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ESTIMATION OF HETEROSIS FOR EARLINESS AND YIELD CONTRIBUTING TRAITS IN CUCUMBER (*Cucumis sativus* L.)

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ABSTRACT

The research was conducted at Experimental Research Farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP during 2015-2016 to estimate the heterosis for earliness and yield contributing traits. Six genotypes were used to develop 15 F_1 hybrids of cucumber by half diallel mating design. The mean sum of squares were highly significant for all the characters indicated a wide genetic variation for the characters studied and there is a possibility of genetic improvement using such genetic pools in future breeding programme.The genotypes P1-618860, UHF-CUC-1, UHF-CUC-2 and Khira-75 were found superior on the basis of mean performance for earliness and yield related characters. Appreciable heterosis was observed over better parent and standard check for most of the characters studied. The F_1 hybrids those found to be superior in performance over better parent and standard check for various characters under study were Khira-75 x PI-618860 (16.30 & 65.71), Khira-75 x UHF-CUC-2 (23.48 & 60.22) and Khira-75 x UHF-CUC-1 (23.01 & 59.60) including yield per plot and per hectare respectively, can be exploited for commercial cultivation.

INTRODUCTION

Cucurbits form an important and big group of vegetable crops. Cucumber (*Cucumis sativus* L.) is considered as 4th most important vegetable crop after tomato, cabbage and onion (Tatlioglu, 1993 and Jat *et al.*, 2014). It is an important salad vegetable crop grown throughout India (Veena *et al.*, 2013). It belongs to family Cucurbitaceae is an important summer vegetable, grown for its immature fruits, used as salad, making pickles, *rayata* preparations and even brined on commercial scale in almost every part of the world. Cucumbers with attractive fruit color, high total soluble solids content, less bitterness and high nutritive value are preferred by the consumer (Kumar *et al.,* 2016).

For developing superior varieties, it is necessary to improve the earliness and yield in cucumber. This can be achieved through effective utilization of germplasm resources and integration of genomic tools to impart efficiency and pace of breeding processes (Banga, 2012). Exploitation of heterosis in crop plants is one of the most attractive achievements in boosting up the production and productivity of cucumber. Heterosis breeding can be one of the most viable options for breaking the present yield barrier (Devi *et al.*,2017). Comprehensive analysis of the combining ability involved in the inheritance of quantitative traits and in the phenomenon of heterosis is necessary for evaluation of various breeding procedures (Allard, 1960 and Meena *et al.,* 2015). Heterosis breeding provides an opportunity for achieving unique improvement in yield and other desirable attributes in one generation that would be more time consuming and difficult with other conventional breeding methods (Sherpa *et al.*, 2014). Since cucumber is a monoecious and cross-pollinated crop and has appreciable number of seeds per fruit, so it provides enough scope for the exploitation of hybrid vigour and has a great scope of improvement over its base population (Bairagi *et al.,* 2005 and Kumar *et al.,* 2017). Among many cucurbits grown across the world, cucumber is distinct with a unique sex mechanism and this feature can easily be manipulated for the production of F_1 hybrid seeds (Arinia *et al*., 2013). Several breeders have confirmed that hybrid vigour was manifested in cucumber in respect of earliness (Hutchins, 1939) and increased yield due to large number of fruits per plant (Singh *et al.*,1970; Pandey *et al*., 2005 and Airina *et al.*, 2013). Using best combiners, heterosis breeding is one of the best methods to improve upon the existing varieties. India being considered the home of cucumber possesses a vast range of genetic diversity and variability for both growth and fruit characters, but this advantage has not been fully assessed and utilised. A large number of hybrids have been developed and in Western countries almost ninety per cent of the area grown for cucumbers is covered by hybrids. Heterosis studies provide information about per cent increase of F_1 over better parent or standard check only and thus help in scoring out the best crosses, but they do not indicate the possible causes for superiority of crosses. The common approach of selecting the parents on the basis of per se performance, adaptation and genetic variability does not necessarily lead to useful results. This is because of differential combining ability of parents which depends upon the complex interactions among the genes and cannot be judged by the per se performance alone (Allard, 1960). Heterosis is rather a function of specific cross combination, so analysis of combining ability helps to determine the feasibility of its utilization and identification of best combiners. It also helps in the identification of superior hybrid combinations, which may be utilized for commercial exploitation of heterosis (Reddy *et al.,* 2014). Therefore, there is a paramount need to develop suitable hybrids, which may be utilized on commercial scale especially in the north Indian plains. Keeping in view the above facts, the present investigation was therefore, initiated with a view to obtain suitable hybrids which can be exploited on commercial scale in the north Indian conditions so the information for assessment of heterosis for earliness, yield and yield attributing traits has been evaluated.

MATERIALS AND METHODS

The present experiments were carried out at the Experimental Research Farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2015 and 2016.The six genetically diverse genotypes of cucumber *viz.,* Khira-75, UHF-CUC-1, UHF-CUC-2, UHF-CUC-3, Poinsette and PI-618860 were crossed in a half-diallel (excluding reciprocals) mating scheme (Hayman, 1954) and 15 F_1 hybrids were obtained. These 15 F_1's along with the 6 parents were evaluated in an experiment in randomized complete block design (RCBD) with three replications during *kharif* season. The crop was grown in rows at 1.0 m apart with spacing of 0.75 m between the plants. All the recommended agronomic practices including weeding, hoeing, manures and fertilisers applications for irrigated conditions were followed to raise a healthy and successful crop (Anonymous, 2016). In each replication per plot out of sixteen plants, ten plants were randomly selected for observations on plant, fruit and yield characters on individual plant basis. The observations were recorded for important characters namely, days taken to first female flower appearance, node number bearing first female flower, days to marketable maturity, fruit length (cm), fruit breadth (cm), average fruit weight (g), number of marketable fruits perplant, harvest duration (days) and marketable yield per plot (kg) and per hectare (q). Therefore, heterosis was calculated in favourable direction as percentage increase of F_1 performance over better parent (BP) and standard check (SC). Increase or decrease was measured as the proportion of deviation of F_1 from better parent (heterobeltiosis) and standard hybrid KH-1 (check) and expressed in percentage.

(i) Heterosis over better parent (BP) = $[(\bar{F}_1 - \overline{BP})/\overline{BP}] \times 100$

(ii) Heterosis over standard check (SC) = $[(\bar{F}_1 - \overline{SC})/\overline{SC}] \times 100$

The standard error was calculated as under

SE (d) = $\pm$ (2 Me/r)

In order to test the significance of heterosis over BP and increase/decrease over check, t-test as follows was conducted:

(i) 't' calculated values for heterosis over BP = $(\bar{F}_1 - \overline{BP})/SE(d)$

(ii) 't' calculated values for heterosis over SC = $(\bar{F}_1 - \overline{SC})/SE(d)$

If the calculated t-value was greater than tabulated value at error degree of freedom and at least significant difference then only the results were declared significant (Hayes, 1955 and Turner, 1953).

RESULTS AND DISCUSSION

There were highly significant differences among the genotypes in respect of different characters studied including total yield per plot and per hectare. The range of mean performance of parents, crosses and check variety for earliness and yield contributing traits is presented in Table 1. Earliness, indicated by negative estimates of heterosis which helps the grower to fetch early market price, is a well recognised and one of the most important desirable parameter in any breeding programme particularly development of hybrids. This trait is associated with characters such as days taken to first female flower appearance, node number bearing first female flower, days to marketable maturity. In order of superiority, the best four F_1 hybrids, which gave best performance over better parent in relation to earliness were, Khira-75 x PI-618860 (-6.10%), Khira-75 x UHF-CUC-2 (-3.41%), UHF-CUC-1 x PI-618860 (-3.40%) and Khira-75 x UHF-CUC-1 (-2.70%) for days taken to first female flower appearance and for standard heterosis out of fifteen cross combinations, five combinations showed significant negative heterosis over check cultivar KH-1, maximum being in Khira-75 x PI-618860 (-19.93%); Khira-75 x PI-618860 (-2.17%), Khira-75 x UHF-CUC-1 (-2.17%), UHF-CUC-1 x UHF-CUC-2 (-2.85%) and Khira-75 x UHF-CUC-2 (-4.61%) for node number bearing first female flower while for standard heterosis negative standard heterosis for node number bearing first female flower was represented by eight cross combinations over standard check; Khira-75 x PI-618860 (-5.18%), UHF-CUC-2 x PI-618860 (-4.09%), UHF-CUC-1 x PI-618860 (-3.54%) and Khira-75 x UHF-CUC-1(-3.29%) for days to marketable maturity and standard heterosis for this trait was revealed by only three cross combinations over check variety (Table 2 and Table 3) . Wide variations with respect to earliness were also reported by Munshi *et al.,* (2007), Kumar *et al.,* (2008), Hanchinamani *et al.,* (2008), Yadav *et al.,* (2009), Kumar *et al.* (2010), Singh *et al.* (2010), Dogra and Kanwar (2011), Kumar *et al.* (2013), Airina *et al.* (2013), Jat *et al.* (2015) and Kumar *et al.* (2017) in cucumber.

Highest yield is the foremost and desirable character for any breeding programme. It is a complex trait resulting from the interaction of its component character of a crop. Moll and Stuber (1974) pointed out that heterosis estimates should indicate whether heterozygote's or homozygote's represent the more ideal genotype. In case of cucumber breeding, number of fruits per plant, fruit weight and fruit size are the direct yield components. In order of merit the best four F_1 hybrids, which gave highest performance over better parent and standard heterosis in relation to yield and its contributing characters were Khira-75 x UHF-CUC-2 (18.11% & 26.33), Khira-75 x PI-618860 (9.45% & 67.99), Khira-75 x UHF-CUC-1 (5.62% & 27.50) and UHF-CUC-1 x UHF-CUC-2 (4.90% & 26.62) for fruit length; UHF-CUC-1 x UHF-CUC-2 (13.61% & 16.57), UHF-CUC-2 x Poinsette (7.99% & 10.80), Khira-75 x UHF-CUC-1 (3.57% & 8.19) and Khira-75 x PI-618860 (3.39% & 8.01) for fruit breadth; Khira-75 x PI-618860 (6.88% &17.28), Khira-75 x UHF-CUC-2 (6.20% & 14.40), UHF-CUC-1 x UHF-

Table 1: Mean performance of parents, crosses and check variety for earliness and yield contributing traits in cucumber

CharacterParents	DTTMM	NNBFFF	DTMM	FL (cm)	FD (cm)	AFW (g)	NMFPP	HD	MYPP (kg)	MYPH (q)
Khira-75	55.85	6.08	62.29	17.01	5.61	268.90	9.29	34.48	39.73	264.87
UHF-CUC-1	52.20	4.59	61.87	20.63	5.48	288.28	7.79	33.20	35.90	239.31
UHF-CUC-2	52.19	4.56	59.61	18.28	5.51	278.35	8.04	34.32	35.98	239.88
UHF-CUC-3	57.74	7.26	67.76	16.42	4.40	235.00	7.57	31.57	28.59	190.60
Poinsette	58.70	7.30	65.74	15.63	4.68	215.07	6.61	30.82	22.79	151.91
PI-618860	45.54	3.69	52.46	26.23	5.22	283.55	9.60	33.46	43.63	290.84
Khira-75 x UHF-CUC-1	50.79	4.49	59.83	21.79	5.81	294.92	10.36	36.57	48.87	325.81
Khira-75 x UHF-CUC-2	50.41	4.35	59.38	21.59	5.74	295.61	10.38	36.44	49.06	327.04
Khira-75 x UHF-CUC-3	62.50	8.09	69.59	15.42	4.51	213.13	6.58	29.48	22.52	150.13
Khira-75 x Poinsette	62.28	8.10	69.84	14.60	4.25	204.96	5.48	28.25	17.91	119.40
Khira-75 x PI-618860	42.76	3.61	49.74	28.71	5.80	303.05	10.48	35.53	50.74	338.25
UHF-CUC-1 x UHF-CUC-2	52.82	4.43	60.77	21.64	6.26	295.98	9.25	35.42	43.84	292.25
UHF-CUC-1 x UHF-CUC-3	60.90	8.08	68.41	16.44	4.21	246.72	6.59	26.96	26.01	173.38
UHF-CUC-1 x Poinsette	63.22	8.17	71.49	17.27	4.97	276.14	6.63	25.90	29.28	195.17
UHF-CUC-1 x PI-618860	43.99	4.26	50.60	26.58	4.29	291.37	10.02	34.65	46.65	311.01
UHF-CUC-2 x UHF-CUC-3	56.16	7.98	64.61	15.70	4.79	212.28	5.89	24.94	19.98	133.19
UHF-CUC-2 x Poinsette	53.22	4.85	61.37	17.28	5.95	266.31	7.55	32.31	32.21	214.72
UHF-CUC-2 x PI-618860	44.39	4.44	50.31	26.70	5.59	285.51	10.19	34.67	46.60	310.68
UHF-CUC-3 x Poinsette	63.52	8.20	71.62	15.39	3.64	238.55	5.49	25.32	20.99	139.96
UHF-CUC-3 x PI-618860	53.50	5.93	61.26	19.79	4.50	247.51	5.54	28.44	21.77	145.10
Poinsette x PI-618860	52.36	5.69	60.86	20.90	3.75	224.43	6.28	28.27	22.59	150.58
KH-1 (check)	53.40	5.97	60.38	17.09	5.37	258.39	7.44	32.86	30.62	204.14
Range	42.76-63.52	3.61-8.20	49.74-71.62	14.60 -28.71	3.64-6.26	204.96-303.05	5.48-10.48	24.94-36.57	17.91-50.74	119.40-338.25
Population mean	54.02	5.91	61.81	19.59	5.03	260.18	7.87	31.54	33.47	223.10
SE(m) ±	0.82	0.47	0.89	0.62	0.29	9.24	0.80	1.18	3.64	24.24
$CD_{(0.05)}$	1.64	0.94	1.77	1.25	0.59	18.51	1.61	2.35	7.28	48.53

*Significant at 5% level of significance; DTTFFF- Days taken to first female flower, NNBFFF-Node number bearing first female flower, DTMM-Days taken to marketable maturity, FL-Fruit length, FD-Fruit diameter, AFW-Average fruit weight, NMFPP- Number of marketable fruits per plant, HD-Harvest duration, MYPP-Marketable yield per plot and MYPH- Marketable yield per hectare

Table 2: Crosses showing heterobeltiosis for earliness and yield contributing traits in cucumber

CharacterParents	DTTMM	NNBFFF	NNBFFF	FL (cm)	FD (cm)	AFW (g)	NMFPP	HD	MYPP (kg)	MYPH (q)
Khira-75 x UHF-CUC-1	-2.70*	-2.17*	-3.29*	5.62*	3.57*	2.30*	11.52*	6.06*	23.01*	23.01*
Khira-75 x UHF-CUC-2	-3.41*	-4.61*	-0.39	18.11*	2.32*	6.20*	11.73*	5.68*	23.48*	23.47*
Khira-75 x UHF-CUC-3	11.91*	33.06*	11.72*	-9.35*	-19.61*	-20.74*	-29.17*	-14.50*	-43.32*	-43.32*
Khira-75 x Poinsette	11.51*	33.22*	12.12*	-14.17*	-24.24*	-23.78*	-41.01*	-18.07*	-54.92*	-54.92*
Khira-75 x PI-618860	-6.10*	-2.17*	-5.18*	9.45*	3.39*	6.88*	9.17*	3.05*	16.30*	16.30*
UHF-CUC-1 x UHF-CUC-2	1.21	-2.85*	1.95	4.90*	13.61*	2.67*	15.05*	3.21*	21.85*	21.83*
UHF-CUC-1 x UHF-CUC-3	16.67*	76.03*	10.57*	-20.31*	-23.18*	-14.42*	-15.40*	-18.80*	-27.55*	-27.55*
UHF-CUC-1 x Poinsette	21.11*	78.00*	15.55*	-16.29*	-9.31*	-4.21*	-14.89*	-21.99*	-18.44*	-18.44*
UHF-CUC-1 x PI-618860	-3.40*	15.44*	-3.54*	1.33	-21.72*	1.07	4.38*	3.56*	6.92*	6.94*
UHF-CUC-2 x UHF-CUC-3	7.61*	75.00*	8.39*	-14.11*	-13.07*	-23.74*	-26.74*	-27.33*	-44.47*	-44.48*
UHF-CUC-2 x Poinsette	1.97	6.36*	2.95*	-5.47*	7.99*	-4.33*	-6.09*	-5.86*	-10.48*	-10.49*
UHF-CUC-2 x PI-618860	-2.52*	20.32*	-4.09*	1.79	1.45	0.69	6.15*	1.02	6.81*	6.82*
UHF-CUC-3 x Poinsette	10.01*	12.95*	8.94*	-6.27*	-23.53*	1.51	-27.48*	-19.80*	-26.58*	-26.57*
UHF-CUC-3 x PI-618860	17.47*	60.70*	16.77*	-24.55*	-13.79*	-12.71*	-42.29*	-15.00*	-50.10*	-50.11*
Poinsette x PI-618860	14.98*	54.20*	16.01*	-20.32*	-28.16*	-20.85*	-34.58*	-15.51*	-48.22*	-48.23*
Range	-6.10- 21.11	-4.61-78.00	-5.18-16.77	-24.55-18.11	-28.16-13.61	-23.78-6.88	-42.29-15.05	-27.33-6.06	-54.92-23.48	-54.92-23.47

*Significant at 5% level of significance ; DTTFFF- Days taken to first female flower, NNBFFF-Node number bearing first female flower, DTMM-Days taken to marketable maturity, FL-Fruit length, FD-Fruit diameter, AFW-Average fruit weight, NMFPP- Number of marketable fruits per plant, HD-Harvest duration, MYPP-Marketable yield per plot and MYPH- Marketable yield per hectare.

Table 3: Crosses showing standard heterosis for earliness and yield contributing traits in cucumber

CharacterParents	DTTFFF	NNBFFF	DTMM	FL (cm)	FD (cm)	AFW (g)	NMFPP	HD	MYPP (kg)	MYPH (q)
Khira-75 x UHF-CUC-1	-4.89*	-24.79*	-0.91	27.50*	8.19*	14.14*	39.25*	11.29*	59.60*	59.60*
Khira-75 x UHF-CUC-2	-5.60*	-27.14*	-1.66	26.33*	6.89*	14.40*	39.52*	10.89*	60.22*	60.20*
Khira-75 x UHF-CUC-3	17.04*	35.51*	15.25*	-9.77*	-16.01*	-17.52*	-11.56*	-10.29*	-26.45*	-26.46*
Khira-75 x Poinsette	16.63*	35.68*	15.67*	-14.57*	-20.86*	-20.68*	-26.34*	-14.03*	-41.51*	-41.51*
Khira-75 x PI-618860	-19.93*	-39.53*	-17.62*	67.99*	8.01*	17.28*	40.86*	8.13*	65.71*	65.70*
UHF-CUC-1 x UHF-CUC-2	-1.09	-25.80*	0.65	26.62*	16.57*	14.55*	24.33*	7.79*	43.17*	43.16*
UHF-CUC-1 x UHF-CUC-3	14.04*	35.34*	13.30*	-3.80*	-21.60*	-4.52*	-11.42*	-17.95*	-15.06*	-15.07*
UHF-CUC-1 x Poinsette	18.39*	36.85*	18.40*	1.05	-7.45*	6.87*	-10.89*	-21.18*	-4.38*	-4.39*
UHF-CUC-1 x PI-618860	-17.62*	-28.64*	-16.20*	55.53*	-20.11*	12.76*	34.68*	5.45*	52.35*	52.35*
UHF-CUC-2 x UHF-CUC-3	5.17*	33.67*	7.01*	-8.13*	-10.80*	-17.85*	-20.83*	-24.10*	-34.75*	-34.76*
UHF-CUC-2 x Poinsette	-0.34	-18.76*	1.64	1.11	10.80*	3.07*	1.48	-1.67*	5.19*	5.18*
UHF-CUC-2 x PI-618860	-16.87*	-25.63*	-16.68*	56.23*	4.10*	10.50*	36.96*	5.51*	52.19*	52.19*
UHF-CUC-3 x Poinsette	18.95*	37.35*	18.62*	-9.95*	-32.22*	-7.68*	-26.21*	-22.95*	-31.45*	-31.44*
UHF-CUC-3 x PI-618860	0.19	-0.67	1.46	15.80*	-16.20*	-4.21*	-25.54*	-13.45*	-28.90*	-28.92*
Poinsette x PI-618860	-1.95	-4.69*	0.79	22.29*	-30.17*	-13.14*	-15.59*	-13.97*	-26.22*	-26.24*
Range	-19.93-18.95	-39.53-37.35	-17.62-18.62	-14.57-67.99	-32.22-16.57	-20.68-17.28	-26.34-40.86	-24.10-11.29	-41.51-65.71	-41.51-65.70

*Significant at 5% level of significance ; DTTFFF- Days taken to first female flower, NNBFFF-Node number bearing first female flower, DTMM-Days taken to marketable maturity, FL-Fruit length, FD-Fruit diameter, AFW-Average fruit weight, NMFPP- Number of marketable fruits per plant, HD-Harvest duration, MYPP-Marketable yield per plot andMYPH- Marketable yield per hectare.

CUC-2 (2.67% & 14.55) and Khira-75 x UHF-CUC-1 (2.30% & 14.14) for average fruit weight; UHF-CUC-1 x UHF-CUC-2 (15.05% & 24.33), Khira-75 x UHF-CUC-2 (11.73% & 39.52), Khira-75 x UHF-CUC-1 (11.52% & 39.25) and Khira-75 x PI-618860 (9.17% & 40.86) for number of marketable fruits per plant; Khira-75 x UHF-CUC-1 (6.06% & 11.29), Khira-75 x UHF-CUC-2 (5.68% & 10.89), UHF-CUC-1 x PI-618860 (3.56% & 5.45) and UHF-CUC-1 x UHF-CUC-2 (3.21% & 7.79) for harvest duration; Khira-75 x UHF-CUC-2 (23.48% & 60.20), Khira-75 x UHF-CUC-1 (23.01% & 59.60), UHF-CUC-1 x UHF-CUC-2 (21.85% & 43.16) and Khira-75 x PI-618860 (16.30% & 65.70) for marketable yield per plot and per hectare (Table 2 and Table 3). These findings were in line with Munshi *et al.*,(2007), Kumar *et al.*,(2008), Hanchinamani *et al.*, (2008), Yadav *et al.*, (2009), Kumar *et al.*, (2010), Singh *et al.*, (2010), Hossain *et al.*, (2010), Dogra and Kanwar (2011), Kumar *et al.*, (2011), Golabadi *et al.*, (2012), Singh *et al.*, (2012), Airina *et al.*, 2013, Jat *et al.*, 2015 and Kumar *et al.*, 2017 who have also been reported wide variations with respect to yield and yield contributing traits in cucumber.

The result indicated that maximum yield per plot in the hybrids mentioned above was attributed by maximum number of fruits per plant. First generation crosses in cucumber frequently exhibit high parent heterosis due to increase fruit size and fruit number per plant was reported by Hayes and Jones (1916). Hence, breeder should concentrate mainly on fruit number rather than fruit size in their efforts to increase yield. The present experiment showed a fairly high degree of heterosis for fruit yield per plot and per hectare in most of hybrids. Singh *et al.*, 2012 observed positive heterosis desirable for length of fruit, weight per fruit, number of fruits perplant and fruit yield per plant was common in most of the crosses. Kushwaha *et al.*, 2011 observed that hybrids manifested significant heterobeltiosis for node bearing first female flower, fruit length, fruit diameter, fruit weight and for number of fruits per vine and fruit yield per vine. Musmade (1986) also reported similar results in cucumber hybrids. Appreciable heterosis in desirable direction was found over better parent and mid parent for all the characters studied (Pandey *et al.*, 2005). In accordance to the present findings, Grafius (1959) was of the opinion that hybrid vigour of even small magnitude of individual yield components may have additive or synergistic effect on the end product, as had mentioned that heterosis for yield is the result of interaction of simultaneous increase in the expression of heterosis for yield components. Based on the performance of 15 F_1 hybrids three best performing hybrids Khira-75 x PI-618860, Khira-75 x UHF-CUC-2 and Khira-75 x UHF-CUC-1 showing 65.71, 60.22, and 59.60% heterosis, respectively over standard check KH-1 for yield per plot and per hectare (Table 3) can be tested under multi-locational trials so that these hybrids can be further utilized for commercial scale in the north Indian conditions .

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