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ESTIMATION OF HETEROSIS IN GYNOECIOUS CUCUMBER UNDER GREENHOUSES CONDITIONS

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ABSTRACT

Five inbred lines of cucumber were crossed in all possible combinations, without reciprocals, to produce ten gynoecious hybrids suitable for the greenhouses culture. All genotypes were evaluated in the greenhouses in two consecutive seasons of 2004/05 and 2005/06. Data were collected on relative increasing in plant height, length of stem internodes, number of lateral branches, number of leaves on stem, days to anthesis, early yield, total yield, average fruit weight, fruit length and fruit diameter. The amounts of herterosis for those traits were calculated.

Heterosis was found to be significant for all characters measured. Generally, heterosis over mid-parents was clearly manifested in most crosses for the examined traits, while heterosis over high parent was less expressed with relatively low amounts. Conversly, negative heterosis was detected in the F_1 populations for days to anthesis, meaning that they were earlier in the first female flower anthesis than their parents. It was observed the superiority of certain F1 hybrids in relation to their parents. Meanwhile, other crosses did not exhibit significant heterosis over their parents according to their combinations.

In conclusion, the choice of parents to produce hybrids and selection of the best parents from different genetic resources is required to produce superior hybrids.

INTRODUCTION

Cucumber (*Cucumis sativus L*) is an important and popular vegetable crop in Egypt. It is grown throughout the entire year in open field and in greenhouses. Nearly all greenhouses cucumber are F_1 hybrids. That is due to the superiority of F_1 hybrids and high yielding ability.

The improvment and development of F_1 hybrids is acheived through successful hybridization plan, depending on the manifestation of heterosis in F_1 progeny. Heterosis is manifested as an increase in vigour, size, growth rate, yield, fruit dimensions, diseases and insect resistance and a number of other characteristics. But in some cases, the hybrid may be inferior to the weaker parent. This is also regarded as heterosis. Hybrid vigour has been used as a synonym of heterosis. It is generally agreed that hybrid vigour describe only superiority of the hybrids over the parents, while heterosis describe all performance rates of F_1 hybrids in relation to their parents (Singh, 1986).

Heterosis has been utilized in cucumber breeding and it was observed in many characters in F_1 populations. Many investigations demonstrated the manifestation of heterosis over mid-parents for plant height, length of internodes, number of lateral branches and number of leaves. In addition, heterosis over high parent was observed in some cases, while negative heterosis over high parent was found (Delaney and Lower, 1987; Gendy, 1991; Awny *et al.,* 1992; Singh *et al.,* 1999 and Asem, 2004).

Early flowering time was observed in F_1 hybrids. Heterosis was significantly negative for number of nodes of the female flower (El-Shawaf and Baker, 1981; El-Gazar and Zaghloul, 1984; and Darwish, 1992).

Pronounced amounts of heterosis for early number and weight of fruits were detected in F_1 progeny, indicating the superiority of F_1 hybrids in producing early yield than parents (El-Gazar and Zaghloul, 1984; Kupper and Staub, 1988; and Metwally *et al*., 1992). On the contrary, the heterosis for early yield was not observed in other studies (Ghaderi and Lower, 1979 and Cramer and Wehner, 1999).

Concerning total yield components, i. e., fruits number and weight, previous studies confirmed the fact that most hybrids showed positive heterosis for total yield (Nienhuis and Lower, 1980; Delaney and Lower, 1987; Darwish, 1992; Abd El-Hafez *et al.,* 1997; Singh *et al*., 1999 and Asem, 2004). While, Cramer and Wehner (1999) found that high parent heterosis for yield components was rare for the cucumber hybrids.

In the same manner, the F_1 hybrids exhibited heterotic effects for fruit traits, e. g., average fruit weight, fruit length and fruit diameter (Lower *et al*., 1982; El-Gazar and Zaghloul, 1984; Gharib, 1991; Singh *et al.,* 1999 and Asem, 2004).

The objective of this study was to examine the amount of heterosis in gynoecious F_1 hybrids ,originated from different inbred lines, under greenhouses conditions.

MATERIALS AND METHODS

Five parental inbred lines were isolated from three gynoecious cucumber hybrids by inbreeding. These hybrids were subjected to controlled self pollination to gain new recombinant inbreds from the segregating generations. Some plants were sprayed with silver nitrate solution at 300 ppm to induce staminate flowers. Individual plants with desirable characterisics were selected, whereas plants with defects were discarded due to decline or unfavourable characteristics. Five gynoecious segregating inbreds were collected from F_5 generation, hereafter will be refered to as P_1, P_2, P_3, P_4 and P_5. The parental inbred lines were crossed in all possible combinations, excluding reciprocals to produce ten single crosses. Therefore, the genetic populations used in the present work included five inbreds and ten single crosses. All the genotypes developed in the present study is characterized by gynoecy plant habit.

All fivteen entries were evaluated under greenhouses at Badaway, Dakahlia Governate in two consecutive seasons of 2004/05 (Y1) and 2005/06 (Y2).

The experimental design used was randomized complet blocks with three replicates. Each block contained 15 plots. Seeds were sown on 8th of October in 2004 and 2005 for the first and second seasons, respectively. The plants were spaced 50 cm apart in rows and 120 cm between rows. All agricultural practices were applied in accordance with the regular procedures for cucumber cultivation under greenhouses. Data were collected for the different characters as follow:

1. Vegetative traits: Relative increasing in plant height (cm) at 50, 70, and 90 days old, length of stem internodes (cm), number of lateral branches, and number of leaves on stem.
2. Earliness traits: Number of days to the first flower anthesis and early yield which was measured as number and weight of fruits.
3. Total yield traits: It was measured as the total number and weight of all harvested fruits throughout the entire season for plot and plant.
4. Fruit traits: Average fruit weight (gm), fruit legnth (cm), and fruit diameter (cm).

The heterosis was assesd on the basis of increase or decrease of a character in the F_1 hybrids over the means of the mid-parents or the high parent. It was calculated using formulas outlined by Mather and Jinks (1982) as follow:

The mid-parents heterosis (M. P.)= (F1-M.P.)/M.P x 100
The high parent heterosis (H.P.)= (F1-H.P.)/H.P x 100
Where; F1: The first hybrid generation
M.P: The mid parents
H.P.: The high parents

RESULTS AND DISCUSSION

Vegetative traits

Heterosis values from mid-parents (M.P.) and high parent (H.P.) were calculated for relative increasing in plant height at 50, 70, 90 days old, length of stem internodes, number of lateral branches, and number of leaves on stem. Results of the estimated amounts of heterosis, M.P and H.P., for vegetative traits are shown in Table 1 and 2 for the 1st and 2nd seasons, respectively

The results show that most F_1 hybrids exhibited positive heterosis values over mid-parents at 50 days stage. However, few crosses exhibited positive heterosis over high parent at both seasons. After 70 days from sowing, only few hybrids showed positive heterosis values from mid-parents in both seasons. Conversely, all hybrids showed negative values for heterosis over high parent, except for the crosses 1x2 and 1x5 in the second season. At 90 days old, the cross 1x5 showed the largest amount of hetreosis over mid-parents, while most hybrids showed negative values. Additionally, most of F_1 hybrids showed negative values for heterosis over high parent in both seasons.

With respect to length of stem internodes, the cross 1x5 had the highest value of mid-parental heterosis in both seasons, while some crosses exhibited negative values. In the same manner, positive amounts of heterosis over high parent were detected from F_1 hybrids ,viz. 1x2, 1x4, 1x5 and 3x5 in both seasons, meaning that they had larger length of stem internodes than their parents. Little heterosis over mid-parents was found for number of lateral branches. The highest value has appeared in the cross 3x4 in both seasons.

As for number of leaves per plant, it is obvious that heterosis was clearly expressed in most F1 hybrids in both seasons. The largest amounts of heterosis were recorded by the crosses 1x3, 1x5 and 3x5. Similarly, the forementioned crosses show the highest heterosis from high parent.

Many investigations declared the manifestation of heterosis for several vegetative traits in cucumber (Miller *et al.,* 1973; Delaney and Lower, 1987; Gendy, 1991; Awny *et al.,* 1992; Yacoup et al., 1994 and Singh *et al.,* 1999).

The results indicated that some F_1 hybrids exceeded their parents, while others were lower. Some hybrids exceeded the higher parent for some traits. Generally, F_1 hybrids showed different amount of heterosis, which could be attributed to their genetic constitutes.

Earliness traits

The results of heterosis for earliness traits at both seasons are arranged in Table 3. The results of heterosis for days to anthesis revealed that low positive heterosis values were presented in some F_1 hybrids. Six crosses showed negative mid-parental heterosis, meaning that they are earlier than their parents. Negative heterosis for flowering time is favourable heterotic result since it is desirable to have anthesis of female flower at less number of days. On the other hand, eight out of ten F_1 populations showed negative estimates for high parent heterosis in both seasons.

Table 3. Percentage of heterosis over mid-parents (M.P) and high parent (H.P) for earliness traits at both seasons.

Crosses	Days to anthesis				Early yield							
					No.				Wt.			
	M.P		H.P		M.P		H.P		M.P		H.P	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
1x2	-1.84	-2.46	-5.03	-6.17	-8.81	-4.99	-22.72	-22.15	13.37	14.93	10.31	11.73
1x3	-4.25	3.57	-10.37	-2.24	25.69	31.41	25.10	26.20	33.00	40.13	23.00	24.82
1x4	-6.89	-8.16	-8.06	-9.27	-0.70	4.20	-7.95	-5.97	-0.02	10.47	-1.90	8.66
1x5	7.28	13.84	0.32	6.61	36.39	33.15	9.42	3.19	36.30	41.15	23.50	23.23
2x3	4.92	1.63	1.38	-0.35	-7.67	-9.90	-22.06	-23.69	8.40	2.34	-2.27	-6.49
2x4	-12.00	-9.94	-16.46	-14.40	-20.61	-22.06	-28.00	-30.09	-8.55	-9.06	-9.33	-10.14
2x5	-9.16	-5.39	-12.31	-7.99	9.28	5.09	2.18	-2.20	27.88	26.56	13.07	13.28
3x4	5.91	10.13	-2.05	2.74	22.25	19.96	12.83	12.42	17.15	18.34	6.46	6.98
3x5	-3.09	-1.41	-3.15	-2.23	37.16	30.43	9.66	4.19	0.29	25.83	26.36	22.98
4x5	2.22	-0.25	-5.53	-7.20	-1.89	0.59	-16.21	-15.32	15.10	15.69	2.53	2.46

Y1= 1st season ; Y2= 2nd season

The same trend was observed in F_1 hybrids as reported by Miller and Quisenberry, 1976; El-Shawaf and baker, 1981; El-Gazar and Zaghloul, 1984; Darwish, 1992 and Asem 2004.

Pronounced mid-parental heterosis was obtained for early yield, determined as number and wiehgt of fruits. The pronounced values were recorded by three crosses, i.e., 1x3,1x5 and 3x5 at both evaluating seasons. Those hybrids exhibited mid-parental heterosis for fruit weight as well as the crosses 2x5 and 3x4. Furthermore , the foregoing crosses exhibited the largest positive heterosis percentages calcualted from the high parent which mean that they produced larger early yield as fruits weight than their earlier parents.

These results are consistent with those of El-Gazar and Zaghloul, 1984; Gendy, 1991; Metwally *et al*., 1992 and Cramer and Wehner, 1999.

Total yield

The results of heterosis over mid-parents and high parent for total yield, based on number and weight of fruits, are illustrated in Table 4 for the two seasons. The results show that the estimated values of mid-parental heterosis were positive in eight crosses for total number of fruits. The cross 3x5 gave the highest heterotic value for total fruit number which was 33.81% and 30.10% in the first and second seasons, respectively. In addition, the best crosses were 3x5 followed by 1x5 then 1x3. Furthermore, the largest mid-parental heterosis for fruits weight was exhibited by the cross1x3 in both seasons which was estimated as 30.25 and 32.23% in the first and second seasons, respectively. In the same manner, the cross 1x3 exhibited the largest amount of heterosis over high parent for total number of fruits per plant with values 25.01 and 20.96 in the first and second seasons, respectively. Heterosis over high parent for total weight of fruits was also expressed in all crosses, except 2x3 and 2x4, since they exhibited significant positive heterotic values, which reveal that they were superior than their parents.

It is clearly evident that eight hybrids manifested positive heterosis in both seasons for total weight of fruits, proving that they produce higher yield than their parents. However, the F_1 hybrids exhibited different estimates of heterosis. It could be concluded that the degree of heterosis depend on the genotypes of the two parents.

Many authors confirmed the fact that most hybrids showed positive heterosis for total yield and its components (Ghaderi and Lower, 1979; Delaney and Lower, 1987; El-Mighawry *et al.,* 1992; Abd El-Hafez *et al.,* 1997; Singh *et al*., 1999 and Asem, 2004).

Fruit traits:

Percent values of heterosis measured over mid-parents and high parent for traits, viz. average fruit weight, fruit length and fruit diameter are arranged in Table 5 for both growing seasons.

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Table 5. Percentage of heterosis over mid-parents (M.P.) and high parent (H.P.) for fruit traits at both seasons.

Crosses	Average fruit weight				Fruit length				Fruit diamter			
	M.P		H.P		M.P		H.P		M.P		H.P	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y	Y2	Y1	Y2
1x2	18.25	18.77	-3.32	-0.86	13.78	18.76	8.05	14.91	19.73	14.53	8.16	10.42
1x3	4.12	7.27	-4.49	-0.84	10.40	10.65	2.58	3.84	-1.17	-3.89	-3.99	-11.08
1x4	1.46	1.42	-8.37	-7.10	6.12	4.03	3.21	2.83	0.31	9.97	-2.42	5.37
1x5	-2.75	0.08	-15.47	-11.62	10.24	12.47	9.16	11.13	6.19	3.31	-1.51	1.63
2x3	12.12	15.17	-14.22	-9.70	11.41	13.85	-1.29	3.55	6.47	3.41	-6.27	-7.48
2x4	15.61	12.64	3.36	1.65	-1.99	-8.12	-4.30	-10.08	11.38	1.61	3.53	-5.97
2x5	17.50	13.13	9.29	6.00	13.37	14.74	8.68	9.75	3.64	4.12	1.06	2.02
3x4	-6.66	-1.92	-21.93	-16.33	-6.82	-7.60	-15.62	-14.25	-6.33	-0.29	-11.40	-3.88
3x5	-13.61	-9.96	-30.18	-25.70	4.64	8.85	-3.65	3.31	10.73	-0.91	0.00	-9.70
4x5	16.27	16.32	11.38	11.73	7.07	-4.11	5.14	-6.32	0.00	-12.66	4.81	-17.61

Y1= 1st season ; Y2= 2nd season

The results of heterosis estimated from mid-parents show the presence of hetrosis values for average fruit weight, fruit length and fruit diameter. The cross 1x2 manifested the largest percentage of heterosis for average fruit weight, which was approximately 18% in both seasons. Generally, most of F_1 hybrids showed positive mid-parental heterosis for this trait. Conversely, most F_1 hybrids showed negative heterosis values when measured from high parent. However, this finding does not imply the absence of superior F_1 hybrids. The manifestion of heterosis in F_1 hybrids was declared by Ghaderi and Lower, 1979; Solanki *et al.,* 1982; El-Gazar and Zaghloul, 1984 and Gendy, 1991.

As for fruit length, the results of heterosis over mid-parents show the presence of positive heterosis values for most crosses. The cross 1x2 manifested the largest amount of heterosis which equalled to 13.78% and 18.76 in the first and second seasons, respectively. In the same manner, positive heterosis values were identified in most F_1 populations. The largest pronounced values were observed on 1x2, 1x5 and 2x5.

The similar findings were observed for fruit length (Lower et al., 1982; El-Gazar and Zaghloul, 1984; Gendy, 1991; and Singh et al, 1999).

It is evident that heterosis over mid-parents was expressed for most F_1 crosses, despite the low values. Otherwise, most F_1 populations exhibited negative or low positive values for heterosis versus high parent, indicating that the higher parent had greater diameter than F_1 progeny.

The same trend was reported by Lower *et al.,* 1982, El-Gazar and Zaghloul, 1984; El-Mighawry *et al.,* and Singh *et al.,* 1999). However, others reported the absence of heterosis for such character (Ghaderi and Lower, 1979 and Asem, 2004).

The results of this investigation revealed the presence of heterosis ,for nearly all studied traits, in the F_1 hybrids of gynoecious cucumber. The F_1 hybrids showed heterosis in different degrees, depending on their genetical combinations. It is suggested the importance of the choice of parents for hybridization and selection of the best parents from hybrid progenies.

REFERENCES

Abd El-Hafez, A. A.; S. F. El-Sayed and A. A. Gharib (1997). genetic analysis of cucumber yield and its components by diallel crossing. Egy. J. Hort., 24(2):141-159.

Asem, A. A. A. 2004. Breeding studies on cucumber crop (Cucumis sativus L.) M. Sc. Thesis. Fac Agric., Tanta Univ.

Awny, S; A. El-Mighawry; F. Mohamed and M. Abd El-Salam (1992). Heterosis, combining ability and heritability associated with F1 hybrids obtained from partial diallel mating design in cucumber (Cucumis sativus L.). J. Agric. Sci. Mansoura Univ. 17(7): 2469-2475.

Cramer, C. S. and T. C. Wehner (1999). Little heterosis for yield and yield components in hybrids of six cucumber inbreds. Euphytica 110:99-108.

Darwish, N. M. (1992). genetic studies on some cucumber hybrids. Ph. D. Thesis, Fac. Agric. Zagazig Univ. (banha branch).

Delaney, D. E. and R. W. Lower (1987). Generation mean analysis of plant characters in crossesbetween two determinate cucumber lines and Cucumis sativus var. hardwickii. J. Amer. Soc. Hort. Sci., 112(4):707-711.

El-Gazar, T. M. and M. M. Zaghloul (1984). Estimation of heterosis and reciprocal effects in cucumber (Cucumis sativus L.). J. Agric. Mansoura Univ. 9(3):433-440.

El-Mighawry, A.; S. Awny; F. Mohamed and M. Abd El-Salam (1992). Importance of genetic parameters determined from the F1 hybrids for fruit yield and quality of cucumber (Cucumis sativus L). J. Agric.Sci. Mansoura Univ. 17(7):2476-2483.

El-Shawaf, I. I. and L. R. Baker (1981). Combining ability and genetic variance of GxH F1 hybrids for parthenocarpic yield in pickling cucumber for once over -mechanical harvest. J. Amer. Soc. Hort. Sci., 106(3):365-370.

Gendy, A. S. A. (1991). Heterosis and nature of gene action in intervarietal crosses of cucumber. M. Sc. Thesis. Fac. Agric., Tanta Univ.

Ghaderi, A and R. L. Lower (1979). Analysis of generation means for yield in six crosses of cucumber. J. Amer. Soc. Hort. Sci., 104(4):567-572.

Gharib, A. A. (1991). Evaluation of F1 hybrid cucumber cultivars under plastic house conditions for some economic characters using diallel analysis. M. Sc. Thesis. Fac. Agric., Cairo Univ.

Kupper, R and J. E. Staub (1998). Combining ability between lines of Cucumis sativus L. and Cucucmis sativus var. hardwickii(R.) Alef. Euphytic 38:197-210.

Lower, R. L.; J. Nienhuis and C. H. Miller (1982). Gene action and heterosis for yield and vegetative characteristics in a cross between gynoecious pickling cucumber inbred and a Cucumis sativus var. hardwickii line. J. Amer. Soc. Hort. Sci., 107(1):75-78.

Mather, K and J. L. Jinks (1982). Biometrical genetics. Great Britain Univ. Press, 3rd Ed., 396 pp.

Metwally, E. I.; A. Y. Mazrouh and A. S. Gendy (1992). Heterosis and nature of gene action in intervarietal crosses of cucumber (Cucumis sativus L). Menofiya J. Agric. Res. 17:1251-1261.

Miller, G. A. and J. E. Quisenberry (1976). Inheritance of time to flowering and its relationship to crop maturity in cucumber. J. Amer. Soc. Hort. Sci. 110:497-500.

Miller, J. C.; L. R. Baker and P. Donald (1973). Inheritance of tolerance to chloramben methyl ester in cucumber. J. Amer. Soc. Hort. Sci., 98(4):386-389.

Nienhuis, J. and R. L. Lower (1980). Gene effects for several characteristics in a cross between a pickling cucumber inbred (Cucumis sativus L.) and Cucumis sativus var. hardwickii. Hortsceince, 15(3):420.

Singh, B. D. (1986). Plant breeding. 2nd Ed.. Kalyani Publishers, New Delhi, India.

Singh, A. K.; N. C. Gautam; R. D. Singh and D. B. Singh (1999). Heterosis and inbreeding depression in cucumber (Cucumis sativus L). Progressive Horticulture 31:74-78.

Solanki, S. S.; J. N. Seth and S. D. Lal (1982). Heterosis and inbreeding depression in cucumber (Cucumis sativus L.) IV Progressive Hort., 14(3):121-125.

Yacoup, H. M.; S. F. Abd El-Sabour; S. H. Mahmoud; M. N. M. Hassan and S. H. Gad El-Hak(1994). Diallel ananlysis of some economic characters in cucumber. Minia first conf. for Hort. crops, 409-430.

تقدير قوة الهجين فى الخيار الانثوى تحت ظروف الصوب الزراعية

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تم التهجين بين خمسة سلالات من الخيار بدون التهجينات العكسية للحصول على عشرة هجن انثوية تلائم الزراعة تحت ظروف الصوب الزراعية.اجرى تقييم الآباء و الهجن فى موسمى ٢٠٠٥/٢٠٠٤ و ٢٠٠٦/٢٠٠٥ فى الصوب الزراعية. و قد كانت الصفات المدروسة التى شملتها الدراسة هى : الزيادة النسبية فى طول النبات, طول سلاميات الساق, عدد الافرع الجانبية , عدد الاوراق على الساق , عدد الايام حتى الازهار , المحصول المبكر , المحصول الكلى , متوسط وزن الثمرة , طول الثمرة و قطر الثمرة.

و تم تقدير قوة الهجين الناتجة فى هجن الجيل الاول. توضح نتائج الدراسة وجود قوة هجين مقارنة بمتوسط الاباء و اعلى الاباء لجميع الصفات محل الدراسة. و قد ظهرت قوة الهجين مقارنة بمتوسط الاباء فى معظم الهجن بالنسبة لجميع الصفات المدروسة بينما كانت قوة الهجين مقارنة باعلى الاباء اقل وضوحا فى الهجن و ذات قيم منخفضة. و على النقيض من ذلك , فقد كانت قوة الهجين سلبية فى قيمتها فى هجن الجيل الاول بالنسبة لصفة ميعاد تفتح اول زهرة مما يدل على ان الهجن كانت اكثر تبكيرا من الاباء. و لقد ظهر تفوق واضح لبعض هجن الجيل الاول عند مقارنتها بالاباء فى حين ان هجن اخرى لم يظهر بها هذا التفوق.

يمكن القول بانه لانتاج هجن متفوقة يجب الاهتمام باختيار الاباء عند انتاج الهجن و انتخاب الاباء من مصادر وراثية مختلفة.

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Table 1. Percentage of heterosis over mid-parents (M.P) and high parent (H.P) for vegetative traits at the first season

Crosses	Relative increasing in plant height						Length of stem internodes		Number of laterals		Number of leaves	
	50		70		90							
	M.P	H.P	M.P	H.P	M.P	H.P	M.P	H.P	M.P	H.P	M.P	H.P
1X2	3.85	-0.17	-0.31	-5.46	5.11	3.67	8.21	5.97	-23.96	-29.44	2.36	0.66
1X3	4.45	4.44	0.45	-0.57	-0.04	-5.44	-12.20	-19.48	-22.69	-30.72	16.14	13.73
1X4	-0.47	-2.44	-1.28	-2.02	2.47	-.0.85	3.44	2.46	-22.11	-27.45	12.96	0.51
1X5	3.31	2.03	7.72	-0.36	8.80	5.24	11.76	2.60	-8.79	-12.32	15.83	13.68
2X3	0.91	-2.99	-0.43	-4.64	-4.93	-11.22	-6.73	-12.79	-21.83	-35.73	13.64	13.14
2X4	-0.24	-2.35	-11.97	-17.13	-7.02	-8.81	-10.09	-11.02	-3.23	-6.01	-5.72	-14.866
2X5	2.02	-0.88	-11.73	-14.00	3.89	-0.84	-9.29	-15.10	-16.51	-21.45	1.89	-1.62
3X4	-0.56	-2.36	-9.42	-11.03	-13.66	-20.82	-8.74	-15.48	8.27	-8.87	8.56	-1.57
3X5	3.67	2.55	4.65	-2.24	0.52	-1.77	7.69	7.69	5.88	-8.35	14.89	10.46
4X5	-1.64	-2.38	6.78	-1.19	2.12	-4.31	2.81	-4.80	-10.04	-12.87	4.67	-8.38

Table 2. Percentage of heterosis over mid-parents (M.P) and high parent (H.P) for vegetative traits at the second season.

Crosses	Relative increasing in plant height						Length of stem internodes		Number of laterals		Number of leaves	
	50		70		90							
	M.P	H.P	M.P	H.P	M.P	H.P	M.P	H.P	M.P	H.P	M.P	H.P
1X2	12.31	10.72	11.75	3.74	0.82	-0.98	8.13	6.09	-30.89	-42.86	5.48	1.59
1X3	10.00	3.86	-1.60	-7.35	8.70	2.91	14.80	-18.64	15.66	8.23	14.85	10.47
1X4	11.71	9.26	-4.91	-7.56	-12.28	-15.38	11.99	10.70	-8.49	-18.99	1.82	-6.53
1X5	13.93	11.12	21.68	7.78	14.25	5.03	31.97	23.96	-18.56	-26.47	19.16	11.35
2X3	-1.08	-7.86	-6.42	-7.74	-8.04	-11.40	-8.29	-10.79	2.57	-19.50	-6.53	-13.27
2X4	0.61	-2.96	- 7 . 3 4	-11.56	-17.61	-21.89	-14.61	-17.17	3.72	-4.03	-7.12	2.49
2X5	9.86	5.67	-15.72	-19.98	-7.52	-13.53	3.81	-0.71	-28.08	-34.79	0.18	-9.60
3X4	-4.77	-8.15	-12.54	-15.34	-21.83	-28.47	-6.98	-12.15	56.40	30.56	-8.47	-18.89
3X5	10.97	7.32	2.51	-3.97	1.07	-2.03	13.89	11.93	-1.34	-16.13	6.95	3.77
4X5	0.11	-0.17	-12.65	-20.63	-11.14	-20.95	4.35	-3.03	13.85	11.37	5.63	-8.83

Table 4. Percentage of heterosis over mid-parents (M.P) and high parent (H.P) for total yield traits at both seasons.

Crosses	Total yield/plot								Total yield/plant							
	No.				Wt.				No.				Wt.			
	M.P		H.P		M.P		H.P		M.P		H.P		M.P		H.P	
	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2	Y1	Y2
1x2	0.48	-2.86	-15.27	-17.83	22.84	19.96	18.28	18.29	0.46	-2.68	-15.31	-17.83	22.81	19.94	18.25	18.72
1x3	25.09	23.61	25.01	20.96	30.25	32.23	19.40	19.85	25.09	23.59	25.01	20.96	30.25	32.23	19.39	19.84
1x4	9.74	7.81	6.23	1.02	11.82	10.77	4.03	7.36	9.74	7.79	6.23	1.00	11.80	10.75	4.01	7.35
1x5	28.78	25.77	3.15	-0.10	29.99	30.35	18.05	15.26	27.63	25.77	1.78	-0.10	29.96	30.33	18.04	15.25
2x3	-18.28	-19.80	-31.00	-31.05	-2.52	-3.33	-13.66	-13.48	-18.05	-19.81	-30.87	-31.06	-2.54	-3.04	-13.66	-31.21
2x4	-20.21	-15.81	-30.84	-24.38	-0.94	-2.83	-4.43	-4.52	-15.96	-15.41	-27.17	-24.38	-0.96	-2.85	-4.43	-0.21
2x5	12.25	14.50	5.44	6.17	31.15	28.87	15.13	12.57	11.42	14.50	4.03	6.18	31.15	22.26	15.12	6.80
3x4	25.95	15.00	21.99	9.97	18.37	14.35	1.63	0.77	25.95	14.95	21.99	9.96	18.38	14.36	1.64	0.78
3x5	34.94	30.11	8.21	5.05	23.86	23.42	22.59	20.06	33.81	30.10	6.77	5.06	23.84	23.41	22.57	20.05
4x5	7.95	1.66	-11.24	-14.95	25.56	19.90	6.88	3.18	7.08	1.65	-12.42	-14.95	24.49	19.90	5.98	3.18

Y1= 1st season ; Y2= 2nd season