ANALYSIS OF HETEROSIS AND LEVEL OF DOMINANCE IN F_1-MANGO (*Mangifera indica* L.)

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ABSTRACT

The magnitude of heterosis over mid-parent, height-parent, two standard varieties, and level of dominance were calculated in twelve mango hybrids derived from ‘Arumanis’ clone and red peel mangos (‘Haden’, ‘Gedong Gincu’, ‘Keitt’, ‘Li’ar’, ‘Saigon’, and ‘Irwin’) for eleven quality characters. The samples were observed toward four years old F_1 were grafted on rootstock 'Madu' clone and planted in the field (Cukurgondang experimental station, Pasuruan, East Java, Indonesia). This study was conducted from July to October 2011. Observation on appearance of all F_1 was shown that all characters were varies widely F_1-5-Ar x GG was exhibited a higher mean value to parents, highest parent, or two standard varieties for fruit length and fruit diameter. F_1-3-Ar x Hd, F_1-4-Ar x Hd, F_1-5-Ar x GG, F_1-6-Ar x GG, F_1-10-Ar x Sg, and F_1-12-Ir x Ar were severe to mid parent, highest parent, and two standard varieties. Consecutively, peel and stone weight character: F_1-2-Ar x Hd, F_1-6-Ar x GG, F_1-9-Ar x GG, and F_1-11-Ir x Ar; including F_1-5-Ar x GG, F_1-6-Ar x GG were more meaningful than other progenies. F_1-3-Ar x Hd, F_1-4-Ar x Hd, F_1-5-Ar x GG, F_1-10-Ar x Sg, and F_1-12-Ir x Ar attested that appearance of phenotypes significantly different to their both parents, highest parents, and two standard varieties. Further, an effort to improve sweetness through increase total soluble solids and decrease total acidity were fulfilled by crossing F_1-1-Ar x Hd, F_1-3-Ar x Hd, F_1-6-Ar x GG, except F_1-10-Ar x Sg was resulted no significant improvement upon these effort. Meanwhile, the only F_1-8-Ar x Keitt which was escalated levels of vitamin C compared with both parents and did not quite mean to highest parent and standards variety 1. All the progenies were displayed no increase in β-carotene and anthocyanins contain. The meaningful degree of dominance was over dominant positive to fruit length, fruit diameter, edible portion, total soluble solids (TSS), and vitamin C content. Over dominant positive and recessive partial to fruit weigh, over dominant negative to stone weight; and over dominant negative and recessive partial to peel weight, include total acidity characters.

Keywords: *Mangifera indica* L., heterosis, level of dominance.

INTRODUCTION

Heterosis or hybrid vigor (Emre *et al*., 2010) describes the superior performance of heterozygous hybrid individuals compared with their homozygous parents (Thiemann *et al*., 2009). In some cases, the hybrid may be inferior to the weaker parent. This is also regarded as heterosis (www.angrau.net). The word heterosis was coined by Shull (1914) to provide a term to describe the phenomenon but it did not include a description of the genetic mechanism involved in its expression. Heterosis is a phenomenon not well understood but has been exploited extensively in breeding and commercially (Hallauer *et al*., 2010). The heterosis could be interpreted by the recombination of gametes from crossbred parents and epistatic superiority from the pure breeds. Advantaged dominant genes restrain the deleterious recessive genes. Different degrees of heterosis may result from different genetic backgrounds among populations (Tian *et al*., 2006). Several hypotheses explaining heterosis among others: 1) The dominance hypotheses attributes the greater yield of hybrids to the suppression of deleterious recessives from one parent by dominant alleles from the other. 2) The overdominance hypotheses assume that at key loci the heterozygote is superior to either homozygote (Crow 1998). Over dominance can also be explained by pseudo-over dominance, which is a case of dominance complementation in which the 2 recessive mutations are linked in repulsion (Iria *et al*., 2009). 3) The epistasis hypotheses, that is, gene-by-gene multiplicative interactions (Allard 1996). The genetic basis of heterosis may also depend on the trait or cross, being one of the above hypotheses the major cause in a particular case, although an alternative hypotheses may be more important in another cases. The genetic complexity under complex genetic control, strongly influenced by environmental conditions and with low heritability, making their genetic analysis even more difficult (Iria *et al*., 2009).

Utilization of heterosis is very helpful in the annual plant breeding strategies that require a long period of time or for the selection (Rubiyo *et al*., 2011). On mango breeding, parent selection based on the performance phenotype (Lavi *et al*., 1998). Components of genetic variation in the character of mango decline are most significant non-additive (Lavi *et al*., 1998 and Usman *et al*., 2001). One of the methods for this purpose is heterosis breeding. Because the mango is an open-pollinated plants, accordingly on this method may be somewhat unique because the parent is not used homozigous (pure line) but is heterozigous.

Mango is a fruit with commodity production the fifth largest in the world after bananas, grapes, apples, and oranges (Bally *et al*., 2009). Until the year 2010 for the commodity producers of mango, mangosteen and guava are still dominated by India, China, Thailand, Pakistan, Mexico, and Indonesia (FAOSTAT 2012). In 2010, production of Indonesia mangoes is 1, 287, 287 tons with export volume of 1626 tones (Ditjen PPHP, 2010). ‘Arumanis’ and ‘Gedong Gincu’ are the greatest mangoes demand, both in the local market and export markets (Qanytah dan Indrie, 2011). Mango varieties are popular in Indonesia and have been obtained from the germplasm selection and selection of local mangos. Nevertheles, it would still be possible to assemble the new varieties that have a phenotypic value that is better than 'Arumanis' and 'Gedong Gincu' through artificial crosses.

Mango breeding can be done through methods: seed selection of natural open pollination, controlled pollination (artificial pollination), with the help of pollinator insects (flies) in mango crops that have properties of self - incompatible, and the connecting rod on the rootstock selected progeny (Usman *et al*., 2001). Since 2000 Indonesian Tropical Fruits Research Institute (ITFRI) has conducted a cross toward some mango cultivars for F_1 with a better quality.

This study is specifically aimed to calculate over mid-parent, height-parent, two standard varieties, and level of dominance of twelve mango hybrids derived from ‘Arumanis’ clone and red peel mangos (‘Haden’, ‘Gedong Gincu’, ‘Keitt’, ‘Li’ar’, ‘Saigon’, and ‘Irwin’) for eleven quality characters.

MATERIALS AND METHODS

Twelve F_1 cross between green peel 'Arumanis' (Ar) clone and red peel clones namely 'Haden' (Hd), 'Gedong Gincu' (GG), 'Keitt', 'Li'ar', 'Saigon' (Sg) and 'Irwin' (Ir) were used in this research. Four years old mango trees were used in this research. All of F_1 were grafted on rootstock 'Madu' clone and planted in the field (Cukurgondang experimental station of Indonesian Tropical Fruit Research Institute (ITFRI), Pasuruan, East Java, Indonesia) This study was conducted from July to October 2011. Fruit quality characteristics were observed include: 1. Fruit length (cm); 2. Fruit diameter (cm); 3. Fruit weight (g); 4. Peel weight (g); 5. Stone weight (g); 6. Weight of edible portion (g); 7. Total soluble solids (° Brix); 8. Total acidity (%); 9. The content of vitamin C (mg/100g); 10. β-carotene content of the fruit flesh (μg/100g); and 11. Anthocyanin content of fruit peels (ppm).

Mid-parent heterosis (MPH), high-parent heterosis (HPH), standard heterosis to ‘Arumanis’ (StH1), and standard heterosis to ‘Gedong Gincu’ were calculated as follows: MPH = F_1-MP/MP x 100; HPH = F_1-HP/HP x 100; StH1 = F_1-MStH1/MStH1 x 100; StH2 = F_1-MStH2/MStH2 x 100; where: MP = mean of two parents, HP = mean of high parent, MStH1 = mean of ‘Arumanis’, and MStH2 = mean of ‘Gedong Gincu’. Testing different average F1 - MP, F1 - HP, F1 - MStH1, F1 - MStH2 performed by t-test.

The level of dominance (potential ratio value) calculated using Petr and Frey (1966) formula: h = (f1-MP) / (HP-MP). Based on the h value, the degree of dominance is classified as: h = 0 there is no dominance; h = 1 or h = -1 dominant or recessive is full; 0 <h <1 the dominant partial; -1 <h <0 recessive partial; h> 1 or h <-1 over-dominance.

RESULTS

The results of significance tests to the two mean values indicated that there was a significant difference in the characters of fruit length, fruit diameter, fruit weight, peel weight, stone weight, weight of edible portion, vitamin C content of flesh, and β-carotene content of flesh.

Fruit length

Range value of MPH varies between -23.747 to 35.658, HPH -25.897 to 9.744, StH1 -25.897 to 9.744, StH2 19.917 to 77.593, and range value of h varies between -8.182 to 1.510.

Fruit diameter

Range value of MPH varies between -19.048 to 20.628, HPH -20.313 to 8.468, StH1-17.742 to 11.290, StH2 -6.849 to 26.027, and range value of h varies between -15.400 to 6.000.

Fruit weight

Range value of MPH varies between -38.684 to 62.999, HPH -43.857 to 32.115, StH1-43.857 to 32.115, StH2 4.335 to 145.520, and range value of h varies between -23.900 to 21.650.

Peel weight

Range value of MPH varies between -27.108 to 100.241, HPH -40.394 to 63.744, StH1-40.394 to 63.744, StH2 3.419 to 184.103, and range value of h varies between -11.000 to 7.857.

Stone weight

Range value of MPH varies between -96.582 to 24.611, HPH -96.687 to 19.048, StH1 -96.471 to 30.719, StH2 -96.786 to 19.048, and range value of h varies between -43.000 to 6.600.

Weight of edible portion

Range value of MPH varies between -46.992 to 90.646, HPH -53.333 to 194.349, StH1 -53.333 to 33.548, StH2 6.634 to 205.160, and range value of h varies between -36.733 to 25.000.

Total soluble solids of flesh

Range value of MPH varies between -33.668 to 28.358, HPH -38.889 to 19.444, StH1 -38.889 to 19.444, StH2 -27.473 to 41.758, and range value of h varies between -7.000 to 3.800.

Total acidity

Range value of MPH varies between -97.032 to 61.508, HPH -98.457 to 13.210, StH1 -61.437 to 295.693, StH2 -98.457 to -84.166, and range value of h varies between -1.051 to 1.442.

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Vitamin C content of flesh

Range value of MPH varies between -94.588 to -9.879, HPH -97.189 to -32.404, StH1 -27.808 to 195.434, StH2 -96.383 to -85.200, and range value of h varies between -1.050 to 3.228.

B-caroten content of flesh

Range value of MPH varies between -97.558 to -30.219, HPH -97.581 to -38.941, StH1 -97.581 to -38.941, StH2 -96.946 to -22.905, and range value of h varies between -103.053 to 0.818.

Anthocyanin content of peel

Range value of MPH varies between -92.521 to -8.355, HPH -96.179 to -52.462, StH1 75.754 to 1, 169.682, StH2 -93.420 to -52.462, and range value of h varies between -0.966 to -0.090.

DISCUSSIONS

The appearances of all F_1 were observed varies widely in all characters. At this crossing, the use of the same parents was not produced similar progeny performance. This is understandable because the mango is a heterozigous and naturally cross-pollinated plants. Thus, resulted progenies from their crosses were unpredictable. Frequenly the appearances of progenies are not to be expected (unpredictable). This is presumably because of the influence of pleitropy and genetic linked (Lavi *et al*., 1998).

Oservations toward fruit length and fruit diameter showed that the F_1-5-Ar x GG had a higher mean value to both parents, highest parent, or two standard varieties used 'Arumanis' and Gedong Gincu'. Hence, a cross between 'Arumanis' and 'Gedong Gincu' likely to produce progenies with the longer and larger fruit than theirs parents, especially for male parent. The degree of dominance to obtain that goal was over dominant positifve (h = 1.510 for length fruit character and h = 1.655 for diameter fruit character). Apparently, attaining the superiority of a particular character was required minimum value of h. As evidence, the value of h for diameter fruit characters that are equally > 1 (over dominant) but it has different effects on the appearance of the resulted progenies.

F_1 progenies of F_1-3-Ar x Hd, F_1-4-Ar x Hd, F_1-5-Ar x GG, F_1-6-Ar x GG, F_1-10-Ar x Sg, and F_1-12-Ir x Ar were exhibited such advance toward fruit weight character. Their fruit weights were more severe to mid parent, highest parent, and two standard varieties. The character of fruit weight superiority can be expressed as the degree of dominance that is over dominant positive. If there is a recessive effect on the appearance of the superiority of fruit weight, it is a partial recessive only that allows for that reason.

On the character of peel weight, progenies: F_1-1-Ar x Hd, F_1-4-Ar x Hd, F_1-5-Ar x GG, F_1-7-Ar x GG, and F_1-12-Ir x Ar were displayed a significantly different to the mean of their parent, highest parent, and two standard varieties. Expression of superiority to the peel weight were more influenced by the degree of dominance i.e., positive over dominant. The degree of dominance as a partial dominant, recessive partial, and negative over dominant also affect to the peel weight, but the effect was smaller than the positive over dominant. (as in F_1-2-Ar x Hd, F_1-3-Ar x Hd, F_1-6-Ar x GG, F_1-8-Ar x Keitt, F_1-9-Ar x GG, F_1-10-Ar x Sg, and F_1-11-Ir x Ar). However, because the peel weight was not prominent desire properties for improving mango quality whereas F_1-2-Ar x Hd, F_1-6-Ar x GG, F_1-9-Ar x GG, and F_1-11-Ir x Ar are more meaningful than other progenies, with degree of dominance are negative over dominant and recessive partial.

Just like the characters peel weight, stone weight character was not a target of quality improvement in mango breeding, so that negative heterosis values were more meaningful than the value of positive heterosis. Based on the t test and the potency ratio values, the F_1-5-Ar x GG and F_1-6-Ar x GG pointed that 'Gedong Gincu' was a potential parent to obtain progeny with a lighter weight stone. Degree of dominance for both progenies was over dominant negative.

Edible portion is one of the important characters in mango breeding. In Table-1, progenies: F_1-3-Ar x Hd, F_1-4-Ar x Hd, F_1-5-Ar x GG, F_1-10-Ar x Sg, and F_1-12-Ir x Ar represent the appearance of phenotypes that significantly different to their both parents, highest parents, and two standard varieties. The degree of dominance that affect the phenomenon is over dominant positive, whereas the partial dominance and partial recessive not always resulting in jack up of edible portion weight of the progenies (as in F_1-6-Ar x GG and F_1-7-Ar x GG).

TSS and total acidity are characters that affect the sweet taste of mango. F_1 progenies of F_1-1-Ar x Hd, F_1-3-Ar x Hd, F_1-6-Ar x GG, and F_1-10-Ar x Sg was indicated an increase of total soluble solid and decrease total acidity. However, there was no significant difference based on t test analysis. The degree of dominance of TSS is over dominant positive, while recessive partial and over dominant negative to total acidity.

Except in F_1-8-Ar x Keitt, the observation toward vitamin C content was not evidenced that all progenies increase levels of vitamin C content. The increase was significantly different and occurs in this progeny of mid parent, not quite mean to the higest and standard variety 1, even lower than standard variety 2. The degree of dominance that affect the appearance of vitamin C content is overdominant positive.

All the progenies in the observation of β-carotene and anthocyanins content were exhibited no increase in these characters. Almost in all heterosis tests of β-carotene content showed a negative or decrease significantly different. This is according with the results of Iyer (1991) which states that the light yellow color (β-carotene content is lower) is dominant over yellow orange (high β-carotene content) in Alphonso and Neelum cvs. The content of anthocyanins value in the peel was indicated a decrease; however, it was not significantly different in comparison between the progenies to the mid-parent, highest parent, and standard variety 2. Although statistically not quite significant, positive value on the comparison between progenies with a standard variety 1 (in green peel = 'Arumanis') denotes that all the progenies tested have increased anthocyanin content in theirs peel. Thus, degree of dominance in partial recessive level apparently able to influence mango peel fruits becomes somewhat reddish.

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Table-1. Heterosis and level of dominance values of eleven characters to twelve mango progenies.

No.	F_1	**Fruit length** (cm)	**Fruit diameter** (cm)	**Fruit weight** (g)	**Peel weight** (g)	**Stone weight** (g)	**Weight of edible portion** (g)	**Total soluble solids of flesh** (° Brix)	**Total acidity** (%)	**Vitamin C content of flesh** (mg/100g)	**β-carotene content of flesh** (µg/100g)	**Anthocyan in content of peel** (ppm)
1.	**1-Ar x Hd**											
	MPH	14.040	-5.159	-33.728 **	100.241 **	-96.582	-46.794 **	19.403	-30.782	-87.782 **	-84.000 **	-81.860
	HPH	2.051	-6.641	-34.759 **	63.744 **	-96.687	-47.463 **	11.111	-51.482	-93.583 **	-84.150 **	-90.706
	StH-1	2.051	-3.629	-34.759 **	63.744 **	-96.471	-46.108 **	11.111	20.720	27.549	-84.150 **	276.051
	StH-2	65.145	9.132	21.243 **	184.103 **	-96.786	23.145 **	31.868	-95.169	-93.610 **	-79.987 **	-85.920
	h	1.195e	-3.250e	-21.350e	4.497e	-30.520e	-36.733e	2.600e	-0.722d	-0.971d	-88.731e	-0.860d
2.	**2-Ar x Hd**											
	MPH	-7.163	-19.048	-37.757 **	-27.108 **	-43.038	-38.747 **	-10.448	-30.782	-71.699 **	-97.558 **	-65.588
	HPH	-16.923	-20.313	-38.725 **	-40.394 **	-44.785	-39.518 **	-16.667	-51.482	-85.138 **	-97.581	-82.369
	StH-1	-16.192	-17.742	-38.725 **	-40.394 **	-41.176	-37.957 **	-16.667	20.720	195.434	-97.581	613.376
	StH-2	34.440	-6.849	13.873 **	3.419 **	-46.429	41.769 **	-1.099	-95.169	-85.200 **	-96.946	-73.291
	h	-0.610d	-12.000e	-23.900e	-1.216e	-13.600e	-30.417e	-1.400e	-0.722d	-0.793d	-103.053e	-0.689d
3.	**3-Ar x Hd**											
	MPH	2.378	3.929	22.354 **	21.084 **	-2.532	26.752 **	28.358	-30.782	-77.880 **	-84.909 **	-64.902
	HPH	-8.385	2.305	20.451 **	-0.985 **	-5.521	25.157 **	19.444	-51.482	-88.384 **	-85.050 **	-82.017
	StH-1	-8.385	5.605	20.451 **	-0.985 **	0.654	28.387 **	19.444	20.720	-130.913	-85.050 **	627.601
	StH-2	48.257	19.589	123.844 **	71.795 **	-8.333	193.366 **	41.758	-95.169	-88.432 **	-81.124 **	-72.758
	h	0.202c	2.475e	14.150e	0.946c	0.800c	21.000e	3.800e	-0.722d	-0.861d	-89.691e	-0.682d
4.	**4-Ar x Hd**											
	MPH	10.602	9.524	34.202 **	60.241 **	20.886	31.847 **	-22.388	61.508	-86.147 **	-83.719 **	-62.391
	HPH	-1.026	7.812	32.115 **	31.034 **	17.178	30.189 **	-27.778	13.210	-92.725 **	-83.872 **	-80.731
	StH-1	-1.026	11.290	32.115 **	31.034 **	24.837	33.548 **	-27.778	181.680	44.612	-83.872 **	679.652

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	StH-2	60.166	26.027	145.520 **	127.350 **	13.690	205.160 **	-14.286	-88.728	-92.756 **	-79.636 **	-70.809
	h	0.902c	6.000e	21.650e	2.703e	6.600e	25.000e	-3.000e	1.442e	-0.953d	-88.435e	-0.656d
5.	**5-Ar x GG**											
	MPH	35.658 **	10.278 **	57.331 **	32.500 **	-9.034 **	79.207 **	-9.548	-96.697	-89.317 **	-81.000 **	-8.355
	HPH	9.744	3.831	20.995 **	4.433 **	-13.950	194.349 **	-16.667	-98.282	-94.391 **	-82.976 **	-52.462
	StH-1	9.744	3.831	20.995 **	4.433 **	-4.575	28.817 **	-16.667	-57.077	11.963	-82.976 **	1,169.682
	StH-2	77.593	17.580	124.855 **	81.197 **	-13.095	194.349 **	-1.099	-98.282	-94.391 **	-78.505 **	-52.462
	h	1.510e	1.655e	1.909e	1.209e	-1.933e	2.025e	-1.118e	-1.048e	-0.987d	-6.978e	-0.090d
6.	**6-Ar x GG**											
	MPH	13.471 *	8.351 *	14.661 **	-0.625 **	-29.595 *	-14.435 **	14.573	-97.032	-89.422 **	-82.293 **	-58.139
	HPH	-8.205	2.016	34.370 **	-21.675 **	-32.738	40.541 **	5.556	-98.457	-94.446 **	-84.135 **	-78.286
	StH-1	-8.205	2.016	34.370 **	-21.675 **	-26.144	-38.495 **	5.556	-61.437	10.868	-84.135 **	479.958
	StH-2	48.548	15.525	21.965 **	35.897 **	-32.738	40.541 **	25.275	-98.457	-94.446 **	-79.968 **	-78.286
	h	0.570c	1.345e	-0.488d	-0.023d	-6.333e	-0.369d	1.706e	-1.051e	-0.989d	-7.090e	-0.627d
7.	**7-Ar x GG**											
	MPH	22.345 *	-2.784 *	15.47 **	61.250 **	24.611 *	2.319 **	-33.668	-96.903	-85.435 **	-82.105 **	-51.329
	HPH	-1.026	-8.468	-11.198 **	27.094 **	19.048	68.059 **	-38.889	-98.390	-92.353 **	-83.966 **	-74.753
	StH-1	-1.026	-8.468	-11.198 **	27.094 **	30.719	-26.452 **	-38.889	-59.760	52.648	-83.966 **	574.310
	StH-2	60.166	3.653	65.029 **	120.513 **	19.048	68.059 **	-27.473	-98.390	-92.353 **	-79.755 **	-74.753
	h	0.946c	-0.448d	0.515c	2.279e	5.267e	0.059c	-3.941e	-1.050e	-0.944d	-7.074e	-0.553d
8.	**F_1-8-Ar x Keitt**											
	MPH	-19.475	-8.606	-28.827 **	-21.818 **	-30.612	-30.209 **	-21.212	-59.836	99.889 **	-74.886 **	-73.983
	HPH	-22.100	-15.991	-40.993 **	-38.040 **	-37.368	-42.202 **	-27.778	-74.909	52.648	-86.892 **	-86.450
	StH-1	-16.667	0.202	-10.342 **	5.911 **	-22.222	-11.935 **	-27.778	0.600	52.648	-86.892 **	225.393
	StH-2	-34.855	13.470	66.618 **	83.761 **	-29.167	101.229 **	-14.286	-95.974	-92.353 **	-83.450 **	-87.817
	h	-5.779e	-0.979d	-1.398e	-0.833d	-2.838e	-1.456e	-2.333e	-0.996d	3.228e	0.818c	-0.804d
9.	**F_1-9-Ar x Li'ar**											
	MPH	-23.747	0.000	-31.320 **	-10.000 **	-6.897	-39.869 **	-26.531	-75.908	-94.588 **	-83.557 **	-92.521
	HPH	-25.897	-0.403	-32.815 **	-11.330 **	-11.765	-40.968 **	-33.333	-86.980	-97.189	-84.635 **	-96.179
	StH-1	-25.897	-0.403	-32.815 **	-11.330 **	-11.765	-40.968 **	-33.333	60.960	-27.808	-84.635 **	75.754
	StH-2	19.917	12.785	24.855 **	53.846 **	-19.643	34.889 **	-20.879	-93.559	-96.383	-80.600 **	-93.420
	h	-8.182e	0.000a	-14.071e	-6.667e	-1.250e	-21.412e	-2.600e	-0.893d	-1.023e	-11.911e	-0.966d
10.	**F_1-10-Ar x**											

	Sg											
	MPH	-923.000	20..628	62.999 **	8.228 **	-12.474	90.646 **	16.923	-80.294	-74.423 **	-78.668 **	-71.511
	HPH	-17.436	8.468	17.496 **	-15.764 **	-30.065	32.581 **	5.556	-89.895	-85.031 **	-86.679 **	-85.423
	StH-1	-17.436	8.468	17.496 **	-15.764 **	-30.065	32.581 **	5.556	295.693	-12.192	-86.679 **	524.459
	StH-2	33.610	22.831	118.353 **	46.154 **	-36.310	202.948 **	25.275	-84.166	-95.601	-83.180 **	-76.620
	h	-0.046d	1.840e	1.627e	0.289c	-0.496d	2.070e	1.571e	-0.845d	-1.050e	-1.308e	-0.749d
11.	**F_1-11-Ir x Ar**											
	MPH	-13.146	-15.682	-38.684 **	-18.644 **	-21.182	-46.992 **	-20.354	-96.848	-9.879 **	-30.219 **	-41.773
	HPH	-24.615	-16.532	-43.857 **	-20.000 **	-21.569	-53.333 **	-23.729	-98.392	-32.404	-38.941 **	-70.084
	StH-1	-24.615	-16.532	-43.857 **	-17.241 **	-21.569	-53.333 **	-16.667	-19.520	35.160	-38.941 **	984.926
	StH-2	21.992	-5.479	4.335 **	43.590 **	-28.571	6.634 **	-1.099	-96.780	-93.229 **	-22.905 **	-59.379
	h	-0.864d	-15.400e	-4.198e	-11.000e	-43.000e	-3.458e	-4.600e	-1.008e	-0.296d	-2.116e	-0.441d
12.	**F_1-12-Ir x Ar**											
	MPH	-148.000	-9.980	26.709 **	13.317 **	-1.478	35.328 **	-30.973	-96.848	-30.796 **	-81.921 **	-60.932
	HPH	-13.333	-10.887	16.019 **	11.429 **	-1.961	19.140 **	-33.898	-98.392	-48.093	-84.180 **	-79.927
	StH-1	-13.333	-10.887	16.019 **	15.271 **	-1.961	19.140 **	-27.778	-19.520	3.790	-84.180 **	627.941
	StH-2	40.249	0.913	115.607 **	100.000 **	-10.714	172.236 **	-14.286	-96.780	-94.801 **	-80.025 **	-72.745
	h	-0.010d	-9.800e	2.899e	7.857e	-3.000e	2.600e	-7.000e	-1.008e	-0.924d	-5.735e	-0.644d