

COMBINING ABILITY AND KERNEL QUALITY IN WHITE MAIZE (*Zea mays* L.) INBRED LINES

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Abstract

Although plant breeding has been extremely successful at improving the yield of maize, but kernel quality was given less attention, the ability of maize breeders to use existing genetic variation and to identify and manipulate economically important genes will open new avenues for the design of novel variation in grain composition, thus providing the basis for the development of the next generation of specialty in maize and of new products to meet future needs. The experiment was conducted to study combining ability and kernel quality of white maize (*Zea mays* L.) populations. A half diallel cross comprising of six parental inbred lines were developed and studied for some combining ability and kernel quality to determine the mode of inheritance of kernel quality traits, heritability and the nature of correlation between agronomic and kernel quality traits. The parental materials consisted of six genotypes of white maize inbred lines which were crossed in a partial diallel pattern, which generated 15F₁s crosses. Twenty five entries comprising of 15F₁'s, six parents, and four checks were evaluated at two locations (Wudil and Dambatta) during 2024 rainy. The entries were arranged in 5×5 lattice with three replications at each location. The effects for GCA and SCA combined across locations revealed that parents P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B and 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B had negative whereas parents 1368×HI ×4269-1368-7-2-B-B-B-B-B and TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B had positive significant GCA effect respectively, indicating that they are good combiners for such traits. High-parent heterosis hybrid 1368×HI ×4269-1368-7-2-B-B-B-B-B × 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B had higher in both locations indicating the effectiveness of direct selection. Finally, crosses with high standard heterosis for yield and yield components could be used for developing high yielding maize hybrids in the future maize breeding program.

Keywords: Combining Ability, Kernel, Inbred Lines, Maize

Introduction

Maize (*Zea mays* L., 2n = 20) is a monoecious; C4 plant belongs to the tribe Maydeae of the family Poaceae. It is a tall, robust, annual, usually with a single dominant stem, although there may be few tillers in some genotypes and environments. Prasanna et al. (2001) noted that the crop is a vital source of calorie, protein and some important vitamins and minerals to billions of people world-wide, particularly in Africa, South America and Asia. Approximately 88% of maize produced in Ethiopia is consumed as food, both as green and dry grain (Tsedeke et al., 2015). Maize is cultivated globally as one of most important cereal crops and ranks third next to wheat and rice. CSA (2017)

Heterosis, or hybrid vigor, is the better performance of a hybrid relative to the parents, and is the outcome of the genetic and phenotypic variation. Most traits of economic

importance are qualitative and controlled by several to many major genes. Generally heterosis can be divided into two broad categories, true heterosis and pseudoheterosis. In case of true heterosis, there is an increase in general vigor, yield and adaptation. In case of pseudoheterosis, the F1 hybrid exhibits increase in vegetative growth only. It refers to the superiority of F1 over the standard commercial check variety. So, it is also called economic heterosis or superiority over checks (Sharief et al., 2009). Recently it has been divulged that the utilization of heterosis is extremely effective for the genetic improvement of different traits and that the concepts of combining ability are the fundamental tools for enhancing productivity of different crops in the form of F1 hybrids (Flint-Garcia et al., 2009). Heterosis occurred in the F1 hybrids for all traits of interest, but their values varied among crosses and characters. However, Genotypes harboring desirable attributes and stable performance are vital, both as cultivars and as source of desirable germplasm for further improvement. Maize production can be boost up by providing some relevant and basic information about the pattern and genetic variability to the breeding community. Combining ability studies provide information on the genetic mechanisms controlling the inheritance of quantitative traits and enable the breeders to select suitable parents for further improvement or use in hybrid breeding for commercial purposes. In biometrical genetics two types of combining abilities are considered i.e. general combining ability (GCA) and specific combining ability (SCA). General combining ability refers to the average performance of the genotype in a series of hybrid combinations and is a measure of additive gene action whereas; specific combining ability is the performance of a parent in a specific cross in relation to general combining ability (Sharief et al., 2009). SCA is due to genes showing non-additive effects (Sprague and Tatum, 1942). Diallel cross technique developed by Hayman and Jinks (1954) provides information on the inheritance mechanism in the early generations and help the breeder to make effective selection.

The objectives of this study are as follows:

- i. To determine the genetic effects of kernel quality traits in maize inbred lines.
- ii. To determine heterosis for kernel quality traits in maize inbred lines

Materials and Methods

The research was conducted at Wudil and Dambatta both in Kano State, Nigeria. Population development was carried out in Wudil while evaluation of six parents, fifteen hybrids and four checks were carried out in both Wudil and Dambatta.

Description of Plant Materials.

Field Evaluation

The six (6) parentals, 15F1's and four (4) checks were evaluated at two (2) locations in June, 2024 rainy season.

The 25 entries evaluated in each location are given in Table 3.

Experimental Design

The 21-entries and four (4) checks were arranged in 5×5 lattice with three replications at each location. Each plot consists of two rows 4 m long, inter and intra row spacings were 75 cm x50 cm respectively. Sowing was done manually; two seeds per hill were sown. At about two weeks after planting, they were thinned to two plants per hill.

Fertilizer Application

Fertilizer was applied at the recommendation of compound fertilizer (NPK 20:10:10) as basal dressing and urea (46 % N) as top dressing, giving a total plant nutrient of 120 kg N, 60 kg P₂O₅ and 60 kg K₂O per hectare.

Weeding

Three hoe weedings were done; first one at two weeks after sowing second at four weeks after sowing and third weeding was six weeks after sowing.

Data Collection and Observation

Assessments of plant characters were started two weeks after planting and continued fortnightly. Data was collected on the following parameters starting from two (2) weeks after planting.

Plant stand per plot: number of plant stand per plot **Days to 50% tasseling (pollen shed):** number of days after planting (dap) to when 50% of the plants in a plot shed pollen, **Days to 50% silking:** the number of days after planting (dap) to when 50% of the plants in a plot produced silk, **Anthesis silking interval:** the difference between Days to 50% silking and Days to 50% tasseling **Plant height (cm):** the height from soil level to the base of the flag leaf, **Days to maturity:** the number of days from planting to physiological maturity, **Ear height (cm):** height from the soil level to the node bearing the top most ear, **Ears per plot:** number of ears in each plot at harvest., **100 grain weight:** weight of 100 grains in kilogram per hectre randomly taken from each plot after shelling, **Percentage of whole kernels:** was determined from sample of 200 kernels, **Percentage of kernels without pericarp damage:** 50 g of whole kernels were placed in 0.1% solution of brilliant blue R-250 dye in distilled water for 30 seconds and then removed, washed with tap water for 30 seconds, placed on paper towels and allowed to dry; then kernels without damage were counted, **Density (g/cm³):** ratio between kernel weight and the volume of alcohol displaced by 100g of whole kernels of maize were obtained., **Milling test:** percent of flour produced from 80g of kernels in a laboratory mill model 4, for 30second, **Moisture content of the seeds at harvest:** per cent of water on kernel weight was measured with seed moisture tester, **Grain yield per hectre (kg/ha):** 10,000 x kernels weight in a plot/Area of a plot.

Combining ability estimation

Plot-mean values were used in the Diallel analysis of fixed effects method 2 model 1 (Griffing's. 1956).

Estimate of combining ability effects

The combined analyses across locations (Table 2) indicated that parent TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B had highly significant GCA effects for three traits (days to fifty percent flowering, days to maturity and moisture content at harvest) and significant for two traits (days to fifty percent silking and yield). Parent 1368×HI ×4269-1368-7-2-B-B-B-B-B showed highly significant and significant effects for one trait (plant height and ears per plot respectively) and parent 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B showed highly significant for one trait (plant height) and significant effects for two traits (ear length and yield). Significant GCA effect was observed on P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B for two traits (days to fifty percent flowering and yield) and 9071-B-B-B indicated significant for one trait (plant height). Highly significant and significant SCA effects were observed for one and two traits (moisture content at harvest, ear height and percent whole kernel) and highly and significant for one and two traits (milling test, days to fifty percent flowering and plant height) on 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B-B-B and 1368×HI ×4269-1368-7-2-B-B-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B-B, crosses respectively. P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B-B-B-B-B-B × 1368×HI ×4269-1368-7-2-B-B-B-B-B, P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B-B-B-B-B-B × 9071-B-B-B and 9071-B-

B-B × (TZMI501×KU1414×501)-1-4-3-1-B-B-B-B-B-B-B-B crosses indicated highly significant SCA effect for one trait (yield, ear length and milling test) and significant for one trait (ear length, yield and ear height) respectively. Highly significant SCA effects were recorded on P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B × 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B and P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B for one trait (ear length) respectively. 9071-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B shows significant SCA effects for two traits (days to fifty percent flowering and ear height).P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B×

(TZMI501×KU1414×501)-1-4-3-1-B-B-B-B-B-B-B-B, 1368×*HI* ×4269-1368-7-2-B-B-B-B-B-B × (TZMI501×KU1414×501)-1-4-3-1-B-B-B-B-B-B-B-B, 1368×*HI* ×4269-1368-7-2-B-B-B-B-B-B × 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B and TZMI501×KU1414×501)-1-4-3-1-B-B-B-B-B-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B crosses revealed significant SCA effect for one trait (yield, ear length, days to fifty percent flowering and milling test) respectively. Similar results were reported by Hossein *et al.* (2014) for plant height, kernel weight and ear length. Estimate of heterosis.

The combined data across locations (Table 3) indicated that four out of fifteen hybrids exhibited negative heterosis for grain yield(P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B × 9071-B-B-B, P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B× (TZMI501×KU1414×501)-1-4-3-1-B-B-B-B-B-B-B-B, P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B × 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B and P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B). The magnitude of percent heterosis for the traits ranged from -0.07 to 195.51. All hybrids shows highly significant percent heterosis for ear length and field weight except 9071-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B and (TZMI501×KU1414×501)-1-4-3-1-B-B-B-B-B-B-B-B × 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B that shows significant and non-significant percent heterosis respectively. The reduction in yields for the hybrids ranged from 195.51% (1368×*HI* ×4269-1368-7-2-B-B-B-B-B-B-B-B × TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B) to -3.51% (P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B × 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B). The results for plant height, ear height, ear diameter, and grain yield ranged from -0.51 to 17.71, -0.27 to 24.52, -0.07 to 77.45 and -3.51 to 195.51 respectively. Ibrahim A.K, (2012) reported highly significant positive heterosis in maize for cob weight and grain yield.

Summary

The study was conducted to determine the genetic effects and heterosis for agronomic and kernel quality traits in white maize inbred lines. The parental materials consist of six genotypes of white maize inbred lines which were crossed in a partial diallel pattern, which generated 15F₁'s crosses. Twenty five entries comprising of 15F₁'s, six parents, and four checks were evaluated at two locations (Wudil and Dambatta). The entries were arranged in 5 × 5 lattice with three replications at each location. The effects for GCA and SCA combined across locations revealed that parent P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B had negative significant GCA effect for days to fifty percent flowering and grain yield. Parent 1368×*HI* ×4269-1368-7-2-B-B-B-B-B-B had positive significant GCA effect for plant height and ears per plot and thus it was a good combiner for these traits. Parent 1368×ICAL224-1×1368-3-1-B-B-B-B-B-B-B-B-B-B-B had negative significant GCA effects for plant height, ear length and yield. Due to lower plant height indicated that it is a good combiner for both tolerant to lodging and high yield and can be crossed with another good combiner to

accumulate desirable allele through recurrent selection. Parent TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B had positive significant GCA effects for days to fifty percent flowering, days to fifty percent silking, days to maturity, moisture content at harvest and negative significant for yield. Hybrid P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B \times 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B had positive significant for ear length and yield. Crosses 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B \times 1368 \times ICAL224-1 \times 1368-3-1-B-B-B-B-B-B-B-B-B-B-B had negative significant SCA effect for days to fifty percent flowering and was a good specific combination for early maturity. Cross 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B \times TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B had positive and negative significant for days to fifty percent flowering, milling test and plant height and was best combination for these traits. Cross 9071-B-B-B \times TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B had negative and positive significant SCA effect for days to fifty percent flowering and ear height and it was a good combination for these traits. Cross 1368 \times ICAL224-1 \times 1368-3-1-B-B-B-B-B-B-B-B-B-B-B \times TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B had positive significant SCA effects for percent kernel without pericarp damage and negative significant for ear height and was therefore considered a good specific combination for these traits.

The high percent heterosis manifested in this study by cross 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B \times TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B in both locations indicated the fact that wide genetic distances on the basis of origin, adaptation and maturity contribute to genetic diversity and to higher heterosis

Conclusion

The results of the study indicated that effects for GCA and SCA combined across locations revealed that parent P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B, 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B, 1368 \times ICAL224-1 \times 1368-3-1-B-B-B-B-B-B-B-B-B-B-B and TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B had negative, positive and negative significant GCA effect respectively, indicating that they are good combiners for such traits. Hybrid P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B \times 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B, 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B \times 1368 \times ICAL224-1 \times 1368-3-1-B-B-B-B-B-B-B-B-B-B-B and 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B \times TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B had positive and negative significant SCA effects combined across locations for some traits under study.

Recommendation

Based on the results of this study, the following recommendations are thus made:

- There is need to select different inbred lines for hybrid production for specific locations for the affected traits. Specific hybrid performance for the traits repeated over different locations, revealing that these hybrids should be produced over the two environment.
- Parent P43SRC9FS100-1-1-8-#1-B1-13-B1-B-B-B-B-B-B-B-B, Parent 1368 \times HI \times 4269-1368-7-2-B-B-B-B-B, Parent 9071-B-B-B, Parent 1368 \times ICAL224-1 \times 1368-3-1-B-B-B-B-B-B-B-B-B and Parent TZL-COMP3-C2-S2-34-4-1-2-B-B-B-B-B-B-B-B-B were the best combiners for better kernel quality and high yield. They are recommended as the better sources for extraction of hybrid with both higher quality kernels as well as higher yield
- Further evaluation of the materials used in this study should be carried out so that their potential as a new source of kernel quality and higher yield can be harnessed.

Table 2 GCA and SCA effects of nineteen traits of maize combined across locations evaluated in 2024

Genotypes	Status	Plant	Days to	Days to	Anthesis	Plant	Days	Ear	Ear	Ear	Ears
		stand	50%	50%	Silking	Height		Height	Length	Diameter	
		Per plot	flowering	silking	interval	(cm)	maturity	(cm)	(cm)	(cm)	Per
P1	G	0.1	-0.89*	-0.5	0.46	1.71	-1.01	2.69	0.49	-0.26	-0.18
P2	G	0.97	-0.51	-0.46	-0.04	8.52**	-0.43	3.48	0.59	-0.69	0.34*
P3	G	-0.69	-0.18	0	0.21	8.21*	0.11	1.88	-0.33	-0.45	-0.06
P4	G	0.39	-0.93*	-0.54	0.29	-1.2	-0.35	-0.45	0.55	1.2	0.14
P5	G	-0.36	-0.43	-0.1	-0.5	-11.77**	-0.39	-5.65*	-0.75*	-1	-0.15
P6	G	-0.4	2.94**	2.46*	-0.42	-5.47	2.07**	-1.95	-0.54	1.21	-0.09
P1P2	S	0.54	-0.14	-0.61	-0.52	3.84	-0.27	-1.54	1.11*	1.29	0.28
P1P3	S	0.88	0.86	0.27	-0.77	-2.76	1.03	-4.06	-1.69**	-0.46	0.18
P1P4	S	-1.71	-0.73	-0.69	-0.02	9.53	0.32	6.46	0.41	-1.13	-0.58
P1P5	S	0.71	0.78	1.89	0.94	-6.56	0.69	1.53	-1.62**	1.04	0.31
P1P6	S	-0.42	-0.77	-0.86	0.36	-4.05	-1.77	-2.4	1.8**	-0.74	-0.19
P2P3	S	-1	0.15	-0.11	-0.27	-1.04	-1.23	2.67	0.64	0.88	-0.07
P2P4	S	0.25	0.23	0.43	0.32	4.4	-0.27	-2.3	-1.30*	-1.42	0.2
P2P5	S	-0.67	-1.6*	-1.82	-0.23	3.92	0.11	1.69	0.46	0.86	-0.44
P2P6	S	0.88	1.36*	2.1	0.69	-11.12*	1.65	-0.52	-0.9	-1.6	0.03
P3P4	S	0.58	0.9	1.64	0.73	-9.28	0.86	-9.22*	0.55	-0.77	0.1
P3P5	S	0.17	-0.27	-0.61	0.03	4.2	-0.27	1.67	0.53	1.13	-0.04
P3P6	S	-0.63	-1.64*	-1.19	0.28	8.87	-0.39	8.95*	-0.03	-0.78	-0.18
P4P5	S	-0.25	0.18	0.4	0.23	6.25	0.98	-3.1	-0.92	1.42	-0.06
P4P6	S	0.63	-0.23	-0.98	-0.81	1.61	0.07	2	-0.58	4.74	0.23
P5P6	S	-0.46	1.28	0.93	-0.52	4.69	0.44	-7.99*	-0.28	-1.61	0.12

Cont. Table 2

Genotypes	Status	Field Weight (kg)	% whole kernel	% kernel Without Pericarp damage	Milling test	Moisture content at harvest (%)	100 Grain Weight (g)	Volume (m3)	Density (kgpm3)	Yield (kgpha)
P1	G	0.28*	-2.55	5.39	0.05	-0.31	37.08*	-0.21	17.69	715.34*
P2	G	0.23	1.47	1.81	-0.04	-0.61	118.75	-0.72	26.59	587.3
P3	G	0.09	-0.28	-3.19	0.22	-0.28	-39.17	-0.12	4.00	231.75
P4	G	0.05	8.24	1.81	0.38	0.17	40.83	0.15	-2.71	113.23
P5	G	-0.33*	-6.4	-1.86	-0.65	-0.57	126.67	0.95	-32.37	-834.92*
P6	G	-0.32	-0.49	-3.94	0.03	1.59**	-284.17	-0.05	-13.2	-812.7*
P1P2	S	0.64**	1.15	-4.22	-0.1	0.77	-17.83	-1.89	68.12	1636.61**
P1P3	S	-0.48	-4.43	3.12	0.89	0.18	-188.25	-0.08	-0.98	-1229*
P1P4	S	-0.44*	4.38	8.12	-0.82	0.57	-99.92*	2.66	-95.67	-1106.24*
P1P5	S	0.28	2.78	1.78	-0.35	-0.21	97.58	0.52	-24.14	705.4
P1P6	S	-0.003	-3.89	-8.8	0.38	-1.31	208.42	-1.21	52.67	-6.77
P2P3	S	-0.1	-9.7	1.03	0.89	0.66	148.42	2.33	-72.26	-254.39
P2P4	S	-0.18	2.03	-0.1	-0.82	-0.83	-316.58	-1.83	42.02	-449.1
P2P5	S	-0.06	4.34	0.7	-0.35	-0.01	154.25	0.43	-4.28	-140.11
P2P6	S	-0.31	2.18	3.45	1.58**	-0.59	31.75	0.95	-33.61	-793.02
P3P4	S	0.4	8.28	4.7	1.59**	0.59	-182	-0.67	16.54	1011.22
P3P5	S	0.007	1.51	-4.63	-0.62	-0.1	168.83	-0.9	36.18	16.51
P3P6	S	0.18	4.34	-4.22	-1	-0.44	530	-0.69	20.5	455.66
P4P5	S	0.08	10.35	9.63	-0.89	0.73	-235.5	0.58	-34.45	190.9
P4P6	S	0.29	-4.35	-2.22	-1.16*	0.4	363	0.42	2.65	735.03
P5P6	S	-0.15	1.72	11.78*	0.2	1.94**	-656.17	0.53	-42.21	-390.9

Significant at 5% and 1% levels respectively

Table 3 Percent Heterosis for six traits of maize combined across locations evaluated in 2024.

Entry	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Field weight (kg)	Yield (kg/ha)
P1P2	-0.51	4.42	-4.52**	-59.85**	22.16**	22.16**
P1P3	-4.19	-0.48	-23.17**	-63.79**	-13.02**	-12.97**
P1P4	-2.67	9.25	-8.51**	-61.25**	13.02**	-12.93
P1P5	-16.90	-2.79	-24.89**	-61.33**	3.60**	3.51*
P1P6	-12.20	-3.06	-7.03**	-60.21**	-11.08**	-11.03**
P2P3	10.79	10.86	11.06**	8.54	25.56**	25.55**
P2P4	15.08	13.10	20.68**	13.31	150.00**	150.75**
P2P5	17.71	14.67*	25.54**	4.15	105.30**	105.98**
P2P6	11.75	24.52**	17.27**	32.11**	193.81**	195.51**
P3P4	1.29	-7.26	13.27**	10.22	42.48**	42.27**
P3P5	3.03	-0.27	4.93**	7.79	13.53**	13.53**
P3P6	9.57	13.25	2.72*	10.22	20.30**	20.35**
P4P5	-4.29	8.06	27.01**	1.24	91.39	92.25
P4P6	4.57	11.52	17.84**	77.45**	91.39**	144.39**
P5P6	10.73	-6.27	19.57**	-0.07	62.25**	62.79**
SE±	12.33	8.65	1.51	9.65	0.48	1226.99

Significant at 5% and 1% levels respectively

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