COMIBINING ABILITY ANALYSIS IN HYBRID RICE

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ABSTRACT

This research was planned to estimate the general and specific combining ability effects of Egyption lines to be evaluated in the rice breeding program. Fifteen hybrids were produced from a partial diallel crosses mating design among six lines, according to Griffing's١٩٥٦ method ٢ model ٢. The six parents and their ١٥ $F_{١}$ S were grown in a randomized complete block design with three replications at RRTC farm, Sakha kafr EL-sheikh , Egypt . Data were collected on ١١ traits including agronomic, yield and its components, panicle traits and floral traits. Both GCA and SCA were found to be significant for all the studied traits except anther width and panicle length. This indicates the importance of both additive and non-additive genetic variances in determining the inheritance of most of these studied traits. The GCA/SCA ratio shows the importance of additive genetic variance in the inheritance of most traits studied .

INTRODUCTION

Rice is an important food crop, as it is a primary food source for more than half of the world's population**.** However, the population of rice consumers is continuing to increase and the demand for rice is also going up due to improved living standards, particularly in Africa. Hybrid rice has proven to be an effective and economic way to increase rice production output. It is estimated to obtain about ١٥-٢٠٪ higher yield just by growing hybrids instead of the common varieties (Virmani *et al*.,١٩٩٣). Hybrid rice is successfully cultivated in China and gives more than ٣٠٪ yield advantage over conventional rice varieties. This technology has enabled China to increase its rice production by nearly ٢٠٠ milion tons from ١٩٧٦ to ١٩٩١ (Yuan,١٩٩٤).

Combining ability is a measure of gene action of both additive and non-additive genetic variation. The general combining ability (GCA) effects largely involve additive gene effects, whereas, specific combining ability (SCA) represents only non-additive gene action including dominance. The presence of non-additive genetic variance offers scope for exploration of heterosis (Yadav *et al.,* ١٩٩٩). To develop hybrid rice with higher yield, better grain quality and multi-resistance, it would be very important to breed CMS lines with good combining ability.

MATERIALS AND METHODS

A Partial diallel crosses mating design was carried out among six rice genotypes (Table ١) To obtain ١٥ $F_{١}$ crosses. These genotypes included four introduced maintainers; IR٥٨٠٢٥B, Pusa ٣B and ٦B and the two Egyptian restorers; Giza ١٧٨R and Giza ٥١٢١R. All the ٢١ genotypes (١٥ $F_{١}$ hybrids and their six parents) were raised in a randomized complete block design of three replications with spacing of ٢٠ cm rows and ٢٠ cm between plants during the summer season ٢٠٠٨ at Rice Research and Training Center (RRTC) ,Sakha ,Kafr El-sheikh, Egypt . The recommended cultural practices were followed. Data were recorded on ten to twenty five randomly plants taken from all replications and the mean values were used for statistical analysis. Combining ability analyses were carried out according to method ٢(model ٢) of Griffing (١٩٥٦). The observations were recorded for ١١ quantitative traits viz, agronomic traits (days to heading and plant height), yield and its component traits (grain yield plant$^{-١}$, ١٠٠٠-grain weight (g), filled grain panicle$^{-١}$ and spikelets fertility) panicle traits (panicle length and panicle weight) and floral traits (anther length and anther width).

Table ١. Parentage, origin and salient features of the parental , restorer and maintainer lines used for the study.

No	Genotype	Origin	Parantage	Salient features
١	Giza ١٧٨R	Egypt (Indica-Japonica type)	Giza ١٧٥/Miliang٤٩	Early maturing, short stature, short grain, good grain quality and good restorer for CMS lines and high yielder.
٢	GZ٥١٢١-R	Egypt (Indica type)	GZ١٣٦٨S-٥-٤/LA١١٠//Milyang٤٩	Medium maturing, semi dwarf, short grain, good grain quality and good restorer for CMS lines and high yielder.
٣	IR٥٨٠٢٥B	IRRI	IR٤٨٤٨٣A/٨*PUSA١٦٧-١٢٠-٣-٢/PUSA١٦٧-١٢٠-٣-٢	Indica type, late maturing ,maintainer for the CMS line IR٥٨٠٢٥A line ,extra long grain ,low amylase content and strong aroma
٤	IR٦٩٦٢٥B	IRRI	——	Indica type, med .early maturing, maintainer for the CMS line IR٦٩٦٢٥A, med grain type and med. amaylose content
٥	BUSA ٣B	Egypt -IRRI	IR٥٨٠٢٥B/Pusa Basmati ١	Indica type, late maturing, maintainer for CMs line Busa ٣A, Extra long grain type, aromatic and high amaylose content
٦	BUSA ٦B	Egypt -IRRI	IR٥٨٠٢٥B/Pusa Basmati ٢	Indica type, late maturing, maintainer for CMs line Busa ٦A, Extra long grain type, aromatic and high amaylose content

RESULTS AND DISCUSSION

The magnitude of genotypic variations and analysis of variance:

In the growing season of ٢٠٠٨, all genotypes were evaluated to determine the magnitude of genotypic variations among each other. The genotypes included ٢١ entries (six parents and ١٥ F١half diallel crosses excluding the reciprocal crosses).

The analyses of variances were made on the all studied traits viz., agronomic yield and its components, panicle and floret traits and results are presents in Table (٢). This data also presentes the partitioning of the total variance among genotypes into general combining ability (GCA) and specific combining ability (SCA) for the studied traits.

All genotypes were also subjected to statistical analysis of variance for five yield and its components traits, two panicle traits and floral traits. The results are also presented in Table (٢).

The results of analysis of variances revealed the presence highly significant differences among the ٢١ genotypes of all traits except for anthers width. similar results were previously obtained by Awd-Allah(٢٠٠٦),El-Diasty *et al.* (٢٠٠٨), Abd El-Hadi *et al.* (٢٠٠٩) and Bagheri and Jelodar (٢٠١٠) and Reda(٢٠١١).

Mean Performance:

The mean performance of the six parental lines and their ١٥ cross combinations for the eleven studied traits are presented in Table(٣). The mean performance of the studied traits varied from cross combination to another. For days to heading, the FI mean value of four crosses were towards the lower parents (early flowering parents), while one cross only tended to the higher parents (late flowering parents). The mean of the rest (١٠ crosses) were intermediate between the two parents involved.

With respect to plant height, the desirable mean values towards short stature were found in four crosses. Complete to overdominance was observed in most crosses towards the taller parents, higher productive tillers plants $^{-١}$, heavier ١٠٠٠- grain weight, higher filled grain panicle $^{-١}$, higher rate of spikelet fertility, higher grain yield plant$^{-١}$, longer panicle, heavier panicle weight and longer anther.

Some crosses combinations exhibited dominance effect towards the lower parents viz, for spikelet (three crosses), and for anther width (two crosses).

However, the rest of the hybrid combinations showed intermediate mean values between the parents involved for all studied characters.

Analysis of combining ability variances:

Statistical analysis was done using method ٢, Model ٢ of Griffing (١٩٥٦).

Table (٢) revealed highly significant differences for the mean square values of general combining ability (GCA) and specific combining ability (SCA) for days to heading , plant height , panicles plant$^{-١}$, grain yield plant$^{-١}$, ١٠٠٠- grain weight (gm), panicle weight(gm), field grains panicles$^{-١}$, spikelet fertility % and anther length traits . This indicates the importance of both additive and non –additive genetic variance in determining the inheritance of most studied traits.

The relative importance of each gene was determined using GCA /SCA. The GCA/SCA ratios were found to be in favour of additive genetic variance in the inheritance of most traits. This indicates the importance of additive genetic variance. therefore, it could be concluded that selection procedures based on the accumulation of additive effect would be successful in improving traits with cytoplasmic male sterile lines and restoring ability gene's transfer.

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Similar results were obtained by El Mowafi *et al*. (٢٠٠٥), Abd-El Hadi and El Mowafi (٢٠٠٥), Abd-El Hadi *et al.* (٢٠٠٩), El-Diasty *et al.* (٢٠٠٨) bagheri and Jelodar (٢٠١١), Rahimi *et al*. (٢٠١٠) and Saidaiah *et al* (٢٠١٠).

Estimation of general combining ability effect:

Table (٤) illustrates the magnitude of GCA effects for the six parents. The restorer variety Giza ١٧٨R is the best combiner for days to heading, plant height, grain yield plant$^{-١}$ and panicle length. The restorer line GZ ٥١٢١R is the best combiner for panicle weight and anther width traits. The line IR ٦٩٦٢٥B is the best combiner for days to heading, ١٠٠٠-grain weight, spikelet fertility% and anther width. While, IR ٥٨٠٢٥B is the best combiner for panicles plant$^{-١}$, filled grains panicle$^{-١}$, panicle length and panicle weight traits . The line Pusa ٣B is the best combiner for panicle and anther length, while line Pusa ٦B is the best combiner for plant height and anther traits.

Estimation of specific combining ability effects (SCA):

The results presented in Table(٥), indicate that the traits depend not only on GCA but also on the SCA.

The SCA effects were important for the crosses GZ ٥١٢١R × Pusa ٦B for days to heading, GZ ٥١٢١R × IR ٥٨٠٢٥ B for days to heading and filled grains panicle $^{-١}$,Giza ١٧٨R × IR ٥٨٠٢٥B for plant height and ١٠٠٠-grain weight, Giza ١٧٨R × IR ٦٩٦٢٥B for grain yield plant$^{-١}$ and ١٠٠٠-grain weight , Giza ١٧٨R × Pusa ٣B ,and Giza ١٧٨R × Pusa ٦B for panicle length and ١٠٠٠-grain weight, GZ ٥١٢١R × IR ٦٩٦٢٥B for grain yield plant$^{-١}$,panicles plant $^{-١}$,panicles plant$^{-١}$ and١٠٠٠-grain weight , IR ٥٨٠٢٥ B × Pusa ٣B for panicles plant$^{-١}$ and anther length , IR ٥٨٠٢٥B × Pusa ٦B for grain yield plant $^{-١}$, panicles plant$^{-١}$,panicle weight ,filled grains panicle $^{-١}$ spikelet fertility % and anther width and Pusa ٣B × Pusa ٦B for grain yield plant$^{-١}$. All these crosses showed highly significant values of SCA effects.

The data in Table (٥) indicated that among ١٥ cross combinations, GZ ٥١٢١R × IR ٥٨٠٢٥ B × Pusa ٦B were the best specific combinations for grain yield plant$^{-١}$ which is the most important trait.

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القدرة علي الائتلاف في بعض هجن الأرز الهجين.

علي ماهر العدل[1] ، زكريا محمد الديسطي[1] ، حمدي فتوح الموافي[2] و سناء عبدالهادي حبسه[1].
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تم إنتاج خمسة عشر هجينا من تهجين نصف دوري بين ست سلالات من الأرز. استخدم في التحليل الإحصائي لهذه التجربة طريقة جريفنج ١٩٥٦ الثانية ،النموذج الثاني.حيث تمت زراعة الآباء والجيل الأول في تجربة قطاعات كاملة العشوائية من ثلاث مكررات بمزرعة مركز البحوث و التدريب في الأرز بسخا- كفر الشيخ.

أخذت البيانات علي ١١ صفة تشمل الصفات الحقلية و صفات المحصول والسنبلة والصفات الزهرية .

ولقد أظهرت البيانات معنوية كل من تباين القدرة العامة و الخاصة علي الائتلاف لكل الصفات ماعدا صفة عرض المتك و صفة طول السنبلة .

اتضح من النتائج أهمية كل من الفعل التجميعي و الفعل السيادي للجين في وراثة معظم الصفات. ولقد تبين من النسبة بين تباين القدرة العامة و الخاصة علي الائتلاف أن التباين الوراثي التجميعي له الدور الأهم في وراثة معظم الصفات المدروسة.

قام بتحكيم البحث

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Table ٢ . Estimates of the mean square of ordinary analysis and combining ability analyses for all the studied traits.

s.o.v	d.f	Agronomic character		Yield and its component					Panicle character		Floral Trait	
		Days to heading (days)	Plant height (cm)	Panicles plant$^{-١}$	١٠٠٠-grain weight (g)	Filled grains panicle$^{-١}$	Spikelet fertility %	Grain yield plant$^{-١}$ (g)	Panicle length (cm)	Panicle Weight (g)	Anther length	Anther width
Reps	٢	٠,٣٩	١,٦٧	٠,٤٥	٠,٢٩	٥٢,٨١	٥,٧٦٤	٢,٩٦	٠,٧٨	٠,٠١٨	٠,٠٠١١	٠,٠٠٢٩**
Genotypes	٢٠	٦٩,٩٤**	٦١,٧٣**	١٧,٩٥**	٦,٦١**	١٦٦٤,٠٤**	١٨,٦٥٩**	١٧,٩٥**	٨,٩٤**	١,٣٦٩**	٠,١٣٥٦**	٠,٠٠٣٤
GCA	٥	٧٣,٢٠**	٢٧,٤٤**	٢٠,٢١**	٥,٨٠**	١٣١١,٢١**	٧,٨٧٧**	٢٠,٢١**	٦,٩٥	٠,٢٩٤**	٠,١٣٠٥**	٠,٠٠٤١**
SCA	١٥	٦,٦٨**	١٨,٢٩**	١,٢٤	١,٠**	٣٠٢,٥٠**	٥,٦٦٧**	١,٢٤	١,٦٦**	٠,٥١٠**	٠,٠١٦٨**	٠,٠٠٠٢
Error	٤٠	١,٢٧	٢,٩٠	٠,٦٦	٠,١٧	٣١,٢١	٦,٤٢٨	٠,٦٦	٠,٣٥	٠,٠٥٤	٠,٠٠٥٧	٠,٠٠٠٤
GCA/SCA ratio		١,٦٦	٠,٢٠	٤,٢٠	٠,٧٦	٠,٥٥٧	٠,٢٠٣	٤,٢٠	٠,٦٣	٠,٠٧٠	١,٤٠٢٨	٠,٠٥٧

***,**significant at ٠,٠٥ and ٠,٠١ levels, respectively.**

Table ٣. Mean performance for all studied traits:

Genotype	Agronomic character		Yield and its component					Panicle characters		Floral Traits	
	Days to heading (days)	Plant height (cm)	Panicles plant$^{-١}$	١٠٠٠-grain weight (g)	Filled grains panicle$^{-١}$	Spikelet fertility %	Grain yield plant$^{-١}$ (g)	Panicle length (cm)	Panicle Weight (g)	Anther length	Anther width
Parents:											
Giza ١٧٨R	١٠١,٥٣	٩٦,١٠	٢٣,١٧	٢١,٤٧	١٧٨,٢٧	٩١,٩١	٣٩,٢٧	٢٣,٢٣	٣,٦٠	١,٥٧	٠,٤٤
GZ ٥١٢١R	١٠٨,٣٠	٩٣,٢٠	٢٤,٦٠	٢٦,٠٧	١٤٠,١٧	٩٢,٩٢	٣٣,١٧	٢١,٠٠	٣,٦٨	١,٥٣	٠,٤٨
IR ٦٩٦٢٥B	٩٩,٣٣	١٠٣,١٠	٢٠,٥٧	٢٧,٤٢	١٣٥,٨٧	٩٧,٥٤	٣٤,٨٥	٢٣,٠٣	٣,١٦	١,٧٤	٠,٤٤
IR ٥٨٠٢٥B	١١٦,١٠	١٠٥,٤٧	٢٦,٠٠	٢٣,٢٤	١٩٤,٠٠	٨٦,٨٧	٣٠,٢٠	٢٥,١٣	٣,٦٩	١,٧٠	٠,٣٧
Pusa ٣B	١١٠,٥٠	١٠٢,٧٠	١٧,٠٧	٢٣,٣٣	١٧٠,١٧	٩٥,٣٧	٢٤,١٩	٢٤,٦٣	٢,٧٦	٢,٠٧	٠,٤٠
Pusa ٦B	١٠٧,٥٠	٩٥,٧٣	٢٠,٧٧	٢٣,٣٧	١٧٣,٧٠	٩١,٢٣	٣٦,٩٩	٢٢,٠٣	٣,٠٦	٢,٠٤	٠,٣٥
Hybrid combinations:											
Giza ١٧٨R × GZ ٥١٢١R	١٠٥,٥٠	١٠١,٦٣	٢٥,٥٠	٢٤,٨٠	١٩٢,٩٧	٩٥,٦٨	٤٤,٢٨	٢٤,٤٠	٤,٣٨	١,٨٥	٠,٤٦
Giza ١٧٨R ×IR ٦٩٦٢٥B	٩٩,٤٣	١٠٧,٨٠	٢٢,٩٧	٢٦,٨٠	١٨٤,٧٧	٩٢,٥٦	٤٩,٠٧	٢٦,٠٣	٤,٤٨	١,٩٠	٠,٤٢
Giza ١٧٨R ×IR٥٨٠٢٥B	١٠٦,٧٧	٩٩,٨٧	٢٤,٨٣	٢٤,٩٣	٢١٥,٠٠	٩٢,٨٣	٣٧,٨٤	٢٦,٨٧	٤,٣٨	١,٨٠	٠,٣٧
Giza ١٧٨R × Pusa ٣B	١٠٥,٥٣	١٠٧,٥٠	٢٠,٤٣	٢٤,٦٣	١٩١,٢٠	٩١,٥٨	٣٦,٧٦	٢٧,٤٧	٤,٣٧	٢,١٣	٠,٤١
Giza ١٧٨R × Pusa ٦B	١٠٤,١٧	١٠٥,٨٠	٢٢,٨٧	٢٥,١٧	١٩٨,٩٧	٩٠,٠٧	٤٠,٥١	٢٦,٣٠	٤,٦٧	٢,٠٣	٠,٣٨
GZ ٥١٢١R ×IR ٦٩٦٢٥B	١٠٠,٦٠	١٠٠,١٠	٢٥,٧٣	٢٨,٣١	١٥٤,٢٧	٩٤,٩٧	٤١,١٤	٢٢,٢٣	٤,٣٠	١,٧٨	٠,٤٤
GZ ٥١٢١R ×IR٥٨٠٢٥B	١٠٥,٨٧	١٠٩,٢٠	٢٦,٢٧	٢٤,٨٣	٢١٧,٣٠	٩٣,٠١	٣٠,٨١	٢٤,٦٧	٥,١٥	١,٧٠	٠,٣٩
GZ ٥١٢١R × Pusa ٣B	١٠٤,٦٠	١٠٧,٢٧	٢١,٧٣	٢٥,٠٨	١٨٣,٥٣	٩٠,٦٩	٢٨,١٣	٢٣,٨٣	٥,٠٢	١,٩١	٠,٤٤
GZ ٥١٢١R × Pusa ٦B	١٠٠,٤٣	١٠١,٨٣	٢٢,٧٠	٢٥,١٣	١٨٩,٣٠	٨٨,٠٥	٣٩,٧٥	٢٣,١٧	٤,٤٩	١,٧٤	٠,٤٢
IR ٦٩٦٢٥B ×IR٥٨٠٢٥B	١٠٨,٨٧	١٠٩,٨٧	٢٣,٧٧	٢٥,٣٥	١٧٨,٠٧	٩١,٥٢	٣١,١٣	٢٥,٥٧	٣,٩٥	١,٨١	٠,٣٩
IR ٦٩٦٢٥B × Pusa ٣B	١٠٦,٠٧	١٠٦,٢٣	٢٠,٦٠	٢٥,٨٠	١٧٣,٠٠	٩٣,٣٥	٢٩,١٠	٢٥,٥٠	٤,٠٥	٢,١٦	٠,٤٢
IR ٦٩٦٢٥B × Pusa ٦B	١٠٣,٦٠	١٠٠,٧٣	٢٢,٣٣	.٢٥,١٢	١٨٩,٣٣	٩٢,٨٠	٣٩,٦٩	٢٣,٨٠	٤,١٣	٢,٠٨	٠,٣٩
IR ٥٨٠٢٥B × Pusa ٣B	١١٧,٤٣	١٠٦,٠٧	٢٤,٥٠	٢٤,٨٨	٢١٨,٥٧	٩٥,٠٧	٢٦,٥٧	٢٦,١٧	٥,١٤	٢,١٨	٠,٣٩
IR ٥٨٠٢٥B × Pusa ٦B	١١٠,٤٠	١٠١,٠٠	٢٥,٦٧	٢٤,١٩	٢٢٤,٨٣	٩٤,٠١	٤٢,٦٩	٢٦,٢٠	٥,٠٢	٢,١٠	٠,٣٧
Pusa ٣B×Pusa٦B	١٠٧,٢٠	١٠٥,٠٠	١٩,٨٧	٢٤,٦٧	١٩٣,٥٠	٩٢,٤٠	٢٠,٩١	٢٥,٨٠	٣,٩١	٢,٢٩	٠,٣٩
LSD ٠,٠٥			١,٣٤	٠,٦٩	٩,٢٢	٤,١٨	٣,١٧	٠,٩٧	٠,٣٨	٠,١٢٤	٠,٠٣٣
٠,٠١			١,٧٩	٠,٩٢	١٢,٣٣	٥,٦٠	٤,٢٤	١,٣٠	٠,٥١	٠,١٦٦	٠,٠٤٤

Table ٤: Estimates of GCA effects for all studied traits:

Parent	Agronomic character		Yield and its component					Panicle character		Floral Trait	
	Days to heading (days)	Plant height (cm)	Panicles plant-١	١٠٠٠- grain weight	Filled grains panicle-١	Spikelet fertility %	Grain yield plant-١ (g)	Panicle length (cm)	Panicle Weight (g)	Anther length	Anther width
Giza ١٧٨R	-٢,٣٢٦*	-٠,٩٠٨	٠,٢٨٦	-٠,٧٠٠*	٥,٠٦٤	-٠,٢٠٠	٤,٣٣١**	٠,٦٤٧	٠,٠٤٥	-٠,٠٦٥	٠,٠٠٩
GZ ٥١٢١R	-١,١٨٥	-١,٩٥٤	١,٣١١	٠,٦٧٧	-١٠,١٥٣*	٠,٠١٢	-٠,٢٣٧	-١,٥٠٧**	٠,١٩٧	-٠,١٦٧**	٠,٠٣١
IR ٦٩٦٢٥B	-٣,٢٩٣**	١,١٠٨	-٠,٥١٤	١,٤٢١**	-١٨,٤٦٩**	١,٥١٥	٠,٩٣٥	-٠,٣٩٤	-٠,٢٣٩	-٠,٠٢٠	٠,٠١٣
IR ٥٨٠٢٥B	٤,٧٤٤**	١,٨٥٨	٢,٠٤٩**	-٠,٥٢٤	١٧,٨٥٦**	-٠,٩٩٤	-٢,٨٦٣	٠,٩٢٢	٠,٢٣٦	-٠,٠٤٨	-٠,٠٢٦
Pusa ٣B	٢,٣٤٤*	١,٩٢٥	-٢,٤٢٢**	-٠,٣٩٢	٠,١٥١	٠,٧١٢	-٥,٣١٣**	٠,٧١٠	-٠,١٤٠	٠,١٨٠**	-٠,٠٠١
Pusa ٦B	-٠,٢٨٥	-٢,٠٢٩	-٠,٧١٠	-٠,٤٨٢	٥,٥٥١	-١,٠٤٥	٣,١٤٩	-٠,٣٧٨	-٠,٠٩٩	٠,١٢٠	-٠,٠٢٦
SD	١,٨٦	٢,٨١٢	١,٣٤	٠,٦٩	٩,٢٢	٤,١٨	٣,١٧	٠,٩٧	٠,٣٨	٠,١٢٤	٠,٠٣٣

***,**significant at ٠,٠٥ and ٠,٠١ levels, respectively.**

Table ٥: Estimates of SCA effect for all studied traits.

Hybrid	Agronomic character		Yield and its component					Panicle character		Floral Trait	
	Days to heading (days)	Plant height (cm)	Panicles plant-١	١٠٠٠-grain weight	Filled grains panicle-١	Spikelet fertility %	Grain yield plant-١ (g)	Panicle length (Cm)	Panicle Weight (g)	Anther length	Anther width
Giza ١٧٨R × GZ ٥١٢١R	٢,٨٥٧**	١,٣٤٣	٠,٩٥٤	-٠,١٥٧	١٢,٤٩٥**	٣,٢٨٠	٤,١٣٣*	٠,٦٣٧	-٠,٠٢٠	٠,١٧٤**	٠,٠١١
×IR ٦٩٦٢٥B	-١,١٠١	٤,٤٤٨**	٠,٢٤٥	١,٠٩٩**	١٢,٦١٢**	-١,٣٤٩	٧,٧٥١**	١,١٥٨*	٠,٥١٣**	٠,٠٧٤	-٠,٠٠٧
×IR٥٨٠٢٥B	-١,٨٠٥	-٤,٢٣٦**	-٠,٤٥١	١,١٧٨**	٦,٥٢٠	١,٤٢٨	٠,٣١٩	٠,٦٧٥	-٠,٠٦٣	-٠,٠٠٢	-٠,٠٢٦
× Pusa ٣B	-٠,٦٣٩	٣,٣٣١*	-٠,٣٨٠	٠,٧٣٩*	٠,٤٢٤	-١,٥٢٥	١,٦٩٣	١,٤٨٧**	٠,٣٠٤	٠,١٠٧	-٠,٠٠٣
× Pusa ٦B	٠,٦٢٤	٥٠٥٨٥**	٠,٣٤١	١,٣٦٨**	٢,٧٩١	-١,٢٧٤	-٣,٠١٩	١,٤٠٨**	٠,٥٦٢**	٠,٠٦٧	-٠,٠١٠
GZ ٥١٢١R ×IR ٦٩٦٢٥B	-١,٠٧٦	-٢,٢٠٧	١,٩٨٧**	١,٢٣٢**	-٢,٦٧١	٠,٨٤٦	١,٩٨٧**	-٠,٤٨٨	٠,١٧٧	٠,٠٥٩	-٠,٠١٠
×IR٥٨٠٢٥B	-٣,٨٤٧**	٦٠١٤٣**	-٠,٠٤٢	-٠,٣٠٦	٢٤,٠٣٧**	١,٤٠٤	-٠,٠٤٢	٠,٦٢٩	٠,٥٥٨**	٠,٠٠٦	-٠,٠٢٢
× Pusa ٣B	-٢,٧١٤**	٤,١٤٣**	-٠,١٠٥	-٠,١٨٨	٧,٩٧٤	-٢,٦٢٥	-٠,١٠٥	٠,٠٠٨	٠,٨٠٥**	-٠,٠١٤	٠,٠٠٤
× Pusa ٦B	-٤,٢٥١**	٢,٦٦٤	-٠,٨٥١	-٠,٠٤٦	٨,٣٤١	-٣,٥١٣	-٠,٨٥١	٠,٤٢٩	٠,٢٣٣	-٠,١٢٢	٠,٠٠٢
IR ٦٩٦٢٥B ×IR٥٨٠٢٥B	٠,٧٦١	٣,٧٤٨*	-٠,٧١٧	-٠,٥٢٣	-٦,٨٨٠	-١,٥٩٦	-٠,٧١٧	٠,٤١٧	-٠,٢٠٩	-٠,٠٣٦	٠,٠٠٠
× Pusa ٣B	٠,٨٦١	٠,٠٤٨	٠,٥٨٧	-٠,٢٠٥	٥,٧٥٨	-١,٤٦٩	٠,٥٨٧	٠,٥٦٢	٠,٢٦٨	٠,٨٩	-٠,٠٠١
× Pusa ٦B	١,٠٢٤	-١,٤٩٨	٠,٦٠٨	-٠,٨٠٢*	١٦,٦٩١**	-٠,٢٦٧	٠,٦٠٨	-٠,٠٥٠	٠,٣٠٣	٠,٠٧٢	-٠,٠٠٢
IR ٥٨٠٢٥B × Pusa ٣B	٤,١٩٠**	-٠,٨٦٩	١,٩٢٤**	٠,٨١٧*	١٤,٩٩٩**	٢,٧٦٥	١,٩٢٤**	-٠,٠٨٧	٠,٨٧٩**	٠,١٣٦*	٠,٠٠٥
× Pusa ٦B	-٠,٢١٤	-١,٩٨٢	١,٣٧٩*	٠,٢١٦	١٥,٨٦٦**	٣,٤٥٨	١,٣٧٩*	١,٠٣٣*	٠,٧٢٤**	٠,١٢٠	٠,٠١٦
Pusa ٣B×Pusa٦B	-١,٠١٤	١,٩٥٢	٠,٠٤٩	٠,٥٦٤	٢,٢٣٧	٠,١٤١	٠,٠٤٩	٠,٨٤٦	-٠,٠١٣	٠,٠٨١	٠,٠٠٧
SD	١,٨٦	٢,٨١	١,٣٤٩	٠,٦٩	٩,٢٢	٤,١٨	١,٣٤	٠,٩٧٠	٠,٣٨	٠,١٢٤	٠,٠٣٣

***,** significant at ٠,٠٥ and ٠,٠١ levels, respectively.**