluation.

(K*ey words*: Maize, double crosses, heterosis, quantitative traits)

INTRODUCTION

Maize (*Zea mays* L.) being a highly cross pollinated crop and there is a wide scope for the development of stable hybrids and varieties in maize. The discovery of heterosis phenomenon, the development of hybrid breeding technology and successful commercial exploitation of heterosis in maize is considered as significant landmark achievement in the history of agriculture during the present century. Shull (1908 and 1911) proposed to exploit heterosis in maize by developing single cross hybrids between pure inbred lines derived from open-pollinated varieties. However, parental homozygous inbred lines derived from the open pollinated cultivars were so weak that it was not feasible to use them in commercial hybrid seed production. In 1918, Jones proposed that, the use of double cross hybrids to overcome these difficulties in the single cross hybrids. The report given by Jones in 1958, double cross hybrids are genetically more variable, stable and consistent in performance than single crosses. Now double cross hybrids predominate the commercial hybrids world over. Development of double cross hybrids depends on the *per se* performance of inbreds and their extent of heterosis for important characters. The information about the heterotic pattern facilitates breeders in selection and development of double cross hybrids. The information derived from this research work help in identifying superior double cross hybrids for their exploitation in maize.

MATERIALS AND METHODS

The present research work was conducted in the Research farm of Agricultural Botany Section, College of Agriculture, Nagpur during *rabi* 2016 and *kharif* 2017. During *rabi* 2016 ten single crosses were raised and crossings were followed to produce forty five double crosses from ten single crosses. The experimental materials i.e. crossed seeds of forty five double crosses along with five inbreds and one check (Rajarshi) were grown in Randomized Block Design with two replications with the spacing of 60 cm × 20 cm accommodating 15 plants in each row for evaluation in *kharif* 2017. All the agronomic recommended packages of practices and plant protection practices were followed to raise good crop. The data were recorded on five randomly selected plants from each genotype on seven characters *viz.,* plant height (cm), cob length (cm), cob girth (cm), number of grains cob^{-1}, 100 grain weight (g), grain yield plant^{-1} (g) and grain yield plot^{-1} (kg) except three characters *viz.,* days to 50% tasseling, days to 50% silking and days to maturity which were recorded on plot basis. The analysis of variance for experimental design for different characters were analyzed by the method given by Panse and Sukhatme (1954). The magnitude of heterosis

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was calculated as the deviation of F_1 hybrid over average of two parents while magnitude of useful heterosis was calculated as deviation of F_1 over check variety.

RESULTS AND DISCUSSION

The results of analysis of variance for all ten characters studied are presented in table 1. The mean squares due to genotypes were highly significant for all the ten characters studied i.e. days to 50% tasseling, days to 50% silking, days to maturity, plant height, cob length, cob girth, number of grains cob^{-1}, 100 grain weight, grain yield plant^{-1} and grain yield plot^{-1}. This indicates the presence of wide genetic variation among the genotypes (parents, crosses and check) for all the ten characters. The analysis of variance for the experimental design thus indicated the presence of substantial genetic variability among the genotypes which allows the further estimation in the experimental material. The wide variability for grain yield plant^{-1} and yield contributing characters in maize were also observed by, Shakoor *et al.* (2007), Iqbal *et al.* (2010), Amanullah *et al.* (2011), Avinashe *et al.* (2013) and Ghanwat *et al.*(2016).

The *per se* performance of parents, double crosses and check for ten characters recorded in maize are presented in table 2. On the basis of *per se* performance studied for the yield and yield contributing characters among the 45 double crosses with the check Rajarshi, the double cross DC (NMI-3 × NAUM-8) × (NMI-3 × NAUM-26) recorded significant superiority over the check Rajarshi for eight characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, number of grains cob^{-1}, cob girth, cob length, plant height, days to 50% tasseling and days to 50% silking. The double cross DC (NAUM-8 × NAUM-14) × (NAUM-8 × NAUM-21) performed significantly superior over the check Rajarshi for seven characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, number of grains cob^{-1}, cob girth, cob length, days to 50% tasseling and days to 50% silking. The double cross DC (NMI-3 × NAUM-8) × (NMI-3 × NAUM-21) was found to be significantly superior over the check for six characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, number of grains cob^{-1}, cob girth, cob length and days to 50% tasseling. The double cross DC (NAUM-26 × NAUM-21 × (NAUM-14 × NAUM-21) was found to be significantly superior over the check for six characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, cob length, 100 grain weight, days to 50% tasseling and days to 50% silking. The double cross DC (NMI-3 × NAUM-14) × (NAUM-14 × NAUM-21) was found to be significantly superior over the check for six characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, cob length, cob girth, days to 50% tasseling and days to 50% silking. The double cross DC (NMI-3 × NAUM-14) × (NAUM-26 × NAUM-14) recorded significant superiority over the check Rajarshi for five characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, cob girth, cob length and days to 50% silking. Hence, these six double crosses were identified as potential crosses for exploiting heterosis on the basis of *per se* performance.

The estimation of standard heterosis over the check Rajarshi, revealed the response of heterosis for all ten characters studied as presented in table 2. On the basis of useful heterosis studied for yield and yield contributing characters, among forty five the double cross DC (NMI-3 × NAUM-8) × (NMI-3 × NAUM-26) was identified to exhibit significant useful hetrosis over the check Rajarshi for eight characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, number of grains cob^{-1}, cob girth, cob length, plant height, days to 50% tasseling and days to 50% silking the desirable direction. The double cross DC (NMI-3 × NAUM-14) × (NAUM-26 × NAUM-14) was found to exhibit significant useful heterosis for the four characters *viz.,*grain yield plant^{-1}, plant height, cob girth and cob length. The double cross DC (NAUM-8 × NAUM-14) × (NAUM-8 × NAUM-21) was identified to exhibit significant useful heterosis over the check Rajarshi for six characters *viz.* grain yield plot^{-1}, grain yield plant^{-1}, cob girth, cob length, days to 50% tasseling and days to 50% silking. The double cross DC (NMI-3 × NAUM-8) × (NMI-3 × NAUM-21) was found to exhibit significant useful heterosis for the six characters *viz.,* grain yield plant^{-1}, grain yield plot^{-1}, cob girth, cob length, number of grains cob^{-1} and days to 50% tasseling. The double cross DC (NMI-3 × NAUM-14) × (NAUM-14 × NAUM-21) was found to exhibit significant useful heterosis for the seven characters *viz.,* grain yield plant^{-1}, days to 50% silking, days to 50% tasseling, days to 50% maturity, plant height, cob length and cob girth in the desirable direction.

All above mentioned five double crosses also recorded significant *per se* performance for grain yield plant^{-1} (g) along with or without other traits like days to 50% tasseling, days to 50% silking, days to maturity, plant height (cm), cob length (cm), cob girth (cm), number of grains cob^{-1}, 100 grain weight (g) and grain yield plot^{-1} (kg). The levels of heterosis observed in these five crosses gave the opportunity for the development of commercial hybrid in maize. Such potential of maize crosses for commercial exploitation of heterosis were also reported by many maize breeders like Iqbal *et al*. (2010), Patil *et al.* (2012) and Ghanwat *et al*. (2016).

It is inferred from this study that the five double crosses *viz.,* DC (NMI-3 × NAUM-8) × (NMI-3 × NAUM-26), DC (NMI-3 × NAUM-14) × (NAUM-26 × NAUM-14), DC (NAUM-8 × NAUM-14) × (NAUM-8 × NAUM-21), DC (NMI-3 × NAUM-8) × (NMI-3 × NAUM-21) and DC (NMI-3 × NAUM-14) × (NAUM-14 × NAUM-21) hold promise for further evaluation and commercial exploitation of heterosis.

Table 1. Analysis of variance for various characters in maize

Sources of variation	d.f.	Mean squares									
		Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grain weight (g)	Grain yield plant^{-1} (g)	Grain yield plot^{-1} (Kg)
Replications	1	8.82	0.48	0.01	21.78	1.54	-89.22	567.34	0.40	2.40	0.001
Genotypes	50	8.93**	11.49**	67.47**	218.57**	4.04**	1.00**	4177.08**	5.94**	242.15**	0.25**
Error	50	4.58	5.00	14.19	79.76	1.00	0.30	368.10	2.13	20.90	0.020

*,** = Significant at 5% and 1% level respectively

Table 2. Performance of double cross hybrids for mean and standard heterosis (SH)

Double Cross Hybrids	Days to 50 tasseling		Days to 50% silking		Days to maturity		Plant height (cm)	
	Mean	SH (%)	Mean	SH (%)	Mean	SH (%)	Mean	SH (%)
((NMI-3 × NAUM-8) × (NMI-3 × NAUM-26)	52.00	-7.96*	55.00	-8.33*	95.00	-2.06	199.50	15.65**
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-14)	51.00	-9.73*	54.00	-10.00**	94.00	-3.09	170.80	-0.99
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-21)	50.00	-11.50**	57.00	-5.00	93.50	-3.61	189.52	9.87
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-26)	53.00	-6.19	56.00	-6.67	105.50	8.76*	179.97	4.33
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-14)	48.50	-14.16**	53.50	-10.83**	93.50	-3.61	155.50	-9.86
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-21)	53.50	-5.31	56.50	-5.83	97.50	0.52	177.71	3.02
(NMI-3 × NAUM-8) × (NAUM-26 × NAUM-14)	50.00	-11.50**	53.00	-11.67**	96.50	-0.52	173.47	0.56
(NMI-3 × NAUM-8) × (NAUM-26 × NAUM-21)	53.00	-6.19	56.00	-6.67	97.50	0.52	163.45	-5.25
(NMI-3 × NAUM-8) × (NAUM-14 × NAUM-21)	54.00	-4.42	57.50	-4.17	88.50	-8.76*	173.05	0.32
(NMI-3 × NAUM-26) × (NMI-3 × NAUM-14)	51.00	-9.73*	54.50	-9.17*	86.00	-11.34**	161.80	-6.20
(NMI-3 × NAUM-26) × (NMI-3 × NAUM-21)	52.00	-7.96*	55.50	-7.50	92.00	-5.15	162.65	-5.71
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-26)	50.50	-10.62*	53.00	-11.67**	103.50	6.70	157.75	-8.55
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-14)	50.50	-10.62*	54.00	-10.00**	102.50	5.67	169.30	-1.86
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-21)	54.00	-4.42	58.00	-3.33	95.50	-1.55	161.25	-6.52
(NMI-3 × NAUM-26) × (NAUM-26 × NAUM-14)	50.50	-10.62**	53.00	-11.67**	106.50	9.79*	171.20	-0.75
(NMI-3 × NAUM-26) × (NAUM-26 × NAUM-21)	53.00	-6.19	56.00	-6.67	103.00	6.19	163.65	-5.13
(NMI-3 × NAUM-26) × (NAUM-14 × NAUM-21)	53.00	-6.19	56.00	-6.67	92.50	-4.64	168.60	-2.26
(NMI-3 × NAUM-14) × (NMI-3 × NAUM-21)	52.00	-7.96*	55.00	-8.33*	108.00	11.34**	165.90	-3.83
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-26)	54.00	-4.42	57.00	-5.00	102.50	5.67	168.60	-2.26
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-14)	51.00	-9.73*	55.00	-8.33*	98.00	1.03	160.00	-7.25
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-21)	55.00	-2.65	59.00	-1.67	92.50	-4.64	172.00	-0.29
(NMI-3 × NAUM-14) × (NAUM-26 × NAUM-14)	52.50	-7.08	55.50	-7.50	91.50	-5.67	187.76	8.85**
(NMI-3 × NAUM-14) × (NAUM-26 × NAUM-21)	56.00	-0.88	60.50	0.83	94.00	-3.09	183.92	6.62**
(NMI-3 × NAUM-14) × (NAUM-14 × NAUM-21)	50.50	-10.62**	54.50	-9.17*	108.00	11.34**	186.49	8.11**
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-26)	54.50	-3.54	57.50	-4.17	97.00	0.00	162.20	-5.97
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-14)	54.50	-3.54	59.50	-0.83	88.50	-8.76*	155.10	-10.09**
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-21)	52.50	-7.08	55.50	-7.50	109.00	12.37**	182.25	5.65
(NMI-3 × NAUM-21) × (NAUM-26 × NAUM-14)	49.00	-13.27**	52.50	-12.50**	93.00	-4.12	159.00	-7.83
(NMI-3 × NAUM-21) × (NAUM-26 × NAUM-21)	50.00	-11.50**	53.00	-11.67**	103.50	6.70	181.39	5.15**
(NMI-3 × NAUM-21) × (NAUM-14 × NAUM-21)	53.50	-5.31	57.00	-5.00	97.50	0.52	163.31	-5.33
(NAUM-8 × NAUM-26) × (NAUM-8 × NAUM-14)	51.00	-9.73*	56.00	-6.67	94.00	-3.09	167.81	-2.72
(NAUM-8 × NAUM-26) × (NAUM-8 × NAUM-21)	50.00	-11.50**	53.50	-10.83**	95.00	-2.06	180.60	4.70
(NAUM-8 × NAUM-26) × (NAUM-26 × NAUM-14	49.50	-12.39**	53.00	-11.67**	88.00	-9.28*	163.16	-5.41
(NAUM-8 × NAUM-26) × (NAUM-26 × NAUM-21)	52.00	-7.96	55.00	-8.33*	82.50	-14.95**	159.95	-7.28
(NAUM-8 × NAUM-26) × (NAUM-14 × NAUM-21)	51.50	-8.85*	54.00	-10.00**	96.00	-1.03	179.75	4.20
(NAUM-8 × NAUM-14) × (NAUM-8 × NAUM-21)	47.50	-15.93**	51.00	-15.00**	102.50	5.67	188.52	9.29
(NAUM-8 × NAUM-14) × (NAUM-26 × NAUM-14)	50.00	-11.50**	54.00	-10.00**	94.50	-2.58	158.05	-8.38
(NAUM-8 × NAUM-14) × (NAUM-26 × NAUM-21)	49.00	-13.27**	50.50	-15.83**	93.62	-3.49	169.22	-1.90
(NAUM-8 × NAUM-14) × (NAUM-14 × NAUM-21)	49.50	-12.39**	52.50	-12.50**	94.00	-3.09	177.70	3.02
(NAUM-8 × NAUM-21) × (NAUM-26 × NAUM-14)	48.50	-14.16**	52.00	-13.33**	95.50	-1.55	170.50	-1.16
(NAUM-8 × NAUM-21) × (NAUM-26 × NAUM-21)	50.00	-11.50**	50.50	-15.83**	102.00	5.15	161.78	-6.21
(NAUM-8 × NAUM-21) × (NAUM-14 × NAUM-21)	50.50	-10.62**	52.50	-12.50**	97.50	0.52	173.75	0.72
(NAUM-26 × NAUM-14) × (NAUM-26 × NAUM-21)	48.50	-14.16**	51.50	-14.17**	93.50	-3.61	176.20	2.14
(NAUM-26 × NAUM-14) × (NAUM-14 × NAUM-21)	51.00	-9.73*	54.00	-10.00**	108.00	11.34**	161.80	-6.20
(NAUM-26 × NAUM-21 × (NAUM-14 × NAUM-21)	51.00	-9.73*	53.00	-11.67**	98.00	1.03	184.25	6.81
Standard Check								
Rajarshi	56.50		60.00		97.00		172.50	
S E (±)	1.51	2.14	1.58	2.24	2.66	3.77	6.32	8.93

Table 2. Conted……

Double Cross Hybrids	Cob length (cm)		Cob girth (cm)		Number of grains cob^{-1}	
	Mean	SH (%)	Mean	SH (%)	Mean	SH (%)
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-26)	18.39	33.94**	14.65	16.45**	404.04	23.09**
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-14)	14.99	9.18	12.96	2.98	278.30	-15.22**
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-21)	18.08	31.68**	14.31	13.75**	403.00	22.77**
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-26)	15.96	16.24*	13.39	6.40	306.75	-6.55
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-14)	12.14	-11.58	11.76	-6.56	220.35	-32.87**
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-21)	15.76	14.79*	13.32	5.88	303.05	-7.68
(NMI-3 × NAUM-8) × (NAUM-26 × NAUM-14)	15.32	11.54	13.15	4.53	289.15	-11.91*
(NMI-3 × NAUM-8) × (NAUM-26 × NAUM-21)	14.17	3.20	12.75	1.31	262.27	-20.10**
(NMI-3 × NAUM-8) × (NAUM-14 × NAUM-21)	15.05	9.61	13.15	4.49	288.23	-12.19*
(NMI-3 × NAUM-26) × (NMI-3 × NAUM-14)	13.75	0.15	12.53	-0.40	247.30	-24.66**
(NMI-3 × NAUM-26) × (NMI-3 × NAUM-21)	13.80	0.51	12.60	0.16	255.41	-22.19**
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-26)	12.20	-11.14	11.81	-6.16	220.69	-32.77**
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-14)	14.66	6.77	12.92	2.66	275.70	-16.01**
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-21)	13.69	-0.29	12.33	-1.99	236.30	-28.01**
(NMI-3 × NAUM-26) × (NAUM-26 × NAUM-14)	15.07	9.76	12.96	3.02	281.85	-14.14*
(NMI-3 × NAUM-26) × (NAUM-26 × NAUM-21)	14.24	3.71	12.76	1.43	262.30	-20.09*
(NMI-3 × NAUM-26) × (NAUM-14 × NAUM-21)	14.52	5.75	12.85	2.11	266.84	-18.71**
(NMI-3 × NAUM-14) × (NMI-3 × NAUM-21)	14.25	3.79	12.82	1.91	264.40	-19.45**
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-26)	14.56	6.05	12.86	2.19	268.86	-18.09**
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-14)	13.65	-0.58	12.23	-2.78	229.90	-29.96**
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-21)	15.12	10.09	13.06	3.82	285.56	-13.01*
(NMI-3 × NAUM-14) × (NAUM-26 × NAUM-14)	17.40	26.73**	13.88	10.29*	362.33	10.38
(NMI-3 × NAUM-14) × (NAUM-26 × NAUM-21)	16.38	19.30*	13.57	7.83	322.50	-1.75
(NMI-3 × NAUM-14) × (NAUM-14 × NAUM-21)	16.98	23.67**	13.69	8.78*	360.55	9.84
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-26)	13.80	0.51	12.56	-0.16	252.82	-22.98**
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-14)	11.67	-15.00*	11.40	-9.38*	210.90	-35.75**
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-21)	15.57	13.40	13.48	7.15	322.17	-1.85
(NMI-3 × NAUM-21) × (NAUM-26 × NAUM-14)	13.49	-1.75	11.90	-5.41	222.20	-32.31**
(NMI-3 × NAUM-21) × (NAUM-26 × NAUM-21)	16.20	17.99*	13.40	6.52	322.17	-1.85
(NMI-3 × NAUM-21) × (NAUM-14 × NAUM-21)	14.04	2.26	12.66	0.64	258.80	-21.16**
(NAUM-8 × NAUM-26) × (NAUM-8 × NAUM-14)	14.50	5.61	12.82	1.91	266.80	-18.72**
(NAUM-8 × NAUM-26) × (NAUM-8 × NAUM-21)	16.13	17.44*	13.40	6.52	308.85	-5.91
(NAUM-8 × NAUM-26) × (NAUM-26 × NAUM-14	13.90	1.24	12.63	0.40	257.75	-21.48**
(NAUM-8 × NAUM-26) × (NAUM-26 × NAUM-21)	13.63	-0.73	11.95	-5.01	228.15	-30.50**
(NAUM-8 × NAUM-26) × (NAUM-14 × NAUM-21)	15.76	14.79*	13.37	6.24	305.47	-6.94
(NAUM-8 × NAUM-14) × (NAUM-8 × NAUM-21)	17.81	29.72**	13.97	11.05*	370.33	12.82
(NAUM-8 × NAUM-14) × (NAUM-26 × NAUM-14)	13.40	-2.40	11.89	2.31	221.75	-32.44**
(NAUM-8 × NAUM-14) × (NAUM-26 × NAUM-21)	14.65	6.70	12.87	5.56	270.50	-17.59**
(NAUM-8 × NAUM-14) × (NAUM-14 × NAUM-21)	15.57	13.40	13.28	2.66	301.23	-8.23
(NAUM-8 × NAUM-21) × (NAUM-26 × NAUM-14)	14.74	7.36	12.92	-1.79	277.35	-15.51**
(NAUM-8 × NAUM-21) × (NAUM-26 × NAUM-21)	13.69	-0.29	12.36	5.01	237.80	-27.56**
(NAUM-8 × NAUM-21) × (NAUM-14 × NAUM-21)	15.35	11.80	13.21	5.17	295.59	-9.95
(NAUM-26 × NAUM-14) × (NAUM-26 × NAUM-21)	15.48	12.75	13.23	-1.11	296.65	-9.63
(NAUM-26 × NAUM-14) × (NAUM-14 × NAUM-21)	13.72	-0.07	12.44	7.95	239.80	-26.95**
(NAUM-26 × NAUM-21 × (NAUM-14 × NAUM-21)	15.76	14.79*	13.58	2.31	330.25	0.61
Standard Check						
Rajarshi	13.73		12.58		328.25	
S E (±)	0.71	1.00	0.39	0.54	13.57	19.18

Table 2. Conted……

Double Cross Hybrids	Cob length (cm)		Cob girth (cm)		Number of grains cob^{-1}	
	Mean	SH (%)	Mean	SH (%)	Mean	SH (%)
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-26)	23.05	9.74	91.22	48.56**	2.83	59.15**
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-14)	19.95	-5.02	55.66	-9.35	1.71	-3.66
(NMI-3 × NAUM-8) × (NMI-3 × NAUM-21)	20.87	-0.64	79.50	29.80**	2.47	39.15**
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-26)	20.73	-1.29	62.38	1.60	1.93	8.45
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-14)	23.20	10.48	48.13	-21.61	1.49	-16.06
(NMI-3 × NAUM-8) × (NAUM-8 × NAUM-21)	20.67	-1.57	69.00	12.38**	1.92	7.89
(NMI-3 × NAUM-8) × (NAUM-26 × NAUM-14)	23.19	10.43	68.30	11.24	2.14	20.28*
(NMI-3 × NAUM-8) × (NAUM-26 × NAUM-21)	21.15	0.69	54.56	-11.14	1.68	-5.35**
(NMI-3 × NAUM-8) × (NAUM-14 × NAUM-21)	20.23	-3.67	58.70	-4.40	1.81	1.69*
(NMI-3 × NAUM-26) × (NMI-3 × NAUM-14)	19.40	-7.62	46.22	-24.72**	1.43	-19.72*
(NMI-3 × NAUM-26) × (NMI-3 × NAUM-21)	22.34	6.38	57.35	-6.64	1.74	-1.97*
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-26)	22.10	5.24	46.96	-23.53**	1.46	-18.03*
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-14)	23.62	12.48	63.26	3.02	1.96	10.14
(NMI-3 × NAUM-26) × (NAUM-8 × NAUM-21)	23.81	13.38	54.39	-11.42	1.73	-2.82
(NMI-3 × NAUM-26) × (NAUM-26 × NAUM-14)	24.08	14.64*	65.50	6.68	2.06	15.77
(NMI-3 × NAUM-26) × (NAUM-26 × NAUM-21)	20.93	-0.33	52.70	-14.50	1.62	-9.01
(NMI-3 × NAUM-26) × (NAUM-14 × NAUM-21)	21.65	3.10	54.23	-11.69	1.71	-3.94
(NMI-3 × NAUM-14) × (NMI-3 × NAUM-21)	24.49	16.62*	60.50	-1.47	1.88	5.63
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-26)	24.66	17.43*	63.27	3.04	1.95	9.58
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-14)	22.41	6.71	51.09	-16.81*	1.56	-12.11
(NMI-3 × NAUM-14) × (NAUM-8 × NAUM-21)	21.96	4.57	56.02	-8.76	1.79	0.56
(NMI-3 × NAUM-14) × (NAUM-26 × NAUM-14)	23.16	10.29	81.73	33.11**	2.52	41.97
(NMI-3 × NAUM-14) × (NAUM-26 × NAUM-21)	21.29	1.38	66.00	7.49	2.03	14.08**
(NMI-3 × NAUM-14) × (NAUM-14 × NAUM-21)	22.35	6.43	78.89	28.48**	2.43	36.90
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-26)	23.20	10.48	59.50	-3.09	1.81	1.69**
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-14)	21.95	4.50	45.41	-26.05**	1.41	-20.56
(NMI-3 × NAUM-21) × (NAUM-8 × NAUM-21)	22.60	7.62	67.50	9.93	2.10	18.03*
(NMI-3 × NAUM-21) × (NAUM-26 × NAUM-14)	21.92	4.38	47.25	-23.13**	1.46	-18.03
(NMI-3 × NAUM-21) × (NAUM-26 × NAUM-21)	20.07	-4.43	61.80	0.65	1.92	8.17
(NMI-3 × NAUM-21) × (NAUM-14 × NAUM-21)	19.69	-6.24	50.38	-17.95*	1.54	-13.52
(NAUM-8 × NAUM-26) × (NAUM-8 × NAUM-14)	22.07	5.10	57.85	-5.78	1.79	0.85
(NAUM-8 × NAUM-26) × (NAUM-8 × NAUM-21)	22.30	6.19	66.35	8.06	2.06	15.77
(NAUM-8 × NAUM-26) × (NAUM-26 × NAUM-14	21.47	2.24	55.65	-9.36	1.72	-3.10
(NAUM-8 × NAUM-26) × (NAUM-26 × NAUM-21)	20.39	-2.90	46.35	-24.92**	1.43	-19.44
(NAUM-8 × NAUM-26) × (NAUM-14 × NAUM-21)	21.75	3.57	64.62	5.24	2.00	12.39
(NAUM-8 × NAUM-14) × (NAUM-8 × NAUM-21)	22.35	6.43	81.51	32.74**	2.46	38.31**
(NAUM-8 × NAUM-14) × (NAUM-26 × NAUM-14)	18.98	-9.62	42.00	-31.60**	1.30	-26.76*
(NAUM-8 × NAUM-14) × (NAUM-26 × NAUM-21)	22.97	9.38	62.00	0.98	1.93	8.45
(NAUM-8 × NAUM-14) × (NAUM-14 × NAUM-21)	20.70	-1.43	61.17	-0.37	1.90	7.04
(NAUM-8 × NAUM-21) × (NAUM-26 × NAUM-14)	21.41	1.95	56.15	-8.55	1.76	-1.13
(NAUM-8 × NAUM-21) × (NAUM-26 × NAUM-21)	24.45	16.43*	55.00	-10.42	1.74	-1.97
(NAUM-8 × NAUM-21) × (NAUM-14 × NAUM-21)	20.27	-3.48	59.50	-3.09	1.84	3.38
(NAUM-26 × NAUM-14) × (NAUM-26 × NAUM-21)	24.20	15.24*	69.35	12.95	2.15	21.13
(NAUM-26 × NAUM-14) × (NAUM-14 × NAUM-21)	24.00	14.29*	56.50	-7.98	1.74	-1.97
(NAUM-26 × NAUM-21 × (NAUM-14 × NAUM-21)	24.75	17.86*	77.50	26.22*	2.40	35.21
Standard Check						
Rajarshi	21.00		61.40		1.78	
S E (±)	1.03	1.46	3.23	4.57	0.10	0.14

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