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GENETIC DIVERSITY ANALYSIS AND CHARACTER ASSOCIATION IN SOME CHINESE HYBRID RICE UNDER DRY CONDITIONS

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ABSTRACT:- Water shortage, being a serious threat to agriculture in Pakistan can be possibly overcome through development of high yielding drought tolerant varieties. A field study was therefore, conducted to evaluate the performance of 10 hybrid rice along with two high yielding varieties under drought conditions at Arid Zone Research Institute (AZRI), Bahawalpur. The experiment was designed in RCBD with three replications. The crop was maintained under moisture stress conditions. The data on various plant traits including, days to panicle initiation, panicle length, spikelet fertility, days to maturity, plant height, number of grains per panicle, number of productive tillers, 1000 grain weight and paddy yield were recorded. The results of analysis indicated a high range of genetic variation among various hybrids for plant height, number of grains per panicle, number of productive tillers per plant, 1000 grain weight and paddy yield. The variation for days to 50% panicle initiation, panicle length, spikelet fertility and days to maturity were however non-significant. Plant height ranged from 77 to 116 cm, number of grains per panicle from 152 to 449, number of productive tillers per plant from 15 to 29, 1000-grain weight from 23 to 40 (g) and paddy yield from 2.38 to 10 t ha^{-1} in different hybrids. The highest yield (10 t ha^{-1}) was produced by hybrid GSR-H-0140.

Key Words: Chinese Rice Hybrid; Genetic Diversity; Drought Tolerance; Yield Components; Character Association; Pakistan.

INTRODUCTION

Pakistan is not only self sufficient in rice but it also exports surplus to other countries and earns a significant foreign exchange. The average paddy yield in Pakistan is however lower than that of countries like China, USA and Vietnam. Although, present rice production of country is more than the local consumption, yet we still need to improve its yield to pace with advanced countries. China is leading country for rice production due to use of her indigenous hybrid. In Pakistan rice is cultivated on 161 mha, with total production of 6.68 mt (MINFA, 2010). The climatic conditions and existing cropping patterns in Pakistan offers taking single rice crop per year as compared to some other tropical countries where more than one rice crop can be successfully grown.

In Pakistan, there is no scope for expansion in rice area due to multi-cropping system; hence vertical improvement in production is the only option for production enhanc-

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ement in country. Varietal development no doubt, plays major role in crop productivity, but the use of hybrid seed is most important approach for accelerated increase in yield. In Pakistan, rice breeding is focused on development of high yielding varieties suitable under flooded irrigation. But due to ever forecasting water deficit in country, the scientists are required to explore drought tolerant varieties producing high yields. Water use efficiency (WUE) may or may not be related to drought resistance and used as a breeding target in water-saving agriculture (Condon et al., 2004). Xiao et al. (1996) evaluated 45 F_1 rice hybrids for eight traits of agronomic importance and observed a strong heterosis in hybrids for yield and yield related traits. Counce et al. (1996) studied grain yield in various genotypes of rice (*Oryza sativa* L.) and reported higher degree of variation in tiller, grains per panicle, days to maturity and seed weight under drought conditions. Pantuwan et al. (2002) studied the performance of 128 rice genotypes under irrigation and four drought stress treatments and reported that genotypic consistency in drought stress may be different when characteristics of the drought stress environments differ. They also noted that under prolonged and severe drought conditions the flowering time was an important determinant of grain yield. They further reported high range of genotypic variability in various traits like days to maturity, number of tillers per plant, panicle length, grains per panicle and paddy yield. Early flowering genotypes escaped the severe stress and had higher grain yield. Zheng-jin et al. (2006) categorized various rice genotypes in to three varietal groups; high-yielding (HYV), medium-yielding (MYV) and the low-yielding (LYV) and observed that panicle population was in the order of HYV<MYV<LYV, while the grain number per panicle and seed-setting rate were just opposite. Various drought-adaptive mechanisms of the genotypes correlate with drought resistance in terms of yield as measured by the drought resistance index (DRI) (Makara et al., 2006). Akram et al. (2007) evaluated 15 rice hybrids at three different locations in comparison with cultivar KS-282. Two hybrids viz., MK Hybrid 111 and 27P72 produced more productive tillers and grain yield than KS 282. Sabouri et al. (2008) calculated selection indices based on two methods (optimum or base index) using 12 traits and reported that grain weight, number of panicles per plant, panicle length and plant height by using their phenotypic and/or genotypic direct effects as economic traits should serve as an effective selection criterion for using either the optimum or base index under rainfed conditions.

In three line hybrid rice system, IR82363H and R82372H have exhibited up to 23% and 20% standard heterosis over the inbred check, respectively (Manickavelu et al., 2006). Lafarge and Bueno (2009) reported higher yield potential of rice hybrids over the inbred varieties. Zhang et al. (2009) conducted studies to compare grain yield and yield attributes among “super” hybrid, ordinary hybrid and inbred varieties. They observed a significant difference in grain yield among the varieties and varietal groups.

"Super" hybrid varieties have increased rice yield by 12% compared with ordinary inbred varieties. Cultivation of rice under aerobic conditions resulted in 27.5% yield reduction over irrigated rice. Among the yield components assessed, the spikelets per panicle contributed more to the yield and considered the most important factor responsible for yield gap between aerobic and flooded rice (Patil et al., 2010). Studies of Yaqoob et al. (2012) revealed that rice genotypes behaved differently under rainfed conditions. They further observed that genotypes with medium plant height and maturity showed highest number of tillers and ultimately produced maximum paddy yield at low moisture level. In present study rice hybrids along with 2 varieties were evaluated under rainfed conditions to estimate their performance against well adopted high yielding varieties.

MATERIALS AND METHOD

The experiment was conducted at Arid Zone Research Institute (AZRI) Bahawalpur. A set of 10 imported rice hybrids from China namely GSR-H-0140, GSR-H-0143, GSR-H-0149, GSR-H-0141, GSR-H-0146, GSR-H-0144, GSR-H-0148, GSR-H-0142, GSR-H-0147 and GSR-H-0145 along with two well adapted high yielding local varieties IR-6 and KS-282 were sown on June 7, 2010 in Randomized Complete Block Design (RCBD) with three replications. The crop was sown by dibbling three seeds per hill on a well prepared seed bed in field. The soil type was clay loam. Plant to plant and row to row spacing was kept at 20 cm. Each plot comprised five 2m long rows. The plants were thinned later to have one plant per hill. All the recommended agronomic practices were used uniformly during entire crop growth period. The experiment was kept at Alternate Wetting and Drying (AWT) after maintaining flooded conditions for one month to establish the seedling. AWT system started after the disappearance of ponded water. The soil surface was kept wet either through irrigation and/or rainfall. All the plant protection measures were properly adopted. Observations were recorded on 50% panicle initiation (days), panicle length, spikelet fertility, days to maturity, plant height, number of grains per panicle, number of productive tillers per plant, 1000-grain weight and grain yield.

Statistical Analysis

The data were analyzed through computer's software MSTAT-C for analysis of variance. The means of significant traits were further compared through LSD at 0.05% probability level (Steel and Torrie, 1997). The traits showing significant variation in various hybrids are discussed herein.

RESULTS AND DISCUSSION

The results of analysis of variance revealed that performance of various rice hybrids was quite divergent and there was significant variation for plant height, number of grains per panicle, number of productive tillers per plant, 1000 grain weight and paddy yield (Table 1). The statistical differences for 50% panicle initiation (days), panicle length, spikelet fertility and days to

Table 1. Mean squares and level of significance of various plant traits of Chinese hybrid rice under drought conditions

Source of variation	D.F.	50% panicle initiation (days)	Panicle length (cm)	Spikelet fertility (%)	Days to maturity	Plant height (cm)	No. of grains per panicle	No. of productive tillers per plant	1000-grain weight (g)	Paddy yield (tha^{-1})
Replications	2	41.52	14.8	180.36	13.96	18.44	24.89	10.25	9.87	0.96
Genotypes	11	98.26 ^{NS}	18.64 ^{NS}	246.69 ^{NS}	345.58 ^{NS}	331.47**	671.25**	101.36**	86.45**	16.49**
Error	22	34.29	3.25	83.12	119.27	109.11	286.33	35.18	29.44	6.14
Total	35	174.07	36.69	510.17	478.81	459.02	982.47	146.79	125.76	23.59

*** = Highly significant and NS = Non-significant.*

maturity was however non-significant.

Panicle Length

Panicle length was highly significant in different hybrids/ varieties under drought stress conditions. It ranged from 18 cm to 27 cm. The maximum panicle length (27 cm) was measured from the hybrids GSR-H-0144, GSR-H-0148 and cultivar (IR-6). These were however, statistically similar to the hybrids GSR-H-0149, local check KS-282, GSR-H-0142, GSR-H-0140 and GSR-H-0141 (Table 2). The hybrid GSR-H-0145 produced the shorter panicle (18 cm) and remained at the bottom. It was statistically at par with some hybrids with medium panicle length including GSR-H-0149, GSR-H-01414, GSR-H-0146 and GSR-H-01417. The variability in panicle length in different rice genotypes under rainfed conditions has also been reported by Pantuwan et al. (2002), Sabouri et al. (2008) and Zheng-jin and Liu et al. (2009).

Plant Height

In various rice hybrids and local varieties plant height was highly significantly different. Short,

Table 2. Mean performance of various Chinese hybrid rice under drought conditions at AZRI, Bahawalpur in 2010

Designation*	50% panicle initiation (days)	Panicle length (cm)	Spikelet fertility (%)	Days to maturity	Plant height (cm)	No. of grains per panicle	No. of productive tillers per plant	1000-grain weight (g)	Paddy yield (tha^{-1})
GSR-H-0140	64	24ab	98	129	86def	306b	27a	28cd	10a
IR-6 (Check)	62	27a	97	127	103bc	260cd	15def	34b	9.1ab
GSR-H-0143	63	25a	96	129	104bc	241de	17ed	26de	8.13bc
GSR-H-0149	63	26a	97	128	106b	223efg	29a	34b	7.05c
GSR-H-0141	65	24ab	96	129	115a	247de	26ab	29c	6.68cd
GSR-H-0146	62	22b	96	128	105b	160h	19cd	27cd	6.58cde
GSR-H-0144	64	27a	97	128	107b	285c	18cd	35b	6.55cde
GSR-H-0148	63	27a	95	129	100cd	276c	17cd	31c	5.86def
GSR-H-0142	64	23b	93	128	92cde	234def	24b	27cd	5.35def
GSR-H-0147	63	23b	95	128	116a	245de	21bc	37b	5.05ef
KS-282 (Check)	64	26a	97	128	104bc	449a	24b	40a	4.69fg
GSR-H-0145	63	18b	91	129	77fg	152h	16de	23g	2.38h

**The genotypes have been arranged according to their merit in paddy yield.*
Means followed by same letter (s) do not differ significantly at 0.5% level of probability.

medium and tall plants ranging from 77 cm to 116 cm, were noted in the genotypes. The tallest plants were recorded in hybrid GSR-H-0147 (116 cm) followed by hybrid GSR-H-0141 with the height of 115 cm, both statistically at par with each other. The plant height of 107, 106 and 105 cm was measured from hybrids GSR-H-0144, GSR-H-0149, GSR-H-0146 and they were statistically at par with each other and also with GSR-H-0143 and both the local checks (Table 2). The hybrid GSR-H-0145 produced shortest plants with height of 77 cm. It was generally observed that tall plants produced lengthy panicles while dwarf plants produced shorter panicles. Sabouri et al. (2008) recommended plant height as important traits during selection of high yielding rice plants. Similar results have also been reported by Julfiquar et al. (1985), Counce et al. (1996), Pantuwan et al. (2002) and Akram et al. (2007) who reported significant variation in plant height from their studies on rice genotypes. This showed that plant height is positively correlated with length of panicle in rice.

Number of Grains per Panicle

This important yield parameter is directly correlated with grain yield. The variation in number of grains per panicle was highly significant among various rice hybrids. Present studies revealed that number of grains per panicle ranged from 152 to 449 per plant. The highest grains per panicle were produced by local cultivar KS-282 (449) which was followed by hybrids GSR-H-0140, GSR-H-0144 and GSR-H-0148 with 306, 285 and 276 grains per panicle, respectively (Table 2). IR-6 produced 260 grains per panicle and remained statistically similar to hybrids GSR-H-0144, GSR-H-0148, GSR-H-0141, GSR-H-0147, GSR-H-0143, GSR-H-0142 and GSR-H-0148 with 285, 276, 247, 245, 241, 234 and 223 grains per panicle respectively. The hybrids GSR-H-0146 (160) and GSR-H-0145 (152) showed minimum number of grains per panicle. The results of Counce et al. (1996), Xiao et al. (1996), Kuroda (1988), Zhengjin et al. (2006) and Sabouri et al. (2008) suggest considering panicle length and planting height by using their phenotypic and/or genotypic direct effects as economic trait for better varietal development.

Number of Productive Tillers per Plant

Tillers in rice are considered as one of the major yield components. The plants with highest number of tillers usually produced the highest number of panicles and ultimately produce more grain yield. The number of productive tillers is significantly and positively correlated with paddy yield (Mohankumar et al., 2011). In present study variability in number of productive tillers per plant was highly significant due to various rice hybrids/varieties (Table 1). The tiller counts ranged from 15 to 29. The hybrids GSR-H-0149 and GSR-H-0140 had respectively pro-duced 29 and 27 tillers and remained significantly superiors than the other hybrids/varieties. Cultivar IR-6 showed poor performance with only 15 tillers per plant (Table 2). These results got sufficient corroboration from investigations reported

by Julfiquar et al. (1985), Counce et al. (1996), Akram et al. (2007) and Sabouri et al. (2008).

1000-grain Weight

The weight of grain plays an important role in enhancing the final yield of any crop commodity. The 1000-grain weight in present investigations was highly significantly different in various hybrids and varieties (Table 1). It ranged from 23g to 40g. The check variety KSK-282 produced the heaviest grains with 40/1000 and was statistically superior to all hybrids included in study. The hybrids like GSR-H0147, GSR-H0174, GSR-H0149 and local check IR6 had also produced the heavy grains with 37g, 35g, 34g and 34g per 1000-grain respectively (Table 2). All these hybrids were statistically similar to each other and significantly different from rest of the hybrids. The hybrids GSR-H0148, GSR-H0141, GSR-H0140, GSR-H0146 and GSR-H0142 had also shown parity with each other in 1000-grain weight. The hybrid GSR-H0145 produced smallest grain with 1000-grain weight of only 23g (Table 2). Sabouri et al. (2008) also reported that selection for grain weight, number of panicles per plant and panicle length, plant height by using their phenotypic and/or genotypic direct effects as economic traits should serve as an effective selection criterion. Significant differences in 1000-grain weight in rice genotypes have also been reported by earlier workers including Julfiquar et al. (1985), Miyagawa and Kuroda (1988), Xiao et al. (1996), Zheng-jin et al. (2006), Makara et al. 2006), Akram et al. (2007) and Zhang et al. (2009)

Paddy Yield

Being a quantitative trait, it is highly influenced by various biotic and abiotic elements. Yield is a dependent variable and is therefore interplay of various yield components. It depends upon genotypes, environment and their interaction. The paddy yield ranged from 2.38 to 10 tha^{-1}. The highest yield was produced by hybrid GSR-H-0140 followed by cultivar IR-6 and hybrid GSR-H-0143 which produced 9.1 and 8.13 tha^{-1} (Table 2). The yield hybrid GSR-H-0140 was however, statistically at par with that IR-6 (Table 2). The poorest performance was given by local check KSK-282 and hybrid GSR-H-0145 with yield of only 4.69 and 2.38 tha^{-1}, respectively. The hybrid GSR-H-0140 has also produced higher number of productive tillers, maximum grains per panicle, medium grain size and ultimately produced higher yield. Hybrid GSR-H-0145 has also produced shorter panicle, lower number of grains per panicle and poor grain weight (Table 2). Julfiquar et al. (1985), Miyagawa and Kuroda (1988), Counce et al. (1996), Xiao et al. (1996), Pantuwan et al. (2002) Zheng-jin et al. (2006), Jongdee et al. (2006), Akram et al. (2007), Sabouri et al. (2008), Lafarge and Bueno (2009) and Zhang et al. (2009) have reported significant variation in grain yield in different rice genotypes under irrigated and rainfed conditions. Early maturing cultivars are suitable for the drought prone environments with low soil fertility particularly if the adverse effect of very low soil fertility is reduced (Wonprasaid et al., 1996). The studies of Counce et al. (1996) on various genotypes of rice (*Oryza*

sativa L.) revealed higher degree of variation in tiller, grains per panicle, days to maturity, seed weight and grain yield under drought conditions. The genotypic consistency in drought stress may be different when characteristics of the drought stress environments differ. Pantuwan et al. (2002) and Lafarge and Bueno (2009) have also reported yield superiority of hybrid rice over inbred/varieties. The genotypes with medium plant height, maturity period and productive tillers produce higher paddy yield in rice under drought stress (Yaqoob et al., 2012). It was further suggested that selection based on plant traits is more effective in increasing crop yield potential. Main target traits for selection should be plant height, leaf and panicle morphology, grain size, total dry weight, and grain-filling percentage for higher yield production (Yuan et al., 2011).

It is therefore concluded that rice hybrids studied under drought conditions had shown significant variability in most of the yield components. The GSR-H-0140 produced the highest paddy yield and remained superior among all the hybrids and cultivars. This hybrid had also produced significantly more number of grains per panicle, number of productive tillers per plant and also heavier grains as compared to many other hybrids/ varieties. The highest yield obtained in this study was 10 tha^{-1} by hybrid GSR-H0140. This showed that rice crop can produce high yield under low water level with a suitable genotypes. The hybrid GSR-H0140 is suggested to be further tested across different locations for wider adaptability and general cultivation.

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