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STUDY ON HETEROSIS AND GENETIC PARAMETER OF YIELD TRAITS IN PADDY

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Abstract: Sixty hybrids generated from crossing three lines with twenty testers were studied along with parents for heterosis and genetic parameter in rice. The experiment was carried out according to line x tester mating design. Analysis of variance due to treatments, parent and crosses were highly significant for all the characters indicating sufficient variability existed in the treatments, parent and crosses. Mean square due to parent vs crosses were highly significant for all the traits except spikelet fertility and test weight indicating the presence of substantial heterosis in the crosses. Dominance variance (σ^2_D) was greater than additive variance (σ^2_A) for most of the traits under study. High heterobeltiosis and standard heterosis was exhibited in hybridsIR 58025 A X 21-2-5-B-1-1, IR 58025 A X Narendra Usar 3 and IR 58025 A X IR 71829-3R-73-1-2-B for grain yiled plant^{-1}.

Keywords: Heterosis, Hybrid, Line×Tester and Rice.

Introduction: Rice is one of the most important crop plants in the world and is the main nutritional staple food for approximately of the world's population. Therefore, increasing its productivity is of high importance in breeding programs. Since some rice hybrids show heterosis, it subsequently result to production yields which is to higher than inbred varieties [1,2] and finding a better cross combination is of high importance. Line × tester analysis is used to evaluate the general and specific combining ability of various lines and to estimate gene effects and it is useful in deciding the relative ability of female and male lines to produce desirable hybrid combinations [3]. It also provides information on genetic components and enables the breeders to choose appropriate breeding methods for hybrid variety or cultivar development programs. The nature and magnitude of gene action involved in expression of quantitative traits is important for successful development of crop varieties [4].

Materials and Methods

The experimental materials comprised of 3 CMS lines *viz*., IR 68897 A, IR 58025 A and Pusa 6 A possessing "wild abortive" (WA) cytoplasm as lines (females), 20 diverse rice varieties/genotypes as testers (males) and 60 crosses obtained through crossing in a "line × tester" mating design [3]. One check *viz*., Narendra Sankar Dhan-2 (NDRH 2) a rice hybrid were also included for assessing standard heterosis. The analysis of variance for 83 entries (3 female lines + 20 male lines + 60 crosses) was done for thirteen characters *viz*., seedling height, number of leaves seedling^{-1}, days to 50% flowering, flag leaf area, plant height, panicle bearing tillers plant^{-1}, panicle length, spikelets panicle^{-1}, spikelet fertility, grain yield plant^{-1}, test weight, biological yield plant^{-1} and harvest index.

Results and Discussion

Genetic Components of Variance and Gene Action: Relative magnitude of variance components revealed that SCA variance was greater than the gca variance for all the character except flag leaf area, plant height, panicle bearing tillers plant^{-1} (Table 1.1).

Table 1.1: Additive (σ^2_A) and dominance (σ^2_D) genetic components of variance, degree of dominance (DD), predictability ratio, genetic advance (GA), genetic advance as % of mean (GM%) for 13 characters in rice

Characters	Genetic components of variance		DD	GA	GM (%)	Predictability ratio
	σ^2_A	σ^2_D				
Seedling height	20.943	28.063	1.158	15.280	51.89	0.427
Number of leaves per seedling	-0.002	0.248	12.914	0.754	20.89	@
Days to 50 per cent flowering	5.354	15.051	1.677	7.188	7.10	0.262
Flag leaf area (cm^2)	14.883	10.285	0.831	8.655	25.98	0.591
Plant height (cm)	144.802	43.470	0.548	21.388	21.48	0.769
Panicle bearing tillers per plant	2.494	1.886	0.870	6.233	46.12	0.569
Panicle length (cm)	3.335	3.424	1.013	4.946	19.56	0.494
Spikelets per panicle	172.394	624.227	1.903	63.321	32.23	0.216
Spikelet fertility (%)	-3.338	145.614	6.605	22.940	28.90	@
Test weight (g)	-0.721	9.619	3.653	5.952	26.40	@
Biological yield per plant (g)	922.160	1534.241	1.290	92.747	74.98	0.375
Harvest-index (%	23.849	84.025	1.877	18.934	55.66	0.221
Grain yield per plant (g)	-3.437	288.757	9.166	36.621	89.07	@

@ Negative estimates

Degree of dominance was higher than unity (>1) except flag leaf area, plant height, panicle bearing tillers plant^{-1} and predictability ratio was low (<1) for all the characters. Dominance variance was greater than additive variance for each character except flag leaf area, plant height, panicle bearing tillers plant^{-1}. These findings showed that dominance gene action had greater role in the inheritance of these traits and fully supported [5,6, 7, 8 & 9] studied under salinity and also found yield traits was governed by non-additive gene action.

Heterosis for Yield and its Component Traits: Economic heterosis is usually expressed as an increase or decrease of F_1 value over better parent (heterobeltiosis) but from practical point of view, increase of F_1 value over the best commercial variety (standard heterosis) is more relevant. In the present investigation, the relative magnitude of heterosis over pollen parent and SH (NDRH 2) have been studied for thirteen characters in 60 hybrids. The results suggested that the magnitude of hybrid vigour differed from character to character depending upon hybrid combinations. None of the crosses were consistently good for all the characters.

Among 60 hybrids, 32 hybrids showed significant heterosis over better parent for grain yield plant^{-1} (Table 1.2). However, over the SH (NDRH-2) heterosis was manifested in 36 crosses. Top 5 hybrids exhibiting highest heterosis over SH (NDRH-2) are IR 688897A X Sarjoo 52 (197.81%) followed by IR 58025 A X 21-2-5-B-1-1 (185.04%), PUSA 6A X Sarjoo 52 (172.71%), IR 58025 A X Narendra Usar 3 (158.28%) and IR 58025 A X IR 71829-3R-73-1-2-B (131.61%). For grain yield, [10] also reported high standard heterosis to the extent of 27 and 34% during wet and dry seasons, respectively. Heterosis for grain yield plant^{-1} in saline-alkali soil was also reported [11-14].

The cross combinations, IR 58025 A × NDRK 5013 followed by IR 58025 A × NDRK 5013 exhibited high heterobeltiosis value for both traits, seedling height and number of leaves seedling^{-1} . PUSA 6A X CST 7-1, PUSA 6A X NDRK 5086 and PUSA 6A X Sarjoo 52 showed significant negative standard heterosis for plant height. High heterobeltiosis and standard heterosis for panicle length was exhibited in cross IR 58025 A X 21-2-5-B-1-1. Hybrid cross IR 58025 A X Narendra Usar 3, PUSA 6A X NDRK 5056, IR 58025 A X 21-2-5-B-1-1, and IR 58025 A X NDR 9830119 showed high magnituted of heterobeltiosis and standard heterosis. forspikelets panicle^{-1}. The high heterotic combinations for test weight was exhibited in F1 IR 58025 A X IR 71829-3R-73-1-2-B and IR 688897A X Sarjoo 52, over BP and SH.

The quantum of heterosis obtained in present study fully justify the commercial exploitation of heterosis in rice as a yield advantage of 20-30% over BP is obtained to be sufficient to encourage farmers to take up hybrid rice cultivation. The results obtained from present study indicated that the yield heterosis was mainly influenced by spikelets panicle^{-1}, panicle length, spikelet fertility, and test weight did contribute to increased yield heterosis. A wide range of variations in the expression of heterosis for grain yield was reported by many workers. Many other workers also reported

positive and significant heterosis for grain yield over better parent [15-22].

Table 1.2: Estimates of heterosis over standard hybrid (NDRH-2) of 60 rice hybrids for 13 characters

Hybrids	Seedling height (cm)	Number of leaves per seedling	Days to 50% flowering	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers per plant
IR 688897A X IR 70023-4B-R-12-3-1-1-B	23.51**	-7.69	2.81	17.98**	0.35	-30.37**
IR 688897A X IR 61920-3B-22-2-1	14.32**	4.62	-2.81	19.98**	-2.04	-28.89**
IR 688897A X PNL 1-8-5-17-2	29.73**	-4.62	0.70	25.60**	-4.23**	-15.19**
IR 688897A X NDRK 5095	43.51**	-12.31	3.16	19.64**	2.46	-17.78**
IR 688897A X NDRK 5056	18.11**	-7.69	-0.35	16.67**	0.21	-16.30**
IR 688897A X NDRK 5086	36.76**	-7.69	2.81	15.36**	-3.47	-12.96**
IR 688897A X NDR 9830119	10.00**	-13.85	3.86	19.52**	-2.00	-15.93**
IR 688897A X NDRK 5013	59.73**	-9.23	-1.40	16.67**	-4.18**	-32.59**
IR 688897A X CST 7-1	-10.54**	-16.92*	4.91	10.48**	-4.18**	-21.11**
IR 688897A X 21-2-5-B-1-1	13.24**	-1.54	3.51	21.33**	3.89**	-22.59**
IR 688897A X IR 64	-10.54**	-23.08**	3.16	-1.55	2.14	-17.78**
IR 688897A X NDR 9830148	34.05**	-18.46*	8.42**	11.31**	4.25**	-20.93**
IR 688897A X CSRC(S) 14-1-4-0	25.95**	-6.15	1.75	9.76**	8.42**	-18.52**
IR 688897A X PNL 5-8-1-7-21	13.51**	-21.54**	1.05	18.69**	-2.07	-12.59**
IR 688897A X IR 72048-B-R-2-2-2-1-B	54.05**	-20.00**	9.82**	22.56**	3.86**	-5.19
IR 688897A X IR 71829-3R-73-1-2-B	5.41	-20.00**	9.47**	4.52	-4.88**	-7.41
IR 688897A X NDRK 5094	25.68**	-9.23	12.98**	14.76**	0.91	-24.81**
IR 688897A X 92-H 51-4	26.76**	-16.92*	8.77**	31.43**	-2.07	-18.52**
IR 688897A X Narendra Usar 3	17.84**	-24.62**	3.86	18.50**	-0.67	-5.93
IR 688897A X Sarjoo 52	21.62**	0.00	1.05	-0.83	-3.61**	26.67**
IR 58025 A X IR 70023-4B-R-12-3-1-1-B	45.41**	-27.69**	7.72**	44.05**	30.95**	-31.48**
IR 58025 A X IR 61920-3B-22-2-1	32.43**	-27.69**	12.98**	80.48**	31.16**	-22.22**
IR 58025 A X PNL 1-8-5-17-2	76.49**	-1.54	18.60**	26.43**	4.70**	-28.52**
IR 58025 A X NDRK 5095	87.57**	6.15	3.16	25.48**	25.75**	-30.37**

Contd. Table 1.2 …

Hybrids	Seedling height (cm)	Number of leaves per seedling	Days to 50% flowering	Flag leaf area (cm^2)	Plant height (cm)	Panicle bearing tillers per plant
IR 58025 A X NDRK 5056	37.84**	-26.15**	0.35	25.24**	4.56**	-9.63*
IR 58025 A X NDRK 5086	58.65**	-18.46*	-0.35	26.43**	21.54**	-9.63*
IR 58025 A X NDR 9830119	23.51**	-32.31**	2.81	65.71**	20.63**	-35.93**
IR 58025 A X NDRK 5013	92.16**	13.85	10.53**	15.71**	25.96**	-51.11**
IR 58025 A X CST 7-1	80.00**	-15.38*	3.16	13.57**	-7.58**	-21.11**
IR 58025 A X 21-2-5-B-1-1	71.89**	-6.15	2.46	47.50**	25.89**	-10.74**
IR 58025 A X IR 64	89.05**	3.08	7.37**	23.10**	1.68	-50.37**
IR 58025 A X NDR 9830148	69.46**	-9.23	4.91	17.14**	28.91**	-53.33**
IR 58025 A X CSRC(S) 14-1-4-0	-11.89**	-52.31**	5.61*	48.10**	27.44**	-44.44**
IR 58025 A X PNL 5-8-1-7-21	57.30**	-9.23	5.96*	15.95**	-3.79**	-29.26**
IR 58025 A X IR 72048-B-R-2-2-2-1-B	15.41**	-35.38**	13.68**	19.05**	9.19**	-18.52**
IR 58025 A X IR 71829-3R-73-1-2-B	35.41**	-26.15**	10.18**	9.29**	17.26**	-6.30
IR 58025 A X NDRK 5094	47.84**	-13.85	13.68**	56.19**	6.88**	-34.07**
IR 58025 A X 92-H 51-4	43.51**	-20.00**	4.91	72.62**	26.88**	-26.67**
IR 58025 A X Narendra Usar 3	39.19**	-26.15**	13.68**	19.05**	4.42**	-14.07**
IR 58025 A X Sarjoo 52	-7.16*	-24.62**	-3.86	-1.19	-2.32	22.22**
PUSA 6A X IR 70023-4B-R-12-3-1-1-B	42.57**	-24.62**	11.93**	19.76**	4.32**	-30.00**
PUSA 6A X IR 61920-3B-22-2-1	15.00**	10.77	7.02**	17.98**	-1.07	-32.59**
PUSA 6A X PNL 1-8-5-17-2	34.05**	-29.23**	10.53**	29.40**	-0.95	-15.93**
PUSA 6A X NDRK 5095	70.41**	-4.62	12.28**	16.79**	-5.23**	-22.96**
PUSA 6A X NDRK 5056	17.84**	-24.62**	5.26*	7.26*	-1.02	-24.81**
PUSA 6A X NDRK 5086	25.81**	-6.15	12.98**	12.86**	-9.44**	-27.78**
PUSA 6A X NDR 9830119	33.92**	-16.92*	8.77**	13.57**	0.04	-25.56**
PUSA 6A X NDRK 5013	13.65**	-24.62**	6.32*	17.98**	-2.07	-30.00**
PUSA 6A X CST 7-1	10.68**	-1.54	10.53**	13.57**	-11.54**	-33.33
PUSA 6A X 21-2-5-B-1-1	9.59**	-13.85	7.02**	23.93**	1.09	-27.41**
PUSA 6A X IR 64	1.49	-21.54**	10.53**	0.60	-4.18**	-28.89**
PUSA 6A X NDR 9830148	25.81**	6.15	3.51	3.21	3.19	-32.96**
PUSA 6A X CSRC(S) 14-1-4-0	29.73**	-7.69	5.26*	6.67	5.72**	-33.70**
PUSA 6A X PNL 5-8-1-7-21	6.89*	-18.46*	7.02**	17.98**	-3.12*	-14.07**
PUSA 6A X IR 72048-B-R-2-2-2-1-B	29.86**	-10.77	1.75	6.55	0.04	-12.59**
PUSA 6A X IR 71829-3R-73-1-2-B	1.49	-18.46*	8.07**	6.43	-7.33**	-28.89**
PUSA 6A X NDRK 5094	42.03**	-9.23	4.56	16.07**	-4.18**	-25.56**
PUSA 6A X 92-H 51-4	25.68**	-16.92*	9.12**	31.07**	-5.26**	-28.52**
PUSA 6A X Narendra Usar 3	37.97**	-1.54	10.88**	28.69**	-3.12*	-25.56**
PUSA 6A X Sarjoo 52	25.68**	-12.31	5.61*	-5.00	-8.39**	24.07**

Significant +veheterosis	53	-	33	-	23	3
Significant -veheterosis	**4**	**29**	**-**	**50**	**18**	**53**
Mean heterosis (%)	**32.282**	**-13.872**	**6.234**	**20.794**	**4.012**	**-21.689**
SE	0.770	0.316	2.466	0.961	1.218	0.784
Range	**(-11.89) -92.16**	**(-52.31) -13.85**	**(-3.86) -18.60**	**(-5.00) -80.48**	**(-11.54) -31.16**	**(-53.33) -26.67**

Contd. Table 1.2 …

Hybrids	Panicle length (cm)	Spikelets per panicle	Spikelet fertility (%)	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
IR 688897A X IR 70023-4B-R-12-3-1-1-B	2.44	-9.80	7.61**	-7.27**	35.92**	-19.28**	10.46
IR 688897A X IR 61920-3B-22-2-1	-2.31	-3.17	-0.47	-3.94	25.83**	-11.45*	13.41
IR 688897A X PNL 1-8-5-17-2	-12.18**	-4.37	5.22*	-5.30*	63.04**	-9.49	49.08**
IR 688897A X NDRK 5095	9.10**	-17.50**	2.20	2.88	46.05**	-13.15*	28.14**
IR 688897A X NDRK 5056	-3.33	-18.55**	6.67**	-15.15**	63.33**	-32.59**	10.88
IR 688897A X NDRK 5086	-16.92**	-9.35	-11.69**	-10.76**	43.46**	-21.83**	12.86
IR 688897A X NDR 9830119	0.26	-7.84	5.57*	-8.79**	73.77**	-23.44**	34.38**
IR 688897A X NDRK 5013	-12.31**	-12.97*	-23.53**	13.64**	26.32**	-30.93**	-11.91
IR 688897A X CST 7-1	-16.67**	-27.15**	-8.94**	-4.55*	2.98	-17.61**	-14.30
IR 688897A X 21-2-5-B-1-1	-11.41**	-10.86	-4.71	0.15	48.95**	-24.03**	14.56
IR 688897A X IR 64	-15.51**	-20.21**	8.63**	15.91**	63.60**	-5.10	56.77**
IR 688897A X NDR 9830148	-2.56	-7.24	-12.08**	3.18	43.90**	-18.99**	17.79
IR 688897A X CSRC(S) 14-1-4-0	-3.85	-12.52*	-4.67	4.55*	46.54**	-10.05	33.13**
IR 688897A X PNL 5-8-1-7-21	-11.41**	-15.69**	-4.27	4.55*	55.70**	-13.30*	36.87**
IR 688897A X IR 72048-B-R-2-2-2-1-B	15.38**	-15.84**	-16.08**	0.00	46.62**	-17.60**	22.06*
IR 688897A X IR 71829-3R-73-1-2-B	-2.95	-9.80	-29.02**	-23.64**	35.96**	-45.53**	-25.15*
IR 688897A X NDRK 5094	-9.10**	-13.12*	4.71	17.27**	56.67**	-5.77	49.12**
IR 688897A X 92-H 51-4	7.05*	-11.31*	1.22	18.18**	110.75**	-27.04**	55.28**
IR 688897A X Narendra Usar 3	-5.64	1.36	2.43	-4.39	94.30**	-10.18	77.29**
IR 688897A X Sarjoo 52	-3.72	-8.60	0.78	26.36**	181.10**	4.95	197.81**
IR 58025 A X IR 70023-4B-R-12-3-1-1-B	17.18**	-43.89**	-14.27**	-23.64**	28.51**	-69.74**	-60.67**
IR 58025 A X IR 61920-3B-22-2-1	3.21	-22.47**	-15.29**	-32.42**	290.79**	-85.92**	-44.65**

Contd. Table 1.2 …

Hybrids	Panicle length (cm)	Spikelets per panicle	Spikelet fertility (%)	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
IR 58025 A X PNL 1-8-5-17-2	-17.18**	-13.85*	6.20*	9.39**	31.14**	-3.33	28.26**
IR 58025 A X NDRK 5095	20.26**	-22.78**	-16.55**	15.15**	79.39**	-51.26**	-11.73
IR 58025 A X NDRK 5056	2.56	5.13	6.20*	4.85*	93.51**	-0.01	95.35**
IR 58025 A X NDRK 5086	1.28	-13.73*	-39.14**	19.39**	88.60**	-48.74**	-2.72
IR 58025 A X NDR 9830119	13.85**	16.44**	7.06**	3.64	190.26**	-49.14**	49.38**
IR 58025 A X NDRK 5013	10.51**	-20.18**	-23.53**	21.21**	19.74**	-50.43**	-40.04**
IR 58025 A X CST 7-1	6.41	10.53	6.20*	21.82**	224.91**	-32.46**	121.14**
IR 58025 A X 21-2-5-B-1-1	17.44**	23.53**	6.82**	22.42**	157.02**	9.87	185.04**
IR 58025 A X IR 64	-16.67**	8.81	6.51*	-30.00**	42.89**	-54.64**	-34.59**
IR 58025 A X NDR 9830148	13.85**	-21.24**	8.00**	-0.61	37.98**	-56.11**	-38.89**
IR 58025 A X CSRC(S) 14-1-4-0	-2.82	3.62	-21.25**	14.55**	160.61**	-66.82**	-12.34
IR 58025 A X PNL 5-8-1-7-21	-6.92*	10.26	6.67**	3.94	111.23**	-24.23**	61.50**
IR 58025 A X IR 72048-B-R-2-2-2-1-B	12.56**	12.73*	7.45**	8.08**	179.65**	-27.93**	102.85**
IR 58025 A X IR 71829-3R-73-1-2-B	5.64	-3.77	6.35*	24.94**	123.25**	2.73	131.61**
IR 58025 A X NDRK 5094	12.31**	11.04*	7.14**	13.94**	78.63**	-5.31	69.36**
IR 58025 A X 92-H 51-4	-17.95**	-4.46	-71.45**	-23.94**	203.95**	-89.27**	-67.08**
IR 58025 A X Narendra Usar 3	4.87	29.29**	7.29**	15.76**	135.61**	8.53	158.28**
IR 58025 A X Sarjoo 52	7.44*	-12.82*	-15.06**	-6.67**	76.18**	-11.01*	58.25**
PUSA 6A X IR 70023-4B-R-12-3-1-1-B	1.92	-17.95**	2.00	-4.39	39.21**	-33.85**	-6.58
PUSA 6A X IR 61920-3B-22-2-1	-11.41**	-11.16*	-3.49	2.42	13.20*	-10.47	2.15
PUSA 6A X PNL 1-8-5-17-2	-11.41**	-8.30	-12.71**	4.70*	55.26**	-22.72**	21.01*
PUSA 6A X NDRK 5095	3.21	-9.05	4.75	9.24**	60.57**	-9.27	47.10**
PUSA 6A X NDRK 5056	-7.56*	17.80**	0.04	-8.94**	98.16**	-27.16**	45.60**
PUSA 6A X NDRK 5086	-13.08**	3.62	4.82	-7.42**	127.59**	-43.85**	29.15**
PUSA 6A X NDR 9830119	1.54	11.31*	6.82**	-6.67**	129.82**	-36.51**	47.38**
PUSA 6A X NDRK 5013	-6.79*	-9.95	-28.20**	15.61**	62.98**	-46.85**	-12.46
PUSA 6A X CST 7-1	-9.62**	-8.90	3.45	-0.61	33.51**	-18.57**	10.05
PUSA 6A X 21-2-5-B-1-1	-12.31**	-0.90	-3.57	4.70*	50.79**	-15.09**	29.64**
PUSA 6A X IR 64	-7.56*	-13.12*	2.55	17.42**	42.24**	-7.99	32.52**
PUSA 6A X NDR 9830148	-2.18	-13.57*	-29.06**	7.27**	31.80**	-46.36**	-28.36**

PUSA 6A X CSRC(S) 14-1-4-0	1.41	-0.30	0.04	6.74**	46.75**	-13.34*	28.65**
PUSA 6A X PNL 5-8-1-7-21	-2.82	-9.20	7.10**	3.03	65.35**	-0.95	65.34**
PUSA 6A X IR 72048-B-R-2-2-2-1-B	11.03**	-5.43	2020	-4.39	53.95**	-3.61	49.84**
PUSA 6A X IR 71829-3R-73-1-2-B	-10.51**	-1.36	-10.78**	-17.88**	46.89**	-42.48**	-14.58
PUSA 6A X NDRK 5094	-13.59**	-19.31**	5.88*	10.30**	52.72**	-17.71**	26.85*
PUSA 6A X 92-H 51-4	3.08	11.16*	5.92*	12.73**	78.07**	-0.31	79.17**
PUSA 6A X Narendra Usar 3	-1.54	1.81	4.82	-8.79**	75.35**	-25.42**	32.14**
PUSA 6A X Sarjoo 52	2.82	0.15	-6.94**	21.67**	170.18**	-0.01	172.71**
Significant +veheterosis	**13**	**8**	**18**	**28**	**59**	**-**	**36**
Significant -veheterosis	**22**	**23**	**19**	**17**	**-**	**41**	**8**
Mean heterosis (%)	**-1.553**	**-6.083**	**29.473**	**2.690**	**80.884**	**-24.669**	**34.569**
SE	**0.857**	**12.218**	**2.122**	**0.489**	**4.640**	**2.446**	**3.537**
Range	**(-17.95) -20.26**	**(-43.89) -29.29**	**(-71.45) -8.63**	**(-32.42) -26.36**	**2.98-290.79**	**(-89.27) -9.87**	**(-67.08) -197.81**

**, ** significant at 5% and 1% levels, respectively.*

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