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Exploitation of heterosis for yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

Okra, being an often cross-pollinated crop, responds well to heterosis breeding. Exploitation of heterosis is primarily dependent on the screening and selection of available germplasm that could be produced by better combinations of important agronomic characters. An experiment was carried out in *kharif* 2020 to estimate standard heterosis for yield and its contributing traits using 24 hybrids developed through line x tester design were evaluated at three different locations at Navsari Agricultural University, Navsari (Gujarat) with commercial check 'GJOH 4'. Appreciable heterosis was found over commercial check for all the traits studied in desirable direction. Among the 24 hybrids, NOL-17-6 × Arka Anamika gave consistency in performance with respect to pod yield across all environments (E1, E2 and E3) followed AOL-12-59 × Kashi Kranti (E1 and E2) and NOL-18-10 × Kashi Kranti (E2 and E3). An overall view of all the top yielding crosses with respect to pod yield contributing traits revealed that the higher pod yield was mainly due to number of pods plant^{-1}.

Keywords: Okra, fruit yield, attributing characters, standard heterosis, L x T

Introduction

Okra (*Abelmoschus esculentus* (L.) Moench) usually known as bhendi, lady's finger or gumbo is a fast growing vegetable crop of tropical and sub tropical region. It is an annual crop which particularly cultivated for its tender and nutritious green pods (Lamont 1999) [10]. Among all, India is the largest okra producing country in the world comprising of 72 percent of total area under okra (Anonymous, 2017) [1]. Although, India has diverse environmental condition facilitating the existence of numerous okra cultivars still there is unavailability of appropriate high yielding cultivars. To break through yield limiting barrier in okra cultivars, hybridization strategy must be adapt. Okra being as often cross pollinated crop, can open pollinate up to the range of 4% to 42% due to entomophily (Kumar, 2006) [7]. Further, simple process of emasculation and production of numerous seeds per pod leads to extensive commercial exploitation in okra. One of the first reports of hybrid vigor in okra was demonstrated by Vijayaraghavan and Warier (1946) [28]. Moreover, many researchers reported occurrence of considerable magnitude of heterosis in okra for various traits related to fruit yield (Shwetha *et al.*, 2018) [21]. The main focus of any breeding programme is to enhance yield which can attain by hybridization of suitable parental lines. Higher the diversity among parental materials more will be the extent of significant heterosis. The preliminary step for every hybridization programme was selection of appropriate parental genotypes able to produce better hybrids with desirable economic traits. Although, it is a time consuming approach but the magnitude of heterosis act as relevant guide for the screening of appropriate parents which can manifest promising heterotic result during breeding programme. It also assists in selecting significant hybrids that outperform the existing standard check and hence can consider for commercial utilization. Keeping this view, the present investigation aims toward study of magnitude and direction of relative heterosis, heterobeltiosis and standard heterosis for yield and its components in okra.

Materials and Methods

The experimental material was developed at Regional Horticultural Research Station, NAU, Navsari during *kharif* 2020 by crossing 11 diverse parents (8 lines and 3 testers) using L × T mating design.

The evaluation programme was carried out under three consecutive environments *viz*., sowing in 1st March, 2021 (E_1), 15th March, 2021 (E_2) and 1st April, 2021 (E_3) during summer 2021 (evaluation). The experiment was conducted in Randomized Block Design (RBD) with three replications which included 36 genotypes comprising of 8 lines (AOL-10-22, AOL-12-59, JOL-13-05, JOL-9-05, NOL-18-10, NOL-17-6, NOL-19-1, NOL-19-3); 3 testers (Arka Anamika, Arka Abhay, Kashi Kranti); their resultant 24 hybrids and one standard check 'GJOH-4'. Each entry was raised in three rows per replication with spacing of 45 cm row- to-row and 30 cm plant-to-plant accommodating 10 plants per row. Moreover, standard packages and practices were applied to the field throughout the experimental period. Quantitative data *viz.* days to 50% flowering, number of branches per plant, plant height (cm), pod length (cm), pod diameter (cm), average fruit weight (g) and yield per plant were recorded from five randomly selected plants per replication and were applied to L X T analysis as given by Fonseca and Patterson, 1968.

Results and Discussion

Heterosis breeding is an important genetic tool that can facilitate yield enhancement and also helps to enrich many other desirable quantitative and qualitative traits in crops. It is a well established fact that heterosis does occur in F_1 hybrids when the most appropriate and compatible combinations of parents are involved. The goal of okra hybrid breeding is to identify and then reliably reproduce superior hybrid genotypes. The relative heterosis will only help to understand the genetic status of the characters. However, from the practical point of view, the measure of heterosis over mid parental value has relatively limited importance and is more of academic interest than of practical use. Therefore, the heterosis measured in terms of superiority over the better parents is more viable because it is aimed at developing desirable hybrids superior to the existing high yielding commercial varieties. In the present investigation, the extent of heterosis varied from cross to cross for all eleven characters. The estimates of heterosis for 24 F_1 hybrids over standard check GJOH-4 for fourteen characters under study are presented in Table 1.

While interpreting magnitude of heterosis, the positive effects of heterosis were considered as favorable for the characters *viz*., number of branches plant^{-1}, number of pods plant^{-1}, plant height at final harvest, pod yield plant^{-1}, pod length, pod diameter and pod weight. Similarly, negative effects were considered favorable for the traits *viz*; days to 50% flowering, number of dry seeds pods^{-1}, 100 dry seed weight and fibre content.

Days to 50% Flowering

Days to 50% flowering are an effective trait for earliness and negative heterosis is desirable for all the attributes of earliness. The estimates of heterosis ranged from -21.32 percent (NOL-18-10 × Kashi Kranti) to 6.62 (AOL-12-59 × Kashi Kranti) in E_1, -21.67 (NOL-18-10 × Kashi Kranti) to 10.00 percent (NOL-19-1 × Kashi Kranti) in E_2 and -20.33 (NOL-18-10 × Arka Anamika) to 9.76 percent (AOL-10-22 × Kashi Kranti) in E_3. Out of the 24 F_1s, the number of F_1s which exhibited significant and negative estimate for standard heterosis were nine in E_1, four in E_2 and ten in E_3. The promising hybrids were NOL-18-10 × Kashi Kranti (-21.32%), JOL-13-5 × Arka Anamika (-20.59%) and JOL-9-05 × Kashi Kranti (-20.59%) in E_1; NOL-18-10 × Kashi Kranti (-21.67%), JOL-13-5 × Arka Anamika (-14.17%), JOL-9-05 × Kashi Kranti (-11.67%) in E_2; NOL-18-10 × Arka Anamika (-20.33%), NOL-18-10 × Kashi Kranti (-16.26%) and NOL-19-3 × Arka Abhay (-14.63%).

Significant and negative standard heterosis for this trait was obtained by Kumar and Kumar (2019) [8], Sapavadiya *et al.* (2019a) [18], Suganthi *et al.* (2019) [23], Pithiya *et al.* (2019) [17], Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12] and Sidapara *et al.* (2021) [22].

Number of Branches Plant^{-1} at Final Harvest

For number of branches plant^{-1}, the extent of standard heterosis ranged from -36.11 (JOL-13-05 × Kashi Kranti) to 38.89 percent (JOL-13-05 × Arka Anamika) in E_1, -50.00 (JOL-9-05 × Arka Abhay) to 24.32 percent (JOL-13-05 × Arka Anamika) in E_2 and -30.56 (JOL-13-05 × Kashi Kranti) to 11.11 percent (NOL-19-1 × Arka Anamika) in E_3. The number of crosses which exhibited significant and positive standard heterosis were three in E_1, two in E_2 and none in E_3. The promising hybrid was JOL-13-05 × Arka Anamika (38.89%), NOL-17-6 × Arka Abhay (33.33%), AOL-12-59 × Arka Abhay (16.67%) in E_1; JOL-13-05 × Arka Anamika (24.32%) and NOL-17-6 × Arka Anamika (18.92%) in E_2.

For this trait, significant and positive standard heterosis was earlier reported by Suganthi *et al.* (2019) [23], Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12] and Sidapara *et al.* (2021) [22] while, non-significant standard heterosis was reported by Patel (2015) [15], Satish *et al.* (2017a) [19] and Nagendra (2020) [11].

Plant Height at Final Harvest

For this trait, the range of standard heterosis in the environments E_1, E_2 and E_3 varied from -42.45 (NOL-17-6 × Arka Anamika) to 40.90 percent (AOL-10-22 × Kashi Kranti), -24.37 (NOL-17-6 × Arka Anamika) to 78.99 percent (AOL-10-22 × Kashi Kranti) and -24.45 (NOL-17-6 × Arka Abhay) to 44.84 percent (AOL-10-22 × Kashi Kranti), respectively. The significant positive standard heterosis was recorded by six, seventeen and four cross in E_1, E_2 and E_3, respectively. The promising hybrids were AOL-10-22 × Kashi Kranti (40.90%), AOL-10-22 × Arka Abhay (19.18%), JOL-9-05 × Kashi Kranti (17.42%) in E_1; AOL-10-22 × Kashi Kranti (78.99%), NOL-19-3 × Arka Anamika (51.96%), JOL-9-05 × Kashi Kranti (47.76%) in E_2; AOL-10-22 × Kashi Kranti (44.84%), AOL-10-22 × Arka Abhay (30.71%) and JOL-13-05 × Arka Anamika (18.89%) in E_3.

For this trait, significant and positive standard heterosis was earlier reported by Pithiya *et al.* (2019) [17], Koli *et al.* (2020) [6] and Patel (2020) [12], Sidapara *et al.* (2021) [22]. However, non-significant standard heterosis was reported by Nagendra (2020) [11].

Pod Length (cm)

Usually a hybrid with significant and positive estimates of standard heterosis and moderate pod length is desirable a certain level. The number of crosses that exhibited significant and positive estimates for standard heterosis was one in E_1, none for both E_2 and E_3. A perusal of the data on pod length revealed that the percent standard heterosis was in the range of -23.55 (AOL-12-59 × Arka Abhay) to 24.94 percent (NOL-18-10 × Arka Anamika) in E_1; -38.34 (NOL-19-1 × Arka Abhay) to -7.51 percent (NOL-19-3 × Kashi Kranti) in E_2 and

-28.49 (JOL-13-05 × Kashi Kranti) to -0.38 percent (NOL-19-3 × Kashi Kranti) in E_3, respectively. The promising hybrid was NOL-18-10 × Arka Anamika (24.94%) in E_1.

For this trait, significant and positive heterosis was earlier reported by Kumar and Kumar (2019) [8], Suganthi *et al.* (2019) [23], Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Patel (2020) [12], Jayanth (2021) Karadi and Hanchinamani (2021) [5] and Sidapara *et al.* (2021) [22]. Non-significant standard heterosis was reported by, Sapavadiya *et al.* (2019a) [18] and Nagendra (2020) [11].

Pod Weight (g)

The range of standard heterosis varied from -32.80 (NOL-18-10 × Kashi Kranti) to 7.13 percent (AOL-10-22 × Arka Abhay) in E_1, -27.56 (NOL-19-1 × Arka Abhay) to 9.48 percent (AOL-10-22 ×Arka Abhay) in E_2 and -31.84 (NOL-19-1 × Arka Abhay) to 3.70 percent (JOL-13-05 × Kashi Kranti) in E_3. The significant positive standard heterosis was recorded by one, three and none crosses in E_1, E_2 and E_3, respectively. The promising hybrids were AOL-10-22 × Arka Abhay (7.13%) in E_1; AOL-10-22 ×Arka Abhay (9.48%), AOL-12-59 × Arka Abhay (8.26%) and JOL-13-05 × Kashi Kranti (6.15) in E_2.

Significant and positive heterosis for this trait was earlier noted by Suganthi *et al.* (2019) [23], Pithiya *et al.* (2019) [17], Koli *et al.* (2020) [6], Patel (2020) [12] and Karadi and Hanchimani (2021) [5], Jayanth (2021) [4] and Sidapara *et al.* (2021) [22]. Non-significant standard heterosis for this trait was reported by Kumar *et al.* (2017) [9], Gavint *et al*. (2018a) [2], Hadiya *et al.* (2018a) [3], Vekariya *et al.* (2019) [25-26] and Nagendra (2020) [11].

Number of Pods Plant^{-1}

A perusal of the data revealed that the percent standard heterosis was in the range of from -40.21 (JOL-9-05 × Arka Anamika) to 38.62 percent (NOL-18-10 × Kashi Kranti) in E_1, -44.38 (NOL-17-6 × Kashi Kranti) to 51.52 percent (NOL-18-10 × Kashi Kranti) in E_2 and -37.13 (AOL-12-59 × Arka Abhay) to 61.08 percent (NOL-18-10 × Kashi Kranti) in E_3. The number of crosses, which exhibited significant heterosis were five in E_1, three in E_2 and five in E_3. The promising hybrids were NOL-18-10 × Kashi Kranti (38.62%) NOL-17-6 × Arka Anamika (33.33%), NOL-18-10 × Arka Anamika (29.10%) in E_1; NOL-18-10 × Kashi Kranti (51.52%), AOL-12-59 × Kashi Kranti (24.72%), NOL-17-6 × Arka Anamika (15.17%) in E_2; NOL-18-10 × Kashi Kranti (61.08%), NOL-17-6 × Arka Anamika (40.72%) and AOL-12-59 × Kashi Kranti (32.34%) in E_3.

For this trait, significant and positive heterosis was earlier reported by Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12], Karadi and Hanchimani (2021) [5], Jayanth (2021) [4] and Sidapara *et al.* (2021) [22].

Pod Yield Plant^{-1} (g)

The quantum of standard heterosis ranged from -51.76 (NOL-19-1 × Kashi Kranti) to 13.26 percent (NOL-17-6 × Arka Anamika) in E_1; -47.21 (NOL-19-1 × Kashi Kranti) to 18.48 percent (NOL-18-10 × Kashi Kranti) in E_2 and -58.15 (NOL-19-1 × Kashi Kranti) to 10.86 percent (NOL-18-10 × Kashi Kranti) in E_3, respectively. Out of 24 F_1s, significant and positive standard heterosis was observed with three F_1s in E_1, three F_1s in E_2 and none F_1s in E_3. The promising hybrids were NOL-17-6 × Arka Anamika (13.26%), NOL-18-10 × Arka Anamika (12.25%), AOL-12-59 × Kashi Kranti (9.61%) in E_1; NOL-18-10 × Kashi Kranti (18.48%), NOL-17-6 × × Arka Anamika (12.87%) and AOL-12-59 × Kashi Kranti (13.32%) in E_2.

For this trait, significant and positive standard heterosis was earlier reported by Koli *et al.* (2020) [6], Nagendra (2020) [11], Patel (2020) [12], Karadi and Hanchimani (2021) [5], Jayanth (2021) [4] and Sidapara *et al.* (2021) [22]. However, non-significant standard heterosis was reported by Kumar *et al.* (2017) [9], Satish *et al.* (2017a) [19] and Vekariya *et al.* (2019) [25-26].

Number of Dry Seeds Pod^{-1}

The standard heterosis ranged from -8.24 (JOL-9-05 × Arka Anamika) to 17.73 percent (NOL-17-6 × Arka Anamika) in E_1, -14.85 (JOL-9-05 × Arka Anamika) to 9.62 percent (AOL-12-59 × Arka Abhay) in E_2 and -16.86 (AOL-10-22 × Arka Abhay) to 13.74 percent (NOL-17-6 × Arka Abhay) in E_3. The number of crosses which exhibited significant negative standard heterosis were none in E_1, four in E_2 and seven in E_3. The promising hybrids were JOL-9-05 × Arka Anamika (-14.85%), JOL-9-05 × Kashi Kranti (-14.57%), NOL-18-10 × Kashi Kranti (-14.29%); AOL-10-22 × Arka Abhay (-16.86%), NOL-18-10 × Kashi Kranti (-16.15%), NOL-18-10 × Arka Anamika (-15.72%) in E_2 and E_3, respectively.

For this trait, significant and negative standard heterosis was earlier reported by Patel *et al.* (2015a) [16], Kumar *et al.* (2017) [9], Satish *et al.* (2017a) [19], Vekariya *et al.* (2019) [25-26] and and Jayanth (2021) [4]. Non-significant standard heterosis for this trait was reported by Kumar and Kumar (2019) [8], Koli (2020) [6], Nagendra (2020) [11].

100 Dry Seed Weight (g)

The spectrum of standard heterosis ranged from -32 .90 (NOL-19-3 × Kashi Kranti) to -0.65 percent (NOL-19-3 × Arka Abhay) in E_1; -35.84 (JOL-13-05 × Kashi Kranti) to -5.78 percent (NOL-19-3 × Arka Abhay) in E_2 and -19.55 (NOL-18-10 × Arka Anamika) to 12.03 percent (JOL-13-05 × Arka Anamika) in E_3. The number of crosses, which exhibited significant negative standard heterosis were sixteen in E_1, twenty-four in E_2 and four in E_3. The promising hybrids were NOL-19-3 × Kashi Kranti (-32.90%), JOL-13-05 × Kashi Kranti (-29.68%), NOL-19-1 × Arka Abhay (-25.16%) in E_1; JOL-13-05 × Kashi Kranti (-35.84%), AOL-12-59× Kashi Kranti (-31.79%), NOL-17-6 × Arka Anamika (-30.64%) in E_2; NOL-18-10 × Arka Anamika (-19.55%), NOL-17-6 × Kashi Kranti (-15.79%), JOL-13-05 × Kashi Kranti (-15.04%) in E_3.

For this trait, significant and negative standard heterosis was earlier reported by Patel and Patel (2016) [13], Koli (2020) [6] and Nagendra (2020) [11]. Non-significant standard heterosis for this trait was reported by Kumar and Kumar (2019) [8] and Vekariya *et al.* (2019) [25-26].

Fibre Content (%)

For fibre content, low value is desirable quality parameter. A perusal of the data revealed that the percent standard heterosis was in the range of -6.97 (NOL-19-3 × Kashi Kranti) to 13.08 percent (JOL-13-05 × Kashi Kranti) in E_1; -8.79 (JOL-13-05 × Arka Abhay) to 13.26 percent (AOL-12-59 × Arka Abhay) in E_2 and -1.72 (NOL-17-6 × Arka Anamika) to 12.36 percent (AOL-10-22 × Kashi Kranti) in E_3. Out of 24 F_1s, significant and negative heterosis was observed in hybrid JOL-13-05 ×

Arka Abhay (-8.79%) in E_2.

For fibre content, significant and negative standard heterosis was also observed by Patel *et al.* (2015) [15], More *et al.* (2017a), Kulkarni *et al.* (2018), Vekariya *et al.* (2019) [25-26], Nagendra (2020) [11], Patel (2020) [12] and Sidapara *et al.* (2021) [22] while, non-significant heterosis was reported by Jayanth (2021) [4]. An overview of the results on heterotic effect for various traits suggested that the estimates and magnitude of heterosis varied with different crosses and characters. Similar findings were recorded by Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12] and Jayanth (2021) [4]. However, the consistency in performance of most of the crosses over the different environments for various traits also varied with different cross combinations. Most of the crosses showed inconsistent performance across the environments which suggests that parental genes and their combinations responded differently to environmental variation as a example from the results, trait like in pod diameter three different crosses *viz.*, JOL-13-05 × Arka Abhay, NOL-19-3 × Arka Anamika, NOL-19-1 × Kashi Kranti in E_1, E_2 and E_3, respectively showed different performance in different environments. Similar findings were recorded by Vekariya (2019) [25-26], Patel (2020) [12] and Jayanth (2021) [4]. The top hybrids (crosses) showing standard heterosis and their performance for pod yield and related parameters have been summarized in Table 2. A good number of hybrids had significant desired heterosis over the commercial check for various traits.The heterotic response of F_1 is an indicative of genetic diversity among the parents involved. Top ranking hybrids based on *per* se performance always same with respect to standard heterosis. Similar findings were recorded by Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12], Jayanth (2021) [4] and Sidpara *et al.* (2021).

In the current investigation, significant and desirable standard heterosis of varying magnitude for pod yield and its component traits was observed for most of the traits except pod diameter. Similar results were reported by Suganthi *et al.* (2019) [23], Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12] and Jayanth (2021) [4]. The perusal of results suggested that for heterosis with respect to pod yield plant^{-1}, only one cross NOL-17-6 × Arka Anamika gave consistency in performance across all environments (E_1, E_2 and E_3) due to number of pods plant^{-1}. Whereas, other two different crosses AOL-12-59 × Kashi Kranti (in E_1 and E_2) and NOL-18-10 × Kashi Kranti (in E_2 and E_3) gave similar results across respected environments due to plant height at final harvest, number of pods plant^{-1} and days to 50% flowering, number of pods plant^{-1}, number of dry seeds pod^{-1}, respectively. Similar results were reported by Suganthi *et al.* (2019) [23], Vekariya *et al.* (2019) [25-26], Koli (2020) [6], Nagendra (2020) [11], Patel (2020) [12] and Jayanth (2021) [4].

Pod yield plant^{-1} is a complex trait and multiplicative product of the above mentioned basic component traits. Heterosis for pod yield plant^{-1} could be attributed mainly to heterosis observed for days to 50% flowering, number of branches plant^{-1}, number of pods plant^{-1}. Therefore, heterosis for pod yield could be a result of combinational heterosis. In order to obtain maximum heterotic effects for pod yield, higher magnitude of heterosis in desirable direction for each component traits is very much essential and hence, should be estimated with great care to identify superior cross combinations. Similar observations were reported earlier for pod yield plant^{-1} by many researchers like Tiwari *et al.* (2016b) [24], Patel and Patel (2016) [13], Koli (2020) [6], Nagendra (2020) [11], Vekariya *et al.* (2020) [27], Patel *et al.* (2021) [14] and Jayanth (2021) [4].

Among the parental genotypes, NOL-17-6, AOL-12-59, NOL-18-10, Arka Anamika and Kashi Kranti gave superior heterotic hybrids for pod yield and its component traits. However, undesirable effects of these parents for some of the other characters like days to 50% flowering and fibre content might be taken care of while developing superior hybrids with respect to all economic traits. Component-wise examination of the crosses showing significant economic heterosis revealed that only few component traits *viz.*, number of pods plant^{-1}, number of branches plant^{-1}, plant height at final harvest, pod length, pod weight and were important for the expression of heterotic effects, however, the heterotic effects of these component traits were widely influenced by the imposed environmental differences (Vekariya, 2019, Patel, 2020 and Jayanth, 2021) [[25-26], 20, 4]. Therefore, as a breeding strategy the promising hybrids evaluated over array of environments.

Table 1: Top three performing hybrid for various traits in okra over different environments

Traits	Environments		
	E_1 1st March, 2021	E_2 15th March,2021	E_3 1st April, 2021
Days to 50% flowering	NOL-18-10 × Kashi Kranti(-21.32**)	NOL-18-10 × Kashi Kranti (-21.67*)	NOL-18-10 × Arka Anamika (-20.33**)
	JOL-9-05 × Kashi Kranti and JOL-13-05 × Arka Anamika (-20.59*)	JOL-13-05 × Arka Anamika (-14.17*)	NOL-18-10 × Kashi Kranti (-16.26**)
	JOL-13-05 × Kashi Kranti (-13.97**)	JOL-9-05 × Kashi Kranti (-11.67**)	JOL-9-05 × Arka Anamika (-14.63**)
Number of branches plant^{-1} at final harvest	JOL-13-05 × Arka Anamika (38.89**)	JOL-13-05 × Arka Anamika (18.92**)	NOL-19-1 × Arka Anamika (11.11)
	NOL-17-6 × Arka Abhay (33.33**)	NOL-17-6 × Arka Anamika (24.32**)	NOL-19-1 × Arka Anamika (8.33)
	AOL-12-59 × Arka Abhay (16.67**)	NOL-19-3 × Arka Abhay (5.70)	NOL-19-3 × Arka Abhay (5.56)
Plant height at final harvest (cm)	AOL-10-22 × Kashi Kranti (40.90 **)	AOL-10-22 × Kashi Kranti (78.99 **)	AOL-10-22 × Kashi Kranti (44.84 **)
	AOL-10-22 × Arka Abhay (19.18**)	NOL-19-3 × Arka Anamika (51.96**)	AOL-10-22 × Arka Abhay (30.71**)
	JOL-9-05 × Kashi Kranti (17.42**)	JOL-9-05 × Kashi Kranti /(47.76**)	JOL-13-05 × Arka Anamika (18.89*)
Pod length (cm)	NOL-18-10 × Arka Anamika (24.94*)	NOL-19-3 × Kashi Kranti (-7.51)	NOL-19-3 × Kashi Kranti (-0.38*)
	NOL-18-10 × Kashi Kranti (-0.06)	AOL-10-22 × Arka Abhay (-13.01**)	JOL-13-05 × Arka Anamika (-3.68*)
	NOL-19-3 × Kashi Kranti (-4.29)	AOL-12-59 × Kashi Kranti (13.47**)	AOL-10-22 × Kashi Kranti (-7.19)
Pod weight (g)	AOL-10-22 × Arka Abhay (7.13*)	AOL-10-22 × Arka Abhay (9.48**)	JOL-13-05 × Kashi Kranti (3.70)
	JOL-13-05 × Kashi Kranti (3.75)	AOL-12-59 × Arka Abhay (8.26**)	AOL-10-22 × Arka Abhay (2.13)
	AOL-12-59 × Arka Abhay (1.66)	JOL-13-05 × Kashi Kranti (6.15*)	AOL-12-59 × Arka Abhay (-3.26)
Number of pods plant^{-1}	NOL-18-10 × Kashi Kranti (38.62**)	NOL-18-10 × Kashi Kranti (51.12**)	NOL-18-10 × Kashi Kranti (61.08**)
	NOL-17-6 × Arka Anamika (33.33**)	NOL-18-10 × Arka Anamika	NOL-17-6 × Arka Anamika (40.72**)

		(26.97**)	
	NOL-18-10 × Arka Anamika (29.10**)	AOL-12-59 × Kashi Kranti (24.72**)	AOL-12-59 × Kashi Kranti (32.34**)
Pod yield plant^{-1} (g)	NOL-17-6 × Arka Anamika (13.26**)	NOL-18-10 × Kashi Kranti (18.48**)	NOL-18-10 × Kashi Kranti (10.86**)
	NOL-18-10 × Arka Anamika (12.25**)	AOL-12-59 × Kashi Kranti (13.32*)	NOL-17-6 × Arka Anamika (8.99**)
	AOL-12-59 × Kashi Kranti (9.61*)	NOL-17-6 × Arka Anamika (12.87*)	AOL-12-59 × Arka Anamika (-2.00)
Number of dry seeds pod^{-1}	JOL-9-05 × Arka Anamika (-8.24)	JOL-9-05 × Arka Anamika (-14.85**)	AOL-10-22 × Arka Abhay (-16.86**)
	NOL-18-10 × Arka Anamika (-6.53)	JOL-9-05 × Kashi Kranti (-14.57**)	NOL-18-10 × Kashi Kranti (-16.15*)
	NOL-19-1 × Arka Anamika (-4.67)	NOL-18-10 × Kashi Kranti (-14.29**)	NOL-18-10 × Arka Anamika (-15.72*)
100 dry seed weight (g)	NOL-19-3 × Kashi Kranti (-32.90**)	JOL-13-05 × Kashi Kranti (-35.84**)	NOL-18-10 × Arka Anamika (-19.55)
	JOL-13-05 × Kashi Kranti (-29.68**)	AOL-12-59 × Kashi Kranti (-31.79**)	NOL-17-6 × Kashi Kranti (-15.79**)
	NOL-19-1 × Arka Abhay (-25.16**)	NOL-19-1 × Arka Abhay (-30.06)	JOL-13-05 × Kashi Kranti (-15.04**)
Fibre content (%)	NOL-19-3 × Kashi Kranti(-6.97)	JOL-13-05 × Arka Abhay (-8.79*)	JOL-9-05 × Kashi Kranti and (-1.72)
	NOL-18-10 × Arka Anamika (-3.64)	JOL-9-05 × Arka Anamika (-5.83)	NOL-19-1 × Kashi Kranti (-1.69)
	NOL-17-6 × Arka Abhay (-2.40)	JOL-9-05 × Kashi Kranti and NOL-17 6 × Arka Anamika (-3.94)	NOL-19-1 × Kashi Kranti (-1.17)

Table 2: Promising hybrids for pod yield plant^{-1} with standard heterosis and component traits showing significant and desired heterosis in all environments in okra

Sr. No.	Hybrid	Pod yield plant^{-1} (g)	Standard heterosis (%)	Useful and significant standard heterosis (%) for component traits
E_1				
1.	NOL-17-6 × Arka Anamika	186.45	13.26**	Number of pods plant^{-1}, 100 dry seeds weight
2.	NOL-18-10 × Arka Anamika	184.78	12.25**	Pod length, number of pods plant^{-1}
3.	AOL-12-59 × Kashi Kranti	180.43	9.61*	Plant height at final harvest, number of pods plant^{-1}
E_2				
1.	NOL-18-10 × Kashi Kranti	195.12	18.48**	Days to 50% flowering, number of pods plant^{-1}, number of dry seeds pod^{-1}, 100 dry seeds weight
2.	AOL-12-59 × Kashi Kranti	186.61	13.32**	Plant height at final harvest, number of pods plant^{-1}, 100 dry seeds weight
3.	NOL-17-6 × Arka Anamika	185.87	12.87**	Number of pods plant^{-1}
E_3				
1.	NOL-18-10 × Kashi Kranti	190.89	10.86**	Days to 50% flowering, number of pods plant^{-1}, number of dry seeds pod^{-1}
2	NOL-17-6 × Arka Anamika	187.67	8.99**	Number of pods plant^{-1}

Conclusion
It is evident from the above results that hybrids *viz.,* NOL-17-6 × Arka Anamika (E_1, E_2 and E_3); AOL-12-59 × Kashi Kranti (E_1 and E_2) and NOL-18-10 × Kashi Kranti (E_2 and E_3) were found promising for pod yield and its component traits.

References

1. Anonymous. FAOSTAT; c2017. Retrieved from http://faostat.fao.org/. [Accessed 14 September, 2021].
2. Gavint KN, Vadodariya KV, Bilwal BB. To study the nature and magnitude of heterosis for fruit yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]. J Pharma. and Phyto. 2018;7(1):2583-2587.
3. Hadiya DN, Mali SC, Baraiya VK, Patel AI. Studies on assessment of heterosis for fruit yield and attributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. Int. J. Chem. Studies. 2018a;6(5):1919-1923.
4. Jayanth S. Genetic and stability analysis for pod yield and its contributing characters in okra [*Abelmoschus esculentus* (L.) Moench], Thesis Ph. D. (Horti.), Navsari Agricultural University, Navsari, 2021, 192.
5. Karadi SM, Hanchinamani CN. Estimation of heterosis in okra [*Abelmoschus esculentus* (L.) Moench] for fruit yield and its components through line × tester mating design. Bangladesh J Bot. 2021;50(3):531-540.
6. Koli H. Genetic analysis for fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]. Thesis M.Sc. (Agri.), Navsari Agricultural University, Navsari, 2020, 189.
7. Kumar N. Breeding of Horticultural Crops. New India Publishing Agency, New Delhi; c2006. p. 173-177.
8. Kumar R, Kumar GS. Identification of best hybrid combination for fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]. J Pharma. and Phyto. 2019;8(1):1875-1877.
9. Kumar S, Singh AK, Yadav H, Verma A. Heterosis study in okra [*Abelmoschus esculentus* (L.) Moench] genotypes for pod yield attributes. J Appl. Natural Sci. 2017;9(2):774-779.
10. Lamont WJ. Okra—A Versatile Vegetable Crop. Hort Technology, 1999, 179-184.
11. Nagendra. Heterosis and combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. Thesis M.Sc. (Hort.), Navsari Agricultural University, Navsari, Gujarat, 2020, 107.
12. Patel A. Genetic analysis in okra [*Abelmoschus esculentus* (L.) Moench]. Thesis Ph. D. (Hort.), Navsari Agricultural University, Navsari, Gujarat, 2020, 171.
13. Patel BG, Patel AI. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Ann. Agr. Env. Sci. 2016;1(1):15-20.
14. Patel BM, Vachhani JH, Godhani PP, Sapovadiya MH. Combining ability for fruit yield and its components in okra [*Abelmoschus esculentus* (L.) Moench]. J Pharma. and Phyto. 2021;10(1):247-251.
15. Patel HB. Genetic analysis of yield and its quality parameters in okra [*Abelmoschus esculentus* (L.) Moench], Thesis M.Sc. (Horti.), Navsari Agricultural University, Navsari, 2015, 139.
16. Patel HB, Bhanderi DR, Patel AI, Tank RV, Kumar A. Magnitude of heterosis for pod yield and its contributing characters in okra [*Abelmoschus esculentus* (L.)

Moench]. Bioscan. 2015a;10(2):939-942.
17. Pithiya DJ, Jethava AS, Zinzala SN, Vachhani JH. Study on combining ability in okra [*Abelmoschus esculentus* (L.) Moench.]. Int. J Chem. Studies. 2020;8(1):676-679.
18. Sapavadiya SB, Kachhadia VH, Savaliya JJ, Sapavadiya MH, Singh SV. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. Pharma Innov. J. 2019a;8(6):408-411.
19. Satish K, Bhatt K, Suresh K, Prajapati DB, Agalodiya AV. Heterosis study in okra [*Abelmoschus esculentus* (L.) Moench]. Multilogic Sci. 2017a;7(24):85-89.
20. Satish K, Suresh K, Agalodiya AV, Prajapati DB. Combining ability for yield and its attributing traits in okra [*Abelmoschus esculentus* (L.) Moench]. Int. J. Curr. Microbiol. App. Sci. 2017b;6(9):1944-1954.
21. Shwetha A, Mulge R, Evoor S, Kantharaju V, Masuti DA. Diallel analysis for combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench] for yield and quality parameters. Int. J. Curr. Microbiol. Appl. Sci. 2018;7(9):2114-2121.
22. Sidapara MP, Gohil DP, Patel PU, Sharma DD. Heterosis studies for yield and yield components in okra [*Abelmoschus esculentus* (L.) Moench]. J. Pharma. and Phyto. 2021;10(1):1268-1275.
23. Suganthi S, Sathiskumar P, Kamaraj A, Shanmugapriya R. Exploitation of heterosis through diallel analysis in bhendi (*Abelmoschus esculentus* (L.) Moench). Journal of Pharmacognosy and Phytochemistry. 2019;8(2S):598-601.
24. Tiwari JN, Kumar S, Ahlawat TR. Combining ability studies for various horticultural traits in okra [*Abelmoschus esculentus* (L.) Moench] under South-Gujarat conditions. J. Farm Sci. 2016;29(1):53-56.
25. Vekariya RD. Genetic study and stability analysis over environments in okra [*Abelmoschus esculentus* (L.) Moench]. Thesis Ph.D. (Agri.), Navsari Agricultural University, Navsari, 2019, 232.
26. Vekariya RD, Patel AI, Modha KG, Mali SC. Study of heterosis over environments for fruit yield and its related traits in okra [*Abelmoschus esculentus* (L.) Moench]. IJCS. 2019;7(5):484-90.
27. Vekariya RD, Patel AI, Modha KG, Kapadiya CV, Mali SC, Patel AA. Estimation of Heterosis, Gene Action and Combining Ability over Environments for Improvement of Fruit Yield and its Related Traits in Okra [*Abelmoschus esculentus* (L.) Moench]. Int. J. Curr. Microbiol. App. Sci. 2020;9(9):866-81.
28. Vijayaraghavan C, Warrier VA. Evaluation of high yielding hybrids in bhendi (*Hibiscus esculentus*). Proceedings of 33rd Indian Science Congress, Banglore, India, 1946, 165.