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Stability of TGMS Lines under Different Temperature Regimes for Pollen Sterility

S. Manonmani*, R. Pushpam and S. Robin

Hybrid Rice Evaluation Centre, Gudalur
Agricultural College and Research Institute, Killikulam
Centre of Excellence in Molecular Breeding,
Department of Rice, Tamil Nadu Agricultural University, Coimbatore 641 003
*Corresponding author: swamimano@yahoo.co.in

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Abstract

The new TGMS lines developed at TNAU *viz*., TNAU 45S, TNAU 60S, TNAU 95 S, TNAU 19S and TNAU 39S were evaluated for their stability of pollen sterility under different temperature regimes. A multi location experiments were conducted at Coimbatore, Sathiyamangalam and Hybrid Rice Evaluation Centre, Gudalur during the *rabi and kharif* seasons in 2013 & 2014. During the flowering stage all these lines showed 100% pollen sterility at both the locations and was test verified for next year also. The sterile stubbles of these lines were planted at HREC, Gudalur during May to induce fertility for their seed multiplication and were exposed at critical stages to fertility inducing temperature. At the time of flowering pollen fertility was observed and found that there was reversion in pollen fertility (more than 90%). The above TGMS lines with wider pollen sterility period under plains can be very well exploited for developing two line rice hybrids during the period of December to April. The same lines can be easily seed multiplied at Gudalur during April to November.

Keywords: Stability, TGMS, pollen sterility, rice

Introduction

Globally, rice is now being cultivated in 160 Mha with an annual production of around 650 million tonnes of rough rice and average productivity of 4.18 tons/ha. More than 90% of the rice is produced and consumed in Asian countries. In India, rice is cultivated in an area of 44.0 million hectare with a production of 103.41 million tons of paddy and an average productivity of 2.35 t/ha milled rice or 3.52 t/ha rough rice (India stat, 2012). The current Indian population of 1.22 billion is expected to reach 1.3 billion by 2020 and 1.53 billion by 2030 AD. So, to support such a huge population, rice production has to be increased by at least 70 per cent over next three decades to meet growing demand (Balkunde *et al*., 2013). A 70% increase in food production is required over the next four decades to feed an ever-increasing population. With the dwindling or stagnant agricultural land and water resources, the sought-after increases will therefore be attained mainly through the enhancement of crop productivity under eco-efficient crop production systems. Hybrid rice technology is one of the best options to increase the productivity. A new vista in hybrid rice breeding has been opened by successful development of two line hybrids using

Thermo Sensitive Genetic Male Sterile (TGMS) lines which further enhances the scope of exploiting the additional heterotic potential by 20–30 per cent. The main advantages of two-line heterosis breeding include the ability to use a wide range of genotypes as male parents, absence of negative effects associated with sterility-inducing cytoplasm and no need for maintainer lines. Male sterility in temperature sensitive genic male sterile (TGMS) lines is heritable. Higher temperature (>30°C) results in sterility while lower temperature (<23°C) results in fertility. These characteristic features of TGMS ease out the hybrid seed production and subsequently it was demonstrated that the TGMS was more effective in increasing grain yield and seed production efficiency (Yuan, 1990). Hence, the present study was undertaken with the specific objective of studying a set of promising TGMS lines for their fertility behaviour at different locations so as to use them in two-line heterosis breeding.

Materials and Methods

The new TGMS lines developed through various breeding methods at TNAU *viz*., TNAU 45S, TNAU 60S, TNAU 95S, TNAU 19S and TNAU 39S were selected for studying their sterility behavior across the environments. These TGMS lines were developed by pedigree breeding, mutation breeding and identification of spontaneous mutant in the breeding material. These TGMS lines are having medium duration with better agronomic characters and very good floral traits *viz*., high stigma exertion, wider glume opening and acceptable grain quality characters like medium slender grain type *etc*. Multi location experiments were

conducted at Paddy Breeding Station, Coimbatore, Farmers field at Sathiyamangalam and Hybrid Rice Evaluation Centre, Gudalur during the *rabi and kharif* seasons in 2013 & 2014 to assess the pollen fertility expression under different temperature regimes in new generation temperature sensitive genic male sterile lines of TNAU. Weather parameters at Coimbatore and Gudalur during the past fifteen years were analyzed for fixing the sowing season (Fig. 1 & 2). *Tgms* lines were evaluated under two sterility inducing environments Coimbatore and Sathiyamangalam during the month of December 2013 & 2014 (*Rabi* 2013 & 2014). The same lines were stubble planted and evaluated for pollen sterility under pollen fertility inducing environment during the month of July *Kharif* 2013 & 2014 at high altitude (1500 MSL) with cool climate at Hybrid Rice Evaluation Centre, Gudalur. At the time of flowering pollen sterility was determined by staining the pollen grains with 1% Iodine Potassium Iodide solution (IKI) in all locations.

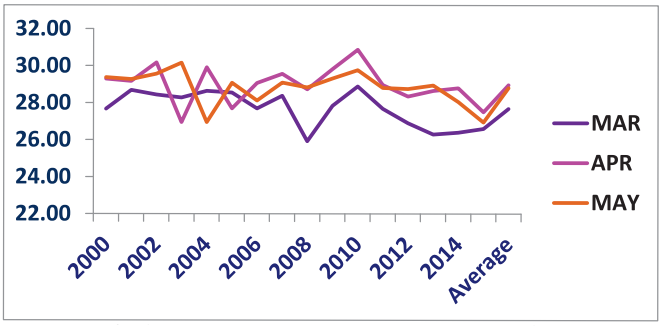

Fig. 1. Mean Weather data at Coimbatore Location

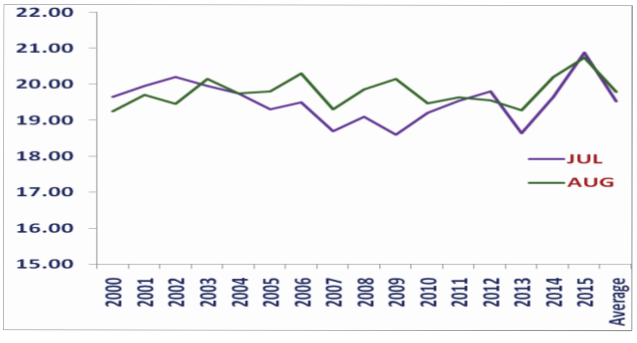

Fig. 2. Mean Weather data at Gudalur Location

Results and Discussion

The new TGMS lines developed at TNAU *viz*., TNAU 45S, TNAU 60S, TNAU 95 S, TNAU 19S and TNAU 39S were evaluated for their stability of pollen sterility under different temperature regimes were given in the Table 1. At sterility inducing environments, the lines showed 100 % pollen sterility. These lines were seeded during December at Coimbatore and Sathiyamangalam to expose them to a sterility inducing temperature (>29^{o}C /< 23^{o}C day night) during panicle initiation to flowering stage to test their sterility behavior so that their critical stage of flowering coincides with more than 29^{o}C. Both the locations weather data is provided in fig. 1 & 3 and it showed that both the places temperature recorded was >25^{0}C during the month of March, April and May. During the flowering stage, all these lines showed 100% pollen sterility at both the locations for more than 60 days and were test verified for next year also. (Latha *et al.,* 2012) characterized a set of six promising TGMS lines for their fertility behaviour under field conditions. The pollen and spikelet fertility recorded on the plants raised at fortnightly interval revealed that all lines had stable sterile phase with 100 per cent pollen sterility for more than 50 consecutive days during high temperature condition (30/20°C maximum/minimum temperature) and they reverted to fertile during low temperature condition (less than 30/20°C) with more than 60 per cent pollen and spikelet fertility. The daily mean temperature of 24 to 26°C was found to be the critical temperature for fertility alteration. The sterile stubbles of these lines were planted at HREC, Gudalur during May to induce fertility for their seed multiplication and were exposed at critical stages to fertility inducing temperature (24^{o}C / 18^{o}C day / night). Maximum, minimum and mean temperature significantly influenced the pollen and spikelet fertility in all five TGMS lines at high altitude. Seed production potential in the TGMS lines during fertility reversion phase can be enhanced by growing them under medium hill regions of Gudalur (1500m MSL) in Nilgiris district (Kesary *et al.,* 2015). At the time of flowering pollen fertility was observed and found that there was reversion in pollen fertility (more than 90%). The lines with complete pollen sterility under high temperature condition and more than 30 per cent self seed set under low temperature condition are considered as promising TGMS lines for commercial exploitation (Lu *et al.,* 1994). Sanchez and Virmani, (2005) and Ramakrishna *et al*. (2006) also reported that the maximum, mean and minimum temperature played a significant role in the fertility of TGMS lines. The eight TGMS lines DDR 1S, DDR 18S, DDR 19S, DDR 20S, DDR 23S, DDR 27S, DRR 28S and DDR 29 which showed satisfactory seed-set percentage at high altitude (Bhaderwah) were completely sterile at low altitude (Chatha). (Sagotra *et al.,* 2012). Evaluation of TGMS lines under Coimbatore and Gudalur increase the breeding efficiency of TGMS line development. Wide range of temperature differences prevailing in Tamil Nadu favour both hybrid seed production and the maintenance of TGMS in different locations (Siddiq and Ali, 1999). Jiang *et al.* (2015) reported that analysis of pollen sterility data in relation to temperature weather charts showed that when the DMT during 13 to 16 of September declined to below 22°C, the pollen grains of developed TGMS lines and C815S had shown reversal to partial fertility around 26 September and indicated that the sensitive stage to temperature located at 13 days before heading. At Gudalur the temperature range during the month of July and August was less than 20^{0}C. The appropriate sowing date of TGMS

lines was fixed during June-July in such a way that the critical stages of panicle development would be exposed to the required temperature. The individual lines were maintained under isolation and genetically pure seeds were produced at Gudalur.

Table 1: Pollen sterility of different TGMS lines in Rice

TGMS lines	*Rabi* 2013		*Rabi* 2014		*Kharif* 2013	*Kharif* 2014
	COIMBATORE	BSR	CBE	BSR	GDR	GDR
TNAU 45S	100	100	100	100	5	4
TNAU 60S	100	100	100	100	3	5
TNAU 95S	100	100	100	100	6	5
TNAU 19S	100	100	100	100	7	9
TNAU 39S	100	100	100	100	4	6

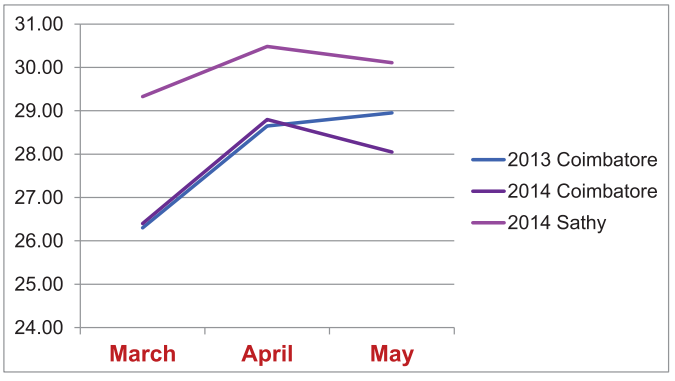

Fig. 3. Mean Weather data at Coimbatore and Sathyamangalam

Conclusion

The above TGMS lines with wider pollen sterility period under plains can be very well exploited for developing two line rice hybrids during the period of December to April. Seed production of the same lines can be easily done at Gudalur between July to November. These TGMS lines will not only reduce the cost of seed production but also increase the heterosis in rice hybrids as evidenced in our research. These TGMS lines with stable sterility can be exploited commercially for the development of two line rice hybrids in India.

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