AJA VOL (3) ISSUE 4, 2016: 82-85

Azarian Journal of Agriculture

www.azarianjournals.ir

Azarian Journals

Research article

ISSN:2383-4420

Inheritance of growth habit, awnnedness and spikelet shattering in interspecific cross of rice (*Oryza sativa* L. × *O. rufipogon* Griff)

Deepak Pandey[1], Laxmi Prasad Subedi[2], Ram Chandra Sharma[2]

Article Info

Accepted:
19 Aug. 2016

Keywords:
Awnnedness, Culm Angle, Inheritance, Growth Habit

ABSTRACT

An inheritance study in the inter-specific cross of *O. sativa* × *O. rufipogon* was conducted in the greenhouse of the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, including the parents, F1 and subsequent F2 segregants. In the parent as *O. sativa* a local landrace Pokhreli pahele was used. A dominant gene action was observed for the procumbent growth habit, awnedness, and higher spikelet shattering. Awnedness was found to be governed by three genes with the duplicate gene action (63:1.). Digenic complementary gene action was observed for culm angle (9 procumbent: 7 erect) and digenic polymeric gene action for spikelet shattering (9 highly shattering: 6 intermediate shattering: 1 low shattering).

INTRODUCTION

To meet the increasing demand of food supply we have to significantly enhance rice productivity, for which fuller exploitation and utilization of the genetic resource in the wild rice gene pool will provide many more opportunities (Lu and Song 2002). *O. rufipogon*, a deep water rice, has been used for high pollen production, bacterial blight, CMS source and perenniality (Sacks et al. 2003), resistance to blast, brown plant hopper, gall midge and white neck (Li 1994). The usual rice breeding procedures consist of selecting desirable progeny in segregating generations of crosses between different genotypes.

The application of Mendalian genetics has clearly led to many breeding advances in rice as well in other crops (Rutger and Mackill 2001). The segregation pattern for the different trait varies with each other. Selection based upon the knowledge of gene action is a prerequisite in the breeding program. The inheritance study of the traits is beneficial in case of the interspecific crosses. In distant crosses, F_2 segregation ratios are often distorted (Oka 1989). An integration of conventional and molecular linkage map is urgently needed (Maekawa et al. 1991). The transfer of the monogenic trait is easier to transfer than the polygenic trait. The expression of the traits in the F_2 may help plan the breeding procedure.

For culm angle, erectness was recessive to spreading/semi-spreading and was due to five interacting genes where segregation ratio of 54 erect: 970 semi-spreading/spreading culms (Nadaf et al. 1993). According to Misro et al. (2000) the awning is associated with the hardiness, general vigour, drought resistance etc. Some sort of compromise or physiological balance has been attained between awnedness and awnlessness. In many instances it has been shown that awnlessness is recessive to all degrees of awning. Monogenic (3:1) (Ramiah 1993), digenic (9:7, 15:1, 9:6:1, 12: 3:1) (Mitra and Ganguli 1992; Ramiah 1995) and trigenic (63:1) (Sethi 1997) ratios of awned (all degrees) to awnless have been reported. The observations for the F_1s were mostly consistence with the dominant inheritance that is typically observed for awning and shattering (Sacks et al. 2003).

In nature it has been observed that a continuous variation for awning exists, so a system of polygenes besides one or more pairs of major genes, govern awning (Misro et al. 2000). Awning and shattering are the undesirable traits that were generally greater in F_1 progenies of the interspecific cross of *O. sativa* and *O. rufipogon* than cultivars.

[1] National Wheat Research Program, Bhairahawa, Nepal
[2] Institute of Agriculture and Animal Science, Rampur, Chitwan, Nepal
*Email: dpandey5@yahoo.com

Awning is present but the causal relationship between perennial growth and awning or shattering is doubtful (Sacks et al. 2003).

In the inheritance study, shattering has been reported to be dominant to the non-shattering by Ramiah (1990) and Bhalerao (1990). Bhalerao has considered more than one gene involved in the inheritance of shattering. Kadam (1997) showed that duplicate genes govern that character. Grain shattering has also been found to be recessive by Kikuchi (2006) and suggested the existence of linkage relationship in the semi-dwarfism gene and a recessive shattering gene.

MATERIALS AND METHODS

The F1 plants from the cross between O. sativa cv. Pokhreli Pahele (a Nepalese landrace) and O. rufipogon (common wild rice), and the subsequent F2 generation in were grown in the glass house of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal, as the main season crop. The choice of the parents was based on the contrasting characteristics in the preliminary study at the previous year (Table 1). There were 270 plants in the study with 224 F2 plants, 16 O. rufipogon, 16 O. sativa (Pokhrei Pahele), and14 F1 Plants.

All the plants of both the parents, F1 and F2 were characterized using the descriptor for rice (IRRI-IBPGR 1980). Characterization of the culm angle, panicle shattering and awn presence was done.

Segregation of the F_2 materials for the Characterized traits was tested for goodness of fit using chi-square (χ^2) test. The observation was classified into different groups. The expected ratio was calculated by using the following formula for more than 1 degree of freedom.

$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

In case of single degree of freedom, the chi-square test was done by using the Yate's corrected formula (Steel and Torrie, 1980).

$$\chi^2 = \sum \frac{\left\{|(O-E)|-\frac{1}{2}\right\}^2}{E}$$

Where,

O= Observed frequency,

E = Expected frequency

The Microsoft Excel 2000 program was used for data entry and analysis. Descriptive statistics, frequency distribution and correlation analysis were performed for the performance, variation and association study as well.

Table 1. The different contrasting characters in the *O. sativa* (Pokhreli Pahele) and *O. rufipogon* under the preliminary investigation

Characters	Pokhreli Pahele	*O. rufipogon*
Culm angle	Erect	Procumbent
Panicle shattering	Low (1-5%)	High (>50%)
Awn presence	Absent	Present

RESULTS AND DISCUSSION

Culm Angle

The *O. rufipogon* was procumbent in growth habit and *O. sativa* was erect. The F_1 showed spreading and nearly procumbent culm angle. In the F_2 there was variation in the culm angle with narrow to wide angle but the frequency of the intermediates was low. Therefore, the procumbent type showed a partial dominance. In the F_2 there was a segregation pattern of 9: 7 ratio of the spreading to the erect. When the ratio was tested with a Chi-square a non-significant result was obtained (Table 2). Such type of ratio was observed when the intermediates were involved in the spreading types.

Segregation distortion of the genes causing the procumbent habit was observed by Xu et al. (1998) in the F_2 where the intermediates were in low frequency. This showed that two complementary genes were involved in the inheritance of the culm angle. The recessive nature of erect type has also been reported by Ramiah (1990), and Nadaf et al. (1992). The lazy type or the procumbent are not the desirable character. The erect type with low number of tillers is said to be preferred in U.S. due to the drill seeding method of rice cultivation. At IRRI, such type is not preferred because of the low penetration of light, and higher numbers of tillers are expected. Therefore, selection of the growth habit is an important character.

Presence of Awn

There was no awn in the Pokhreli Pahele but *O. rufipogon* had awns (Table 3). In the F_1 awns were present. So, the awned character was transferred from wild rice in F_1. There was a wide variation in nature of awn presence in the F_2

Table 2. Breeding behavior of Culm angle in segregating and non-segregating generations

Parameter	Erect	Procumbent
Pokhreli Pahele	All	________
O. rufipogon	________	All
F_1	________	All
F_2 (Observed)	93	131
F_2 (Expected)	98	126
9 procumbent: 7 erect		
χ^2 (d. f. = 1)	0.47	
Probability	0.3-0.5	

Table 3. Breeding behaviour of awn presence in segregating and non-segregating generations

Parameter	Awned	Awnless
Pokhreli Pahele	________	All
O. rufipogon	All	________
F_1	All	________
F_2 (Observed)	219	5
F_2 (Expected) 63 awned: 1 awnless	220.5	3.5
Chi-square (d. f. = 1)	0.30	
Probability	0.5-0.7	

generation (Table 3).

Sacks et al. (2003) also observed that awnedness in the F1 in the interspecific cross of *O. sativa* with the *O. rufipogon*rice. This shows the dominance of awned trait in interspecific cross of rice. The presence of awn was dominant over the awnlessness. Misro et al. (2000) has also reported that that awnlessness is recessive to all degrees of awning.

Genetical studies of awning conducted by different workers have shown that one to three major genes are involved in the expression of awning (Ramiah 1993; Mitra and Ganguli 1992; Sethi 1997; Rao et al. 1997). In the F_2 the segregation of the awned to awnless tested with Chi-square test in the ratio of 63:1 showed a non-significant result. Therefore, a trigenic inheritance of awned trait in the interspecific cross of rice is concluded. Any of the three genes if present in the dominant condition caused the presence of awn. So, the duplicate dominant gene action controlled the presence of awn. Three genes in the recessive condition caused awnless character otherwise awning of varying degrees was observed. A similar result was also reported by Sethi (1997). Rao et al. (1997) has suggested that a system of polygenes besides three major genes governed awning. The awnless parent had three major genes in recessive conditions and the contribution of the polygenes is little for the expression of the awns. The *O. rufipogon* has $\mathbf{An_1An_1An_2An_2An_3An_3}$and Pokhreli Pahele has $\mathbf{an_1an_1an_2an_2an_3an_3}$. It is suggested that the awning in rice is governed by the action of three major genes and a system of the poly genes governing the expression of the awn length.

Spikelet Shattering

The Pokhreli Pahele showed a low shattering but the *O. rufipogon* had high shattering (Table 4). A high grain shedding was observed in the *O. rufipogon* before full maturity. In the Pokhreli Pahele when the observation was taken by putting the panicle inside the palm and pulling gently no shattering of the seed was observed. The F_1 showed the highly shattering nature of the spikelet as in *O. rufipogon*. Spikelet shattering was found to be dominant over non-shattering.

In the F_2 generation spikelet shattering was found to be ranged from non-shattering to highly shattering. The spikelet shattering in F_2 segregated in 9:6:1 ratio for highly shattering: intermediate shattering: low shattering and a non-significant Chi-square value were observed (Table 4). Panicle shattering was found to be governed by two genes and digenic segregation polymeric gene action can be concluded. The rufipogon has the $\mathbf{Sh_1Sh_1Sh_2Sh_2}$ and Pokhreli Pahele has $\mathbf{sh_1sh_1sh_2sh_2}$. The combination of at least two genes in recessive condition causes the low shattering habit of the plant. The $\mathbf{Sh_1}$ and $\mathbf{Sh_2}$ gene when present in the homozygous or heterozygous dominant condition i.e. $\mathbf{Sh_1\text{-}Sh_2\text{-}}$ that contributes for high shattering character. When any one gene pair among the two pair is in recessive condition i.e. $\mathbf{Sh_1\text{-}sh_2sh_2}$ and $\mathbf{sh_1sh_1Sh_2\text{-}}$ that become intermediate shattering types are observed.

CONCLUSION

Dominance type of gene action was observed for the larger culm angle, awnedness, and higher spikelet shattering. Awned trait was found in the F_1, and variation in the awn length was found in the F_2. Awnedness was found to be governed by three genes with the duplicate gene action (63:1), awn length was contributed by polygenes. The Pokhreli Pahele was erect in the growth habit but the *O. rufipogon* was procumbent. Digenic complementary gene action was observed for culm angle (9 procumbent: 7 erect) and digenic polymeric gene action for spikelet shattering (9 highly shattering: 6 intermediate shattering: 1 low shattering). Dominance of the larger culm angle and higher spikelet shattering was observed for shorter culm angle and lower spikelet shattering, respectively.

REFERENCES

BhaleraoS.G. (1990) The grain shedding character and its importance. Agricultural Research Station, Pusa, Bulletin No., 205.

IBPGR-IRRI Rice Advisory Committee and International Board for Plant Genetic Resources (1980) Descriptors for rice (*Oryza sativa* L.) International Rice Research Institute. Manila, Philippine.

Kadam B.S. (1997) Genetic analysis in rice. I. Grain Shedding. Proceeding of Indian Academy of Science. Section B, 34: 224-229.

Kikuchi F. (2006) Semidwarfing genes of high yielding rice varieties in Japan. Rice Genetics. Proceeding of the International Rice Genetics Symposium, 27-31 May 2005. IRRI Manila, Philippines. Island Publishing House, Inc. Sta. Mesa P. O. Box 406, Manila Philippines. pp 285-295.

Li R. B.(1994) Resistance of Guangxi wild rice to diseases and insect pests. International Rice Research Notes, 19 (2):8-9.

Lu B.R. Song Z.P. (2002) Conserving in-situ biodiversity of wild rice in China. In: International Conference on Wild Rice, Kathmandu, Nepal, October 21-27, 2002. Green Energy Mission/Nepal, pp. 8-9. (abstr.).

Misro B. Seetharaman R. Richharia R.H. (2000) Studies on world genetic stock of rice: I. Patterns of anthocyanin pigment distribution. Indian Journal of Genetics and Plant Breeding, 20:113-116.

Mitra S.K. Ganguli P.M. (1992) Some observations on the characters of wild rice hybrids. Indian Journal of Agricultural Science, 32: 271-279.

Nadaf S.K. Goud J.V. Parameshwara S. (1992) Genetic studies in rice (*O. sativa* L.) XVI: Inheritance of four spikelet type and spreading panicle branch. Indian Journal of Genetics and Plant Breeding, 52:411-415.

Ramiah K. (1993) Inheritance of height of plants in rice. Indian Journal of Agricultural science, 3:411-32.

Ramiah K. (1990) Madras Agricultural Station Report. Paddy Breeding Station. Year, 1989-1990.

Ramiah K. (1995) Rice Genetics. Proc. Assoc. Econ. Biol., Coimbatore, 23: 51-61.

Sacks E.J.Roxas J.P. Cruz M.T. (2003) Developing perennial upland rice I: field performance of *O. sativa/O. rufipogon* F_1, F_4 and $BC1F_4$ Progeny. Crop Science, 43:120-128.

Sethi B.L. (1997) Annual report of rice. Rice Research Station, Nagina 1996-1997.

Steel R.G.D. Torrie S.(1980) Principles and Procedures of Statistics. A Biometrical Approach. 2nd edition. McGraw-Hill Book Company, New York.

Journal sponsorship

Azarian Journal of Agriculture is grateful to the ***University of Maragheh*** and its faculty members for their ongoing encouragement, support and assistance.