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Combining Ability, Heterosis and Heritability of Some Rice (*Oryza Sativa* L.) Vegetative Traits Using Line x Tester Design

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Abstract

The importance of vegetative traits due to the bio mass during early stages which transform to dry mater at late stage. So, the investigation was undertaken to determine the combining ability effects, heterosis and genetic parameters for some vegetative traits. Egypt during 2018 and 2019 growing summer season. Four of the most important local varieties and lines; Sakha 101, Sakha 104, and GZ 9461-4-2-3-1(leaf blast susceptible) and Giza 178 (leaf blast resistant) used as lines and 4 testers contain resistance genes. They are IRBL 7-M, IR12N245, IR12G3239 and Sakha Super300 in Line X Tester design mating design was conducted and 16 F1 hybrid combinations were developed from the crossing between 4 lines and 4 testers. The data recorded on five vegetative traits showed highly significant differences among genotypes; parents, parents vs. crosses, crosses, lines, testers and line × tester for all studied vegetative traits. The estimates of the variance, ratio of general and specific combining ability and degree of dominance indicated preponderance of non-additive gene effect for each trait. Within lines; GZ 9461-4-2-3-1 recorded the best general combining ability effects (GCA) for most of the studied characters. Among testers; IR12G3239 and Sakha Super300 were observed to be good general combiners for most of the studied characters. The cross Sakha101 x IR12G3239 was observed to be good specific cross combinations for the most studied traits due to highly significant specific combining ability effects (SCA) and heterotic effects. High broad and narrow sense heritability estimates were observed for most traits. Correlation estimates revealed that plant height correlated positively and significantly with each of number of tillers per plant and leaf blast reaction to indicate the importance of selection for semi dwarf genotypes.

Keywords: rice, Combing ability, Heterosis, Heritability, correlation, line x tester and Vegetative Traits.

Introduction:

Rice (*Oryza sativa* L.) is the main food for more than half of the human population and as such it plays a key role in ensuring food security all over the world (**Yuan, 2014)**. Rice is the main food cereal crop after wheat for Egyptian population. Rice crop plays a serious role in Egypt, strategy for sustaining the food self-sufficiency and for expanding the export **(Tahany *et al.*, 2021)**.

Amazing advancement has been accomplished in rice productivity during the previous 50 years. Food security is among the greatest difficulties of the 21st century. Worldwide rice request is evaluated to ascend from 676 million tons in 2010 to 763 million tons in 2020 and further increment to 852 million tons in 2035 **(Khush, 2013** and **Ghidan *et al.*, 2019)**. The national yield average had exceeded 9.57 ton/ha during 2011 **(RRTC, 2012)**. The world rice necessity by 2050 will be 943.6 million tons, which requires a yearly increment of about 5.8 million tons from the present degree of creation **(FAO, 2017)**. Population increase will be more in developing countries **(Abd El-Hadi, *et al* 2018)**.

Combining ability analysis is a powerful tool to discriminate good as well as poor combinors and selecting out appropriate parental material and best hybrid combinations **(Patil and Mehta, 2014)**.

Heterosis is communicated in three different ways, contingent upon the criteria used to compare the performance of a hybrid **(Gupta, 2000)**. These three different ways are mid-parent heterosis, better parent heterosis (heterobeltiosis) and standard heterosis. From a practical point of view, standard heterosis is a higher priority than the other two degrees of heterosis because it is planned for creating desirable hybrids superior to the existing better yielding commercial varieties **(Chaudhary, 1984)**. Heterosis breeding is a significant genetic tool that can encourage yield upgrade from between 30 to 400% and improves numerous other desirable qualitative traits in crops **(Srivastava, 2000)**. Breeding methodologies based on hybrid production require an elevated level of heterosis as well as the specific combining ability of crosses. One of the fundamental issues of plant breeders for improving high yielding varieties is to choose acceptable good parents and crosses.

Estimation of general combining ability helps the breeder to identify parents with the superior combining ability that maybe crossed to utilize heterosis **(Fasahat *et al.*, 2016).** In this way, the information on combining ability gives data on the nature and extent of gene effects that organize grain yield and yield traits, hence enabling the breeder to design an effective breeding method for genetic upgrading of yield and its components **(Dar *et al*., 2014)**. Past investigations revealed an expansion in grain yield because of ideal heterosis for

traits such as number of spikelets per plant, flag leaf area and number of filling grains per panicle **(Vanaja and Babu 2004)**.

Line x tester is helpful in choosing the proportional ability of female and male lines to deliver desirable hybrid combinations. It additionally gives data on genetic components and enables the breeder to choose appropriate strategies for development breeding programs **(Ghidan *et al.*, 2019)**. Data on general and specific combining ability for characters will demonstrate valuable in the determination of appropriate parents for the improvement of superior hybrids. The information on heritability and genetic advance might be useful in some promising material selection from the current population, which would be of most significance **(Kempthrone, 1957).** The present research work was done with the targets to evaluate combining ability dependent on mean performance, genetic components, heterosis and heterobeltiosis for some vegetative traits in rice. Broad and narrow-sense heritability and phenotypic correlation coefficient were estimated for all studied traits.

Materials and Methods

This study was carried out at Sakha Agricultural Research Station experimental farm and Rice Research and Training Center **(RRTC)**, Sakha, Kafr Elsheikh, Egypt, during the two successive summer seasons 2018 and 2019.

Experimental design and parental lines

The experimental material consisted of eight parental genotypes and their sixteen F1 crosses according to the line x tester mating design during the 2018 and evaluated during 2019 rice growing seasons. Four Egyptian genotypes i.e., the three commercial varieties; Sakha 101, Sakha 104, Giza 178 and the promising line; GZ 9461-4-2-3-1 used as females (lines) and were crossed with four diverse genotypes i.e., IRBL 7-M, IR12N245, IR12G3239 and Sakha Super300 which used as males (testers). Thus, the resultant sixteen crosses along with their parents were evaluated in a randomized complete block design with three replications. All the recommended package of practices was followed.

Data collection

All agricultural practices were made according to rice recommendations of **RRTC (2015).** The observations on vegetative traits were recorded according to Standard Evaluation System, SES of **IRRI (2014)**, based on five plants in every genotype in each replication. Every genotype was raised in 2.5 m long single row plot, keeping 20 x 15 cm dividing. Five vegetative traits were studied for randomly selected plants from every replication viz., number of days to 50% heading (day), plant height (cm), flag leaf area (cm^2), number of tillers $plant^{-1}$ and leaf blast reaction

Statistical analysis

The data were subjected to analysis of variances for a randomized complete block design as suggested by **Panse and Sukhatme (1954).** The mean data of each trait was exposed to analysis of variance (ANOVA), to estimate significant differences among crosses and parents as proposed by **Steel and Torrie (1980)**.

The general combining ability (GCA) effects of the parents and the specific combining ability (SCA) effects of the hybrids were dictated by the utilization of the line x tester mating design **(Kempthrone, 1957)**. The estimation of heterosis of an individual cross for every characteristic was resolved as the increase of the F1 hybrid mean over either mid-parent and better parent. Heterotic and combining ability effects were tested by the least significant differences (LSD) test at the 0.05 and 0.01 levels using the t-test. Correlation coefficients (r) among every considered trait were registered to utilize the SPSS statistical package according to **Gomez and Gomez (1984)**. Some important genetic parameters such as additive variance, non-additive variance, broad sense heritability (h_2b), narrow sense heritability (h_2n) and genetic advance were also estimated according to **Falconar and Mackey (1996).**

Results and Discussion

Analysis of variance:

The analysis of variance for all studied traits are presented in Table **1**. The results dedicated highly significant differences among the rice genotypes for all the studied characters. The presence of genetic variability is pre-essential for the selection of predominant genotypes during crop improvement programs. Therefore, the assessment of the extent of variation present in the genetic material is important to estimate the magnitude of improvement that can be achieved in breeding material for various characters **(Ghidan *et al.*, 2019)**. Genotypic mean squares were further partitioned into parents, crosses and parents *vs.* crosses. The analysis of variance uncovered highly significant differences among genotypes, crosses, lines, testers, and line x tester were observed in all studied characters. Variation among parents and parent vs. crosses were highly significant for most of the studied in Table 1. The significance of line x tester for all the traits gave an immediate test, showing that non-additive variances were significant for most of these traits. This reveals high variability among the genotypes providing abundant scope of selection for different quantitative traits. A significant variation for various quantitative traits was also reported **(Bekele *et al*., 2013; Sandhya *et al*., 2014** and **Ghidan *et al*., 2018).** Estimates of variance due to general combining ability (σ2gca) were lower than those of variance due to specific combining ability (σ2sca) for all the traits indicate that the dominance genes were played important role in the inheritance of these traits. The ratio of variance due to general to specific combining ability (σ^2gca/σ^2sca), were less than unity for all the traits and degree of dominance being greater than unity. It suggested greater importance of non-additive gene action in its expression and indicated very good prospect for the exploitation of non-additive genetic variation for these traits through hybrid breeding **(Ramalingam *et al*, 1997; Annadurai and Nadarajan, 2001).**

Mean performance of genotypes

The mean performance of the parents and their F_1 crosses for vegetative traits are presented in Table **2**. There were significant differences between the lines for all the measured traits, the line GZ 9461-4-2-3-1 recorded the desirable values for the days to 50% heading, plant height, flag leaf area and no of tillers per plant.

For testers, the IR12G3239 gave the desirable values for days to 50% heading, plant height

and leaf blast reaction. Among the hybrid combinations, Sakha 101 × IR12G3239 showed the desirable value for days to 50 % heading, plant height and flag leaf area.

Table (1): Estimates of the mean square of line x tester analysis for vegetative traits during 2019 season.

* and ** Significant at 0.05 and 0.01 levels, respectively.

Sources of variation	D f	Mean square				
		Days to 50% heading (day)	Plant height (cm)	Flag leaf area(cm)	No of Tillers plant^{-1}	Blast reaction (0-9)
Replication	2	2.58	0.04	0.14	0.89	0.18
Genotypes	23	9946.24**	11721.20**	2070.89**	793.13**	5.84**
Parents (p)	7	6898.50**	7257.60**	1337.32**	321.07**	12.40**
Crosses (c)	15	11703.85**	14447.68**	2524.12**	1055.31**	1.42**
P vs C	1	4916.18**	2069.22**	407.45**	164.82**	26.24**
Lines	3	25714.28**	31934.83**	5428.85**	2251.45**	3.09*
Testers	3	26113.04**	32000.60**	5661.85**	2385.32**	3.05*
L x T	9	2230.65**	2767.65**	509.96**	213.27**	0.32
Error	46	1.31	1.35	1.71	0.80	0.22
δ^2 *gca*		328.93	405.56	69.94	29.24	0.04
δ^2 *sca*		743.11	922.10	169.42	70.82	0.03
δ^2 *gca*/ δ^2 *sca*		0.044	0.044	0.041	0.041	0.08

Table (2): The mean performances of all vegetative traits for studied genotypes during 2019 season.

Genotypes	Days to 50% heading (day)	Plant height (cm)	Flag leaf area(cm)	No of Tillers plant^{-1}	leaf blast reaction (0-9)
lines					
Sakha 101 (P1)	106.67	91.67	41.85	18.00	4.33
Sakha 104 (P2)	100.00	104.00	40.59	16.67	4.33
GZ 9461-4-2-3-1 (P3)	88.00	95.00	49.29	24.33	4.33
Giza 178 (P4)	101.00	100.67	38.97	19.00	1.00
Mean	98.92	97.83	42.67	19.50	3.50
Tester					
IRBL 7-M (P5)	96.67	113.00	38.50	21.00	1.00
IR12N245 (P6)	96.67	101.67	32.76	15.00	1.00
IR12G3239 (P7)	91.33	95.00	42.90	21.33	1.00
Sakha Super300 (P8)	111.67	111.67	52.56	26.00	1.00
Mean	99.08	105.33	41.68	20.83	1.00
Crosses					
Sakha 101× IRBL 7-M	105.67	119.67	39.18	28.00	1.33
Sakha 101× IR12N245	109.33	107.67	41.61	26.00	1.00
Sakha 101× IR12G3239	91.33	101.00	50.16	31.00	1.33
Sakha101× Sakha Super300	107.67	116.00	47.90	33.67	1.00
Sakha 104× IRBL 7-M	95.67	116.00	41.90	28.67	1.00
Sakha 104× IR12N245	100.67	110.00	41.28	24.00	1.00
Sakha 104× IR12G3239	91.67	113.00	48.70	28.00	1.00
Sakha104× Sakha Super300	111.00	114.00	48.75	35.33	1.00
GZ 9461-4-2-3-1× IRBL 7-M	91.33	108.00	41.63	30.33	1.33
GZ 9461-4-2-3-1× IR12N245	97.33	111.33	43.58	30.67	1.33
GZ 9461-4-2-3-1×IR12G3239	90.67	101.67	51.51	29.00	1.00
GZ 9461-4-2-3-1× Sakha Super300	108.00	115.33	58.02	35.33	1.00
Giza 178×IRBL 7-M	104.00	107.67	42.90	24.33	1.00
Giza 178×IR12N245	99.67	109.00	41.09	23.33	1.00
Giza178×IR12G3239	91.33	118.33	41.20	28.67	1.00
Giza178× Sakha Super300	106.00	117.33	55.13	36.33	1.00
Mean	100.08	111.63	45.91	29.54	1.08
G. Mean	99.72	108.28	44.67	26.42	1.47
LSD 0.05	1.88	1.90	2.14	1.47	0.78
0.01	2.51	2.55	2.87	1.97	1.04

Combining ability analysis:

The general combining ability recognizes predominant parents while specific combining ability helps in the distinguishing of good hybrid combinations that may at last lead to the improvement of hybrids **(Shiva *et al.*, 2013)**.

General combining ability (GCA):

The general combining ability effects of some vegetative traits are exhibited in Table **3**. Among the male (testers) parents, IR12G3239 was a good general combiner for most of the studied traits because it has given the desirable values for GCA effects for three characters i.e., days to 50 % heading, plant height and flag leaf area. The tester Sakha S 300 had the highest

GCA effects for flag leaf area, No of Tillers per plant and leaf blast reaction. Previous studies also announced good general combiners for yield and its component characters in rice genotypes **(Raju *et al*., 2014; Sathya and Jebaraj, 2015 and Devi *et al*., 2017).** While, the female (line) GZ 9461-4-2-3-1 recorded negative GCA effects for days to 50 % heading and plant height, as well as recorded high and positive GCA effects for flag leaf area and No of Tillers per plant.

It could be recommended that through the parental genotypes (lines and testers), each parent recorded the highest value for any trait under study is considered as good combiner for this trait and could be used in breeding programs to develop new promising lines for this trait. In other study by **Rahimi *et al.* 2010** found that, the significance of specific combining ability (SCA) and general combining ability (GCA) for all studied traits revealed that, both additive and non-additive gene effects contributed to the inheritance of the traits.

Table (3): Estimates of GCA effects of the studied parents for vegetative traits studied during 2019 season.

Genotypes	Traits				
	Days to 50% heading (day)	Plant height (cm)	Flag leaf area(cm)	No of Tillers plant^{-1}	leaf blast reaction (0-9)
Lines:					
Sakha 101 (P1)	3.42**	-0.54	-1.20	0.13	0.08
Sakha 104 (P2)	-0.33	1.63**	-0.75	-0.54	-0.08
GZ 9461-4-2-3-1 (P3)	-3.25	-2.54	2.78**	1.79**	0.08
Giza 178 (P4)	0.17	1.46**	-0.83	-1.38	-0.08
Testers:					
IRBL 7-M (P5)	-0.92	1.21**	-4.51	-1.71	0.08
IR12N245 (P6)	1.67**	-2.13	-4.02	-3.54	0.00
IR12G3239 (P7)	-8.83	-3.13	1.98**	-0.38	0.00
Sakha Super300 (P8)	8.08**	4.04**	6.54**	5.63*	-0.08
L.S.D. for lines 0.05	0.66	0.67	0.76	0.52	0.27
0.01	0.89	0.90	1.01	0.70	0.37
L.S.D. for testers 0.05	0.66	0.67	0.76	0.52	0.27
0.01	0.89	0.90	1.01	0.70	0.37

* and ** Significant at 0.05 and 0.01 levels, respectively.

Specific combining ability effects (SCA) of F1 Hybrids: The estimates of SCA effects of the 16 hybrids are presented in Table **4**. Minimum days to 50 % heading, short stature plant and negative values for leaf blast reaction desirable trait of rice crop. The crosses Sakha 101x IR12G3239 showed negative combining ability effect for these traits. Yield/plant is an ultimate objective of rice breeding and hybrid development programmes. High SCA effects of hybrids that started from high x low general combining ability combining parents would be unfixable in subsequent generations and thus cannot be abused by pedigree selection strategy **(Sathya and Jebaraj, 2015)**. However, these crosses would deliver desirable transgressive segregates in later generations on change of the conventional breeding methodology approaches to understand both additive and non-additive genetic effects **(Chakraborty *et al*., 2009)**.

Table (4): Estimates of SCA effects (Sij) of hybrid combinations for vegetative traits studied and its component during 2019 season.

Hybrid combination	Traits				
	Days to 50% heading (day)	Plant height (cm)	Flag leaf area(cm)	No of Tillers plant^{-1}	leaf blast reaction (0-9)
Sakha 101 x IRBL 7-M	3.08**	7.38**	-1.02	0.04	0.08
Sakha 101 x IR12N245	4.17**	-1.29	0.91	-0.13	-0.17
Sakha 101 x IR12G3239	-3.33	-6.96	3.46**	1.71**	0.17
Sakha101 x Sakha Super300	-3.92	0.88	-3.35	-1.63	-0.08
Sakha 104 x IRBL 7-M	-3.17	1.54*	1.25	1.38*	-0.08
Sakha 104 x IR12N245	-0.75	-1.13	0.14	-1.46	0.00
Sakha 104 x IR12G3239	0.75	2.88**	1.56*	-0.63	0.00
Sakha104 x Sakha Super300	3.17**	-3.29	-2.95	0.71	0.08
GZ 9461-4-2-3-1 x IRBL 7-M	-4.58	-2.29	-2.55	0.71	0.08
GZ 9461-4-2-3-1 x IR12N245	-1.17	4.38**	-1.08	2.88**	0.17
GZ 9461-4-2-3-1 x IR12G3239	2.67**	-4.29	0.84	-1.96	-0.17
GZ 9461-4-2-3-1 x Sakha Super300	3.08**	2.21**	2.80**	-1.62	-0.08
Giza 178 x IRBL 7-M	4.67**	-6.62	2.33**	-2.13	-0.08
Giza 178 x IR12N245	-2.25	-1.96	0.03	-1.29	0.00
Giza178 x IR12G3239	-0.08	8.38**	-5.86	0.88	0.00
Giza178 x Sakha Super300	-2.33	0.21	3.51**	2.54**	0.08
LSD 0.05	1.33	1.35	1.52	1.04	0.55
0.01	1.78	1.80	2.03	1.39	0.74

* and ** Significant at 0.05 and 0.01 levels, respectively.

Genetic parameters and heritability:

The phenotypic and genotypic coefficients of variance can be utilized for evaluating and contrasting the nature and magnitude of variability contained for different traits in the breeding materials. Heritability in a broad sense measures the extent of heritable genetic variance to total phenotypic change, while heritability in a narrow sense represents the fixable additive genetic variance ratio to total phenotypic change. Estimates of heritability help in assessing anticipated advancement through selection **(Devi *et al*., 2017).** The estimates of genetic parameters were computed for five traits of 16 crosses and their eight parents in Table **5**. Additive and non-additive variances were significant for all the studied traits. However, non-additive effects played more important role as confirmed by value of degree of dominance (d). This parameter in all traits were estimated to be more than unity indicating that over-dominance is preponderant in controlling the studied traits. Several researchers also reported the predominance of dominant gene action for a majority of the yield traits **Satyanarayana *et al*., (2000); Kumar *et al*., (2004),** while **Vijay Kumar *et al.* (1994)** reported that, the predominance of additive gene and must be used in combination with other parameters action. Preponderance of non-additive gene action in the expression of yield and yield-related traits was also reported by **Pradhan *et al.* (2006), and**

Thirumeni *et al*. (2000). The heritability in broad sense (h_2b) was obtained for studied traits over (85%), indicating slight effects of environment on these traits. In all cases, a low narrow sense heritability (h_2n) was obtained. **Ahmadikhah (2008)** also reported a low specific heritability for yield-related traits and **Wu *et al.* (1986)** reported a low specific heritability for tillers number and grain yield. Therefore, it seems that hybridization must be a choice for utilizing the putative heterosis in special crosses. Heritability is a valuable quantitative parameter, which finds the role of heredity and the environment, determining the expression of a trait. In the present study, high estimates of heritability in a broad sense were observed for all traits.

Table (5): Estimates of genetic parameters and heritability in broad and narrow senses for vegetative traits studied during 2019 season.

Genetic parameters and heritability	Traits				
	Days to 50% heading (day)	**Plant height (cm)**	**Flag leaf area(cm)**	**No of Tillers plant^{-1}**	**leaf blast reaction (0-9)**
Additive variance (σ2A)	657.86	811.11	139.87	58.48	0.08
dominant variance (σ2D)	743.11	922.10	169.42	70.82	0.03
Genotypic variance (σ2G)	1400.97	1733.21	309.29	129.30	0.11
Environmental variance (σ2E)	1.31	1.35	1.71	0.80	0.22
Phenotypic variance (σ2P)	1402.28	1734.56	311.00	130.10	0.33
Broad sense heritability (h2b%)	99.91	99.92	99.45	99.38	32.43
Narrow sense heritability (h2n%)	46.91	46.76	44.98	44.95	23.08
Relative importance of gca%*	0.47	0.47	0.45	0.45	0.71
Relative importance of sca%**	0.53	0.53	0.55	0.55	0.29
Dominance of the degree (d)	1.06	1.07	1.10	1.10	0.64

* Relative importance of gca% = σ^2A/σ^2G

** Relative importance of sca% = σ^2D/σ^2G

Heterosis

Heterosis is the reason for the development of harvest yield and heterozygosity, which is because of superior gene content possible in a contributed hybrid by both the parents **(Mather, 1955)**. The heterotic responses of hybrids over mid-parent (average) and better parent (heterobeltiosis) for the five studied traits are presented in Tables **6** and **7**, respectively.

For days to 50% flowering, plant height and leaf blast reaction negative heterosis are desirable, but for the rest of the studied traits, positive heterosis is desirable. It was seen that a significant positive and negative heterosis in the studied traits. None of the hybrids in this investigation had demonstrated the most extreme heterosis for all the traits. In any case, a desirable level and a significant of heterosis over mid-parent and better parent were gotten in several crosses. The negative mid-parent heterosis and heterobeltiosis for the days of 50% flowering was found in hybrids Sakha 101 x IR12G3239, Giza178 x IR12G3239, Sakha 104 x

IR12G3239, Sakha 104 x IRBL 7-M and Sakha101 x Sakha Super300 respectively. Therefore, earlier maturing crosses proposed the possibility of growing early developing lines. Comparable discoveries were additionally revealed by **Rahimi *et al*., (2010)**. For plant height, most hybrid combinations were found to be positive and highly significant heterotic effects which in detected that there is not any negative heterotic for the same trait. Therefore, the dominance plays an important role in the inheritance of this trait. Similar findings were also suggested by **Borah *et al*., (2017)**. For the flag leaf area, the maximum significant and positive mid-parent heterosis and heterobeltiosis were exhibited in hybrids Giza178 x Sakha Super300 and Sakha 101 x IR12G3239 which crosses recorded negative GZ 9461-4-2-3-1 x IRBL 7-M and Sakha 101 x IRBL 7-M. These results confirmed with the earlier findings of **Perera *et al*.(2001) and Nuruzzaman *et al.(*2002).**

In addition, all hybrid combinations gave positive significant and highly significant heterotic effects. As well, the better parent was found to be highly significant and positive heterotic effects in the all hybrids for the same trait.

For No of Tillers plant^{-1}, the all hybrids had the positive and high significant mid-parent heterosis and heterobeltiosis effect the maximum values were hybrids Sakha104 x Sakha Super300 and Giza178 x Sakha Super300.

For leaf blast reaction (0-9), the most hybrids were negative heterosis are desirable mid-parent heterosis and heterobeltiosis effect.

Table (6): Heterosis relative to mid parent for vegetative traits studied during 2019 season.

Hybrid combination	Traits				
	Days to 50% heading (day)	**Plant height (cm)**	**Flag leaf area(cm)**	**No of Tillers plant^{-1}**	**leaf blast reaction (0-9)**
Sakha 101 x IRBL 7-M	3.93**	16.94**	-2.47	43.59**	-55.56
Sakha 101 x IR12N245	7.54**	11.38**	11.54**	57.58**	-66.67
Sakha 101 x IR12G3239	-7.74	8.21**	18.37**	57.63**	-55.56
Sakha101 x Sakha Super300	-1.37	14.10**	1.48	53.03**	-66.67
Sakha 104 x IRBL 7-M	-2.71	6.91**	5.95**	52.21**	-57.14
Sakha 104 x IR12N245	2.37*	6.97**	12.54**	51.58**	-57.14
Sakha 104 x IR12G3239	-4.18	13.57**	16.66**	47.37**	-57.14
Sakha104 x Sakha Super300	4.88**	5.72**	4.67**	65.63**	-57.14
GZ 9461-4-2-3-1 x IRBL 7-M	-1.08	3.85**	-5.17	33.82**	-33.33
GZ 9461-4-2-3-1 x IR12N245	5.42**	13.22**	6.24**	55.93**	-33.33
GZ 9461-4-2-3-1 x IR12G3239	1.12	7.02**	11.74**	27.01**	-50.00
GZ 9461-4-2-3-1 x Sakha Super300	8.18**	11.61**	13.94**	40.40**	-50.00
Giza 178 x IRBL 7-M	5.23**	0.78	10.75**	21.67**	0.00
Giza 178 x IR12N245	0.84	7.74**	14.57**	37.25**	0.00
Giza178 x IR12G3239	-5.03	20.95**	0.65	42.15**	0.00
Giza178 x Sakha Super300	-0.31	10.52**	20.46**	61.48**	0.00

* and ** Significant at 0.05 and 0.01 levels, respectively

Table (7): Heterosis relative to better parent for vegetative studied during 2019 season.

Hybrid combination	**Traits**				
	Days to 50% heading (day)	**Plant height (cm)**	**Flag leaf area(cm)**	**No of Tillers plant^{-1}**	**leaf blast reaction (0-9)**
Sakha 101 x IRBL 7-M	9.31**	30.55**	-6.36	33.33**	33.33**
Sakha 101 x IR12N245	13.10**	17.45**	-0.58	44.44**	0.00
Sakha 101 x IR12G3239	-0.37	10.18**	16.91**	45.34**	33.33**
Sakha101 x Sakha Super300	0.93	26.55**	-8.86	29.49**	0.00
Sakha 104 x IRBL 7-M	-1.04	11.54**	3.23**	36.51**	0.00
Sakha 104 x IR12N245	4.13**	8.20**	1.69	43.97**	0.00
Sakha 104 x IR12G3239	0.37	18.95**	13.52**	31.27**	0.00
Sakha104 x Sakha Super300	11.00**	9.62**	-7.25	35.90**	0.00
GZ 9461-4-2-3-1 x IRBL 7-M	3.79**	13.68**	-15.55	24.67**	33.33**
GZ 9461-4-2-3-1 x IR12N245	10.61**	17.19**	-11.57	26.04**	33.33**
GZ 9461-4-2-3-1 x IR12G3239	3.03**	7.02**	4.50**	19.19**	0.00
GZ9461-4-2-3-1 x Sakha Super300	22.73**	21.40**	10.40**	35.90**	0.00
Giza 178 x IRBL 7-M	7.59**	6.95**	10.09**	15.87**	0.00
Giza 178 x IR12N245	3.10**	8.28**	5.45**	22.81**	0.00
Giza178 x IR12G3239	0.01	24.56**	-3.96	34.40**	0.00
Giza178 x Sakha Super300	4.95**	16.56**	4.89**	39.74**	0.00

* and ** Significant at 0.05 and 0.01 levels, respectively

Phenotypic correlation coefficient:

Complete information of the interrelationship of plant traits with different characters is of fundamental significance to the plant breeder for improving in complex quantitative traits. Hence, investigation was attempted to decide the direction of selection and number of traits to be considered in developing grain yield. (**Ghidan *et al.*, 2019)** stated that correlations are measures of the intensity of association between traits. The selection for one trait results in progress for all characters that are positively correlated and retrogress for traits that are negatively correlated **Steel and Torrie (1984)**. The phenotypic correlation coefficient among the five studied traits was assessed and presented in Table **8**.

Plant height was highly significantly and positively correlated with No of tillers plant^{-1} and leaf blast reaction indicating the importance of these traits as selection criteria in yield enhancement programs. **Hallauer and Miranda, (1988)** in a similar study reported that plant vigour is positively correlated to yield suggesting that during selection emphasis should be placed on plant with vigor as this would be translated with good yield. At last, no of tillers plant^{-1} exhibited a significant and positive phenotypic correlation with the, leaf blast reaction.

Table (8): Phenotypic correlation coefficients among vegetative, yield and its component traits of some rice genotype during 2019 season.

Trait	DTH	PHT	FLA	TIP	LBR
DTH	1.00	0.338	0.182	0.184	-0.102
PHt		1.00	0.174	0.613**	-0.553**
FLA			1.00	0.714	-0.058
TiP				1.00	-0.411*
LBR.					1.00

* Significant at 0.05 level, ** Significant at 0.01 level

Abbreviation Days to 50 %heading= DTH: Plant height= PHT: Flag leaf area(cm)= FLA; No of Tillers / plant= TIP: leaf blast reaction (0-9)=LBR

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