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Combining ability studies for yield and yield traits in ridge gourd

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Abstract

The investigation on general combining ability (gca) effects of all characters resulted in the identification of Pusa Nasdar and Shittahalli local as good combiners and parent Shittahalli local exhibited significant gca effect for vine length (cm), days to first harvest, fruit length (cm), fruit diameter (cm), rind thickness (mm), flesh thickness (cm), fruit circumference (cm), number of fruits per vine and chlorophyll-b. Highest magnitude of positive specific combining ability (sca) effects for vine length (60.58), fruit weight (19.40), node to first female flower (4.34), number of nodes per vine (3.60) and number of fruits per vine (3.05) exhibited by crosses Shittahalli local × TNAU CO – 1, Shittahalli local × TNAU CO – 1, Shittahalli local × TNAU CO – 1, Pusa Nasdar × TNAU CO – 1 and Krishna - 51 × Shittahalli local respectively. These crosses also revealed good sca effects for one or more traits under study. The ratio of gca to sca was less than one for many traits indicating the predominance of non-additive gene action which can be improved through recurrent selection or heterosis breeding.

Keywords: General combining ability, non-additive gene action, ridge gourd, flesh thickness, crosses

Introduction

Ridge gourd [*Luffa acutangula* (L.) Roxb.] is an important vegetable in India and South-East Asia. Belongs to genus *Luffa* of Cucurbitaceae family having a chromosome number of $2n = 26$. It is an annual climbing herb, tender fruits are green in colour which is used in soups and curries or as a cooked vegetable. Cucurbitaceae is the largest family among vegetables consisting of the largest number of edible type species and summer vegetables. Among vegetables, cucurbits occupy a major share regarding total crop grown, area covered, crop produced and consumed worldwide. Among food crops, cucurbits are the largest producers of biological water, easily digestible and are therefore, recommended even to patients suffering from weakness or other illness. Altogether there are two well-defined sub-families, eight tribes, 118 genera and 825 species. The ridge gourd fruits contain edible protein (82%), moisture (92.5 g), fat (0.5 g), carbohydrate (3.4 g), energy (17 kcal), calcium (18 mg), vitamin-C (5mg), riboflavin (0.01 mg), phosphorous (26 mg), iron (0.5 mg) and carotene (33 μ g) (Seshadri and Parthasarthy, 2002) ^[6] per 100 g of edible portion.

Ridge gourd being predominantly a monoecious and cross-pollinated crop produces good number of seeds from single pollination which provides ample scope for utilization of the hybrid vigour. Hence, a speedy improvement can be brought about by assessing the genetic variability and exploitation of heterosis. In heterosis breeding, knowledge on combining ability, gene action and the relative amount of additive and non-additive components of genetic variance present in cross combination helps to determine the feasibility of its utilization and identification of best combiners. Since, yield is a complex and polygenically inherited trait, knowledge of gene action or pattern of inheritance of different quantitative traits including yield will be helpful to formulate the suitable breeding method to be applied for achieving the desired objectives in the improvement of the crop. Hence, the present investigation has been planned with the following

Material and methods

The experimental materials for the study comprised of five genotypes which were selected based on the diversity for various traits and these five genotypes were crossed to obtain 20 hybrids in diallel fashion (with reciprocals). The experiment was laid out during summer 2018 at the research block of Department of Crop Improvement and Biotechnology, College of Horticulture, Mudigere.

The experiment consisted of five parents; twenty hybrids and a standard check were randomized completely among themselves in three replications and grown in continuous block. A spacing of 1.5 m x 1 m was followed and the crop was raised as per the recommended package and practices. The observations were recorded on Vine length (cm), number of nodes per vine, inter-nodal length (cm), days to first female flower, node to first female flower, days to 50 percent flowering, sex ratio, days to the first harvest, fruit length (cm), fruit diameter (cm), rind thickness (mm), flesh thickness (cm), fruit circumference (cm), fruit weight (g), number of fruits per vine, fruit yield (kg/vine), fruit yield (t/ha), vitamin-C content of fruit (mg/100g), Chlorophyll-a (mg/g), Chlorophyll-b (mg/g), Total chlorophyll (mg/g) and fibre content of fruit (g). Combining ability analysis was performed with the data obtained for parents and hybrids according to Model-I and Method-II respectively proposed by Griffing (1956) [2]. This includes partitioning of variation among sources attributing to general combining ability (gca) and specific combining ability (sca) components.

Results and Discussion

In the present investigation combining ability analysis of five parents and their 20 F₁ hybrids showed significant gca and sca effects for all the characters studied (table 1) and indicated the importance of both additive and non-additive gene action for the characters under study. The variance for genetic combining ability was found to be significant for all the characters except for days to 50 percent flowering. On the other hand, the variance due to specific combining ability was found significant for all the traits. The ratio of genetic combining ability to specific combining ability was found to be less than one for most of the characters in hybrids except for vitamin c content of fruit (1.18) and fibre content of fruit (1.47) which indicates the predominant role of non-additive gene action. Similar findings were also reported by Nandhini *et al.* (2018) in ridge gourd.

The combining ability concept was proposed by Sprague and Tatum (1942) in corn. According to them, the general combining ability (gca) is the comparative ability of the parent to combine with other parent used in the study. It is the deviation of the mean performance of the entire crosses involved parent from the overall mean. A positive general combining ability (gca) indicates that a parent that produces above average progeny, whereas parent with negative gca produces progeny that perform below the average of the population. The data about general combining ability for all the traits are given (table 2). For earliness parameters, a negative gca values preferred as lower the time taken by these parameters. Considering days to first female flower Krishna-51 exhibited the highest negative significant gca value of -0.67. Whereas, Pusa Nasdar showed the highest negative significant gca value of -1.40 for the node to first female flower. None of the parents exhibited significant gca value for days to 50 percent flowering. All of the parents were showing significant gca effects for days to first harvest of which Pusa Nasdar showed highest negative significant value (-0.71). The study confirmed with the results of Devi *et al.* (2017) [1] in snake gourd.

In the present study, TNAU CO-1 performed better for both vine length (12.51) and number of nodes per vine (0.54). For inter-nodal length, Shittahalli local showed the lowest positive significant gca value (0.42). None of the parents exhibited significant gca value for sex ratio. Parent Arka Sujath exhibited positive gca values for fruit diameter (0.16), fruit

thickness (0.23), fruit circumference (0.52), fruit yield (kg/vine) (0.15) and fruit yield (t/ha) (1.06). Similar findings were also reported by Laxuman *et al.* (2012) [4] in bitter gourd. Parent Pusa Nasdar showed positive significant gca values for rind thickness (0.19) and the number of fruits per vine (0.58). Significant positive gca value for fruit length (2.48) was recorded by Shittahalli local. Concerned to the quality parameters, parent TNAU CO-1 exhibited highest positive gca in favourable direction for vitamin-C content of fruit (5.35), chlorophyll-a (0.03), chlorophyll-b (0.06), total chlorophyll (0.1). For fibre content of fruit, Pusa Nasdar performed the highest negative significant gca value (-0.24) which is desirable. Similar result was reported by Shaha and Kale (2003) [7] in ridge gourd.

Specific combining ability (sca) was defined as the deviation in the performance of specific cross from the performance expected by general combining ability effects of parents involved in the crosses. Specific combining ability (sca) can be either negative or positive and sca always refers to a specific cross. Table. 3 indicate the specific combining ability effects for all the traits. For exploitation of heterosis, information of gca should be supplement with sca and hybrid performance. Estimation of sca effects for 20 hybrids resulted in identification of good specific combiner for various traits, the crosses Shittahalli local x TNAU CO-1 (60.58) followed by Pusa Nasdar x Shittahalli local (59.18) for vine length and Pusa Nasdar x TNAU CO-1 for number of nodes per plant (3.6) were identified as good specific combiner. Purohit *et al.* (2007) [5] in the ridge gourd also reported significant sca for vine length and number of branches. Days to first female flowering and days to first harvest are the important traits indicate earliness. Among the 20 hybrids, the crosses Pusa Nasdar x Krishna-51 (-1.71) that exhibited maximum and significant sca effects in desirable direction for days to first female flowering followed by Arka Sujath x Shittahalli local (-1.16). The cross Shittahalli local x Krishna-51 exhibited highest negative sca effect (-2.63) for the number of days to first harvest. Thangamani and Pugalenthi (2013) also reported significant sca for the number of days to first harvest in bitter gourd. The crosses Arka Sujath x Pusa Nasdar exhibited the highest negative significant sca effects (-2.45) in desirable direction for inter-nodal length.

Considering the fruit length Krishna-51 x Shittahalli local (2.40) exhibited high sca effect. The cross Krishna - 51 x TNAU CO - 1 (0.24) performed highest sca in desirable direction for fruit diameter. For rind thickness, the cross Pusa Nasdar x Krishna - 51 (0.66) was showed highest sca effects. Similarly, for flesh thickness and fruit circumference the crosses Arka Sujath x Shittahalli local (0.28) and Krishna - 51 x TNAU CO - 1 (0.75) showed the highest significant sca values. The cross Shittahalli local x TNAU CO - 1 (19.40) performed better sca effect for fruit weight. The crosses Krishna - 51 x Shittahalli local (0.29) was identified as a good specific combiner for fruit yield (kg/vine) which possessed significantly high sca effects. Thangamani and Pugalenthi (2013) [9] in bitter gourd and Hedau and Sirohi (2004) [3] in ridge gourd also reported significant sca for fruit yield (kg/vine). Similarly, for fruit yield (t/ha) the same cross, Krishna - 51 x Shittahalli local performed better (1.96) compared to other crosses.

For quality parameters, the cross TNAU CO - 1 x Pusa Nasdar (2.42) showed highest sca effect for vitamin-C. For chlorophyll - a cross Shittahalli local x Arka Sujath (0.13) and TNAU CO - 1 x Pusa Nasdar (0.13) recorded highest sca effect. Similarly for chlorophyll - b cross Shittahalli local x

ArkaSujath (0.09) recorded highest sca effect, Shittahalli local × ArkaSujath (0.22) recorded highest sca effect for total chlorophyll content and cross TNAU CO - 1 × Krishna – 51 (-

0.22) showed significant sca in desirable directions for fibre content of fruit.

Table 1: Analysis of variance for combining ability for different characters in ridge gourd.

Characters	GCA	SCA	GCA/SCA	Degree of dominance
df	4	10	-	-
Vine length (cm)	109.67	4257.14	0.025	2.54
Number of nodes per vine	0.196	5.071	0.038	3.43
Internodal length (cm)	0.624	5.535	0.112	1.35
Days to first female flower	0.340	2.150	0.158	1.96
Node to first female flower	0.786	20.366	0.038	4.84
Days to 50% flowering	-0.006	1.914	-0.003	3.39
Sex ratio	0.546	5.915	0.092	1.25
Days to first harvest	0.287	4.098	0.070	2.16
Fruit length (cm)	2.422	5.880	0.411	1.38
Fruit diameter (cm)	0.013	0.070	0.193	1.43
Rind thickness (mm)	0.044	0.443	0.099	2.26
Flesh thickness (cm)	0.022	0.068	0.327	1.13
Fruit circumference (cm)	0.135	0.695	0.194	1.42
Fruit weight (g)	24.241	225.543	0.107	2.41
Number of fruits per vine	0.358	6.639	0.054	1.62
Fruit yield (kg/vine)	0.013	0.060	0.226	1.12
Fruit yield (t/ha)	0.605	2.657	0.228	1.12
Vitamin-C content of fruit (mg/100g)	9.074	7.626	1.189	1.34
Chlorophyll-a (mg/g)	0.0006	0.0181	0.034	2.03
Chlorophyll-b (mg/g)	0.002	0.013	0.216	1.25
Total chlorophyll (mg/g)	0.0055	0.0448	0.123	2.04
Fibre content of fruit (g)	0.028	0.019	1.474	0.50

GCA – Variance due to general combining ability

SCA – Variance due to specific combining ability

Table 2: Estimates of general combining ability effects of parents for different characters of ridge gourd

Characters	Parents					S.Em (±)	CD @ 5%	CD @ 1%
	Arka Sujath	Pusa Nasdar	Krishna-51	Shittahalli Local	TNAU CO-1			
Vine length (cm)	-10.25**	5.58**	-11.55**	3.71**	12.51**	0.53	1.48	2.45
Number of nodes per vine	-0.19**	0.54**	-0.60**	-0.04**	0.30**	0.01	0.03	0.04
Internodal length (cm)	0.70**	0.91**	1.03**	0.42**	0.16	0.14	0.38	0.64
Days to first female flower	-0.25	-0.37	-0.67**	0.41	0.88**	0.21	0.59	0.99
Node to first female flower	1.02**	-1.40**	0.35**	-0.02	0.04*	0.01	0.04	0.08
Days to 50% flowering	0.32	0.17	-0.02	-0.26	-0.2	0.23	0.64	1.07
Sex ratio	0.68	-0.58	-0.89	0.75	0.02	0.01	0.03	0.05
Days to first harvest	0.71**	-0.71**	0.28**	-0.12**	-0.16**	0.01	0.02	0.04
Fruit length (cm)	-0.14**	-1.63**	0.19**	2.48**	-0.89**	0.01	0.03	0.05
Fruit diameter (cm)	0.16**	0.02**	-0.08**	0.03**	-0.14**	0.001	0.003	0.005
Rind thickness (mm)	-0.31**	0.19**	0.16**	-0.08**	0.04**	0.002	0.006	0.01
Flesh thickness (cm)	0.23**	-0.01**	-0.11**	0.04**	-0.14**	0.001	0.003	0.005
Fruit circumference (cm)	0.52**	0.08**	-0.25**	0.09**	-0.43**	0.003	0.009	0.015
Fruit weight (g)	8.13**	0.62**	-1.15**	-3.46**	-4.13**	0.05	0.14	0.23
Number of fruits per vine	0.39**	0.58**	-0.58**	0.31**	-0.70**	0.008	0.02	0.03
Fruit yield (kg/vine)	0.15**	0.07**	-0.07**	-0.02**	-0.13**	0.001	0.003	0.005
Fruit yield (t/ha)	1.06**	0.48**	-0.49**	-0.16**	-0.89**	0.006	0.018	0.03
Vitamin-C content of fruit (mg/100g)	-0.77**	-1.42**	-1.63**	-1.51**	5.35**	0.01	0.05	0.08
Chlorophyll-a (mg/g)	-0.02**	-0.01**	0.02**	-0.02**	0.03**	0.0004	0.001	0.002
Chlorophyll-b (mg/g)	-0.07**	-0.02**	0.01**	0.02**	0.06**	0.0005	0.001	0.002
Total chlorophyll (mg/g)	-0.10**	-0.031**	0.032**	0	0.10**	0.0008	0.0024	0.0039
Fibre content of fruit (g)	-0.06**	-0.24**	-0.002	0.11**	0.19**	0.001	0.003	0.005

* and ** indicates significance at 5% & 1% levels respectively

Table 3: Estimates of specific combining ability effects for different characters in ridge gourd.

Crosses	Vine length (cm)	Number of nodes per vine	Internodal length (cm)	Days to first female flower	Node to first female flower	Days to 50% flowering	Sex ratio	Days to first harvest
Arka Sujath × Pusa Nasdar	46.98**	0.07**	-2.45**	0.20	-2.42**	-0.08	-0.62	0.08**
Arka Sujath × Krishna - 51	-31.21**	-0.51**	-0.71*	1.67**	2.06**	1.82**	0.23	0.66**
Arka Sujath × Shittahalli local	-17.64**	0.88**	0.12	-1.16*	1.87**	-1.22*	-1.21	0.28**
Arka Sujath × TNAU CO - 1	-24.78**	-1.31**	-0.64*	0.70	-1.27**	0.08	-1.51	-1.52**
Pusa Nasdar × Arka Sujath	1.5	1.05**	0.3	0.5	3.08**	-1.12*	-1.53	1.84**
Pusa Nasdar × Krishna - 51	-22.38**	-1.23**	-0.72*	-1.71**	-4.29**	-1.23*	-1.08	-0.76**
Pusa Nasdar × Shittahalli local	59.18**	-1.72**	-0.11	-0.29	0.24**	0.26	-0.56	-1.97**
Pusa Nasdar × TNAU CO - 1	-50.78**	3.60**	-0.55	0.98	0.85**	0.11	2.04	-0.18**
Krishna - 51 × Arka Sujath	-2.16	0.26**	0.4	0.33	-0.18**	0.33	-0.16	-2.37**
Krishna - 51 × Pusa Nasdar	3.16*	0.81**	0.23	-0.16	-0.08*	0.45	0.66	-0.56**
Krishna - 51 × Shittahalli local	-30.51**	0.54**	-1.30**	-0.33	-1.72**	-1.62**	0.04	1.24**
Krishna - 51 × TNAU CO - 1	16.85**	0.67**	0.55	-0.04	-0.28**	0.10	1.82	0.66**
Shittahalli local × Arka Sujath	-2	0.84**	-0.17	-0.08	-1.36**	0.45	-3.45	0
Shittahalli local × Pusa Nasdar	-2.66*	2.43**	-0.15	0.16	-4.91**	0.04	-2.78	-1.58**
Shittahalli local × Krishna - 51	-3.16*	0.73**	-0.14	-0.16	3.59**	-0.79	-0.04	-2.63**
Shittahalli local × TNAU CO - 1	60.58**	-0.49**	-0.47	0.53	-4.34**	0.34	1.67	1.95**
TNAU CO - 1 × Arka Sujath	3.33*	1.21**	0.33	0.25	4.34**	-1.75**	-0.98	-1.31**
TNAU CO - 1 × Pusa Nasdar	0.5	-3.71**	1.06**	0.08	2.89**	-0.45	-3.65	1.40**
TNAU CO - 1 × Krishna - 51	3.00*	1.42**	0.23	0.41	3.51**	-2.58**	-1.60	-2.01**
TNAU CO - 1 × Shittahalli local	3.00*	1.34**	0.31	0.25	-0.58**	-0.33	0.05	0.79**
S.E±Sii-Sjj	1.09	0.02	0.28	0.44	0.03	0.48	0.02	0.018
CD at 5% (Sij)	2.48	0.04	0.65	1.00	0.08	1.09	0.05	0.042
CD at 1% Sii-Sjj	3.57	0.07	0.94	1.44	0.12	1.56	0.07	0.060

Crosses	Fruit length (cm)	Fruit diameter (cm)	Rind thickness (mm)	Flesh thickness (cm)	Fruit circumference (cm)	Fruit weight (g)	Number of fruits per vine
Arka Sujath × Pusa Nasdar	-0.38**	0.18**	0.32**	0.11**	0.57**	6.62**	-1.23**
Arka Sujath × Krishna - 51	0.75**	-0.20**	-0.14**	-0.17**	-0.65**	8.11**	0.24**
Arka Sujath × Shittahalli local	1.78**	0.21**	-0.36**	0.28**	0.66**	5.73**	-1.17**
Arka Sujath × TNAU CO - 1	0.22**	-0.29**	-0.38**	-0.21**	-0.93**	-12.79**	2.69**
Pusa Nasdar × Arka Sujath	0.38**	0.07**	-0.02**	0.08**	0.24**	3.95**	-0.01
Pusa Nasdar × Krishna - 51	-1.63**	0.06**	0.66**	-0.07**	0.18**	4.95**	-0.44**
Pusa Nasdar × Shittahalli local	-2.10**	-0.11**	0.08**	-0.13**	-0.37**	-16.08**	1.62**
Pusa Nasdar × TNAU CO - 1	1.93**	0.07**	-0.64**	0.20**	0.23**	-1.52**	-0.72**
Krishna - 51 × Arka Sujath	1.0*	-0.02**	-0.15**	0.005	-0.08**	6.64**	-0.49**
Krishna - 51 × Pusa Nasdar	-0.47**	0.07**	0.17**	0.04**	0.24**	2.72**	0.44**
Krishna - 51 × Shittahalli local	2.4**	-0.02**	-0.17**	0.01**	-0.07**	-2.42**	3.05**
Krishna - 51 × TNAU CO - 1	0.07*	0.24**	-0.08**	0.25**	0.75**	-8.69**	0.35**
Shittahalli local × Arka Sujath	1.22**	-0.06**	-0.14**	-0.04**	-0.21**	6.85**	-0.89**
Shittahalli local × Pusa Nasdar	-0.26**	-0.04**	0.08**	-0.06**	-0.13**	-1.40**	1.16**
Shittahalli local × Krishna - 51	2.01**	0.15**	-0.18**	0.19**	0.49**	0.79**	-0.27**
Shittahalli local × TNAU CO - 1	-1.08**	-0.1**	0.06**	-0.16**	-0.46**	19.40**	-1.36**
TNAU CO - 1 × Arka Sujath	-0.07*	-0.05**	-0.24**	-0.01**	-0.18**	1.88**	0.51**
TNAU CO - 1 × Pusa Nasdar	1.08**	0.15**	-0.25**	0.20**	0.48**	0.82**	-0.89**
TNAU CO - 1 × Krishna - 51	-0.19**	0.13**	-0.12**	0.16**	0.43**	-0.91**	-1.27**
TNAU CO - 1 × Shittahalli local	1.31**	0.09**	-0.16**	0.12**	0.28**	3.17**	-0.70**
S.E±Sii-Sjj	0.02	0.002	0.004	0.002	0.006	0.10	0.01
CD at 5% (Sij)	0.05	0.005	0.010	0.005	0.015	0.24	0.03
CD at 1% Sii-Sjj	0.07	0.007	0.015	0.008	0.022	0.34	0.05

Crosses	Fruit yield (kg/vine)	Fruit yield (t/ha)	Vitamin-C content of fruit (mg/100g)	Chlorophyll-a (mg/g)	Chlorophyll-b (mg/g)	Total chlorophyll (mg/g)	Fibre content of fruit (g)
Arka Sujath × Pusa Nasdar	-0.04**	-0.26**	0.10*	-0.10**	0.05**	-0.04**	0.05**
Arka Sujath × Krishna - 51	0.13**	0.9**	0.26**	0.04**	0.06**	0.10**	0.08**
Arka Sujath × Shittahalli local	-0.04**	-0.28**	-0.86**	-0.02**	-0.07**	-0.09**	-0.10**
Arka Sujath × TNAU CO - 1	0.10**	0.68**	1.59**	-0.01**	0.07**	0.06**	-0.03**
Pusa Nasdar × Arka Sujath	0.05**	0.35**	0.08	-0.03**	0.08**	0.04**	0.02**
Pusa Nasdar × Krishna - 51	0.01**	0.12**	-0.71**	-0.08**	-0.11**	-0.19**	-0.01**
Pusa Nasdar × Shittahalli local	-0.07**	-0.52**	0.43**	-0.06**	0.01**	-0.05**	0.02**
Pusa Nasdar × TNAU CO - 1	-0.09**	-0.63**	1.22**	0.09**	0.02**	0.12**	0.006**
Krishna - 51 × Arka Sujath	0.03**	0.21**	0.41**	-0.04**	-0.07**	-0.11**	0.08**
Krishna - 51 × Pusa Nasdar	0.09**	0.59**	0.14**	0.08**	0.07**	0.15**	0.06**
Krishna - 51 × Shittahalli local	0.29**	1.96**	-0.61**	0.08**	0.02**	0.10**	-0.11**
Krishna - 51 × TNAU CO - 1	-0.07**	-0.49**	2.12**	-0.05**	-0.07**	-0.13**	-0.14**

Shittahalli local × Arka Sujath	-0.01**	-0.10**	-0.13*	0.13**	0.09**	0.22**	0.02**
Shittahalli local × Pusa Nasdar	0.08**	0.56**	0.43**	-0.03**	0.05**	0.01**	0.26**
Shittahalli local × Krishna - 51	-0.01**	-0.10**	0.46**	0.02**	0.02**	0.04**	0.03**
Shittahalli local × TNAU CO - 1	0.11**	0.75**	1.77**	0.12**	0.08**	0.20**	0.05**
TNAU CO - 1 × Arka Sujath	0.08**	0.56**	2.10**	-0.04**	0.02**	-0.01**	0.04**
TNAU CO - 1 × Pusa Nasdar	-0.08**	-0.56**	2.42**	0.13**	0.07**	0.20**	0.10**
TNAU CO - 1 × Krishna - 51	-0.13**	-0.91**	2.21**	0.03**	0.04**	0.07**	-0.22**
TNAU CO - 1 × Shittahalli local	-0.04**	-0.31**	2.14**	0.01**	0.03**	0.04**	0.10**
S.E±Sii-Sjj	0.002	0.013	0.03	0.001	0.001	0.001	0.002
CD at 5% (Sij)	0.005	0.030	0.08	0.002	0.002	0.004	0.005
CD at 1% Sii-Sjj	0.007	0.044	0.14	0.003	0.003	0.005	0.008

* and ** indicates significance at 5% & 1% levels respectively

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