



Yield of aerobic rice affected by high temperature stress during summer season -A study from red and laterite zone of West Bengal, India

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Abstract: Field experiment on the performance of aerobic direct seeded rice (ADSR) under red and laterite zone of West Bengal was conducted at Rice Research Station, Bankura, West Bengal, India during summer season, 2012. The experimental soil was sandy loam with acidic in nature (pH: 5.2). The results exhibited that the grain yield (1 t ha⁻¹) of rice in aerobic situation was low. This might be due to high atmospheric temperature during flowering period, which results in poor grain setting in panicle and most of them became chaffy due to spikelet sterility. Ultimately, it produced low grain yield of rice in aerobic situation during summer season due to high temperature at flowering period, grain formation and grain ripening stages. Thus, aerobic rice system of cultivation needed good management practices.

Keywords: Aerobic rice, High temperature, Low yield, Spikelet sterility

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereals crop and grown across the world. By the end of 21st Century, the earth's climate is predicted to warm by an average of 2-4°C (IPCC, 2007), due to anthropogenic and natural factors (Eitzinger *et al.*, 2010). Rice cultivation is a water intensive enterprise. However, lowland rice fields have relatively high water requirements and their sustainability is threatened by increasing water shortages (Bouman and Tuong, 2001). Aerobic rice system is a new way of growing rice that needs less water than low land rice. It is grown like an upland crop in soil that is not puddled, non-flooded or saturated. It is a sustainable rice production methodology for immediate future to address water scarcity and environmental safety arising due to global warming. Most rice is currently grown in regions where current temperatures are already close to optimum for rice production. Therefore, any further increase in mean temperature or of short episodes of high temperature during sensitive stages may be supra-optimal and reduce grain yield. Yields of rice have been estimated to be reduced by 41% by the end of the 21st Century (Ceccarelli *et al.*, 2010)

But, the incidence of very variable yield and complete yield failure were observed in dry season in the Philippines (Kreye *et al.*, 2007). The optimum temperature for the normal development of rice is ranges from 27 to 32°C (Yin *et al.*, 1996). Very high temperature is a threat to rice production, particularly during

flowering period. Temperature higher than the optimum induced floret sterility and thus caused decreased rice yield (Nakagawa *et al.*, 2003). The impact of high temperature at night is more devastating than day-time or mean daily temperature. Among the physiological growth stages of rice, booting and flowering stages are most sensitive to high temperature, which may sometimes lead to complete sterility (Shah *et al.*, 2011). Flowering (anthesis and fertilization) and to a lesser extent the preceding stage booting are considered to be the stages of development most susceptible to temperature in rice (Farrell *et al.*, 2006). Humidity at increased temperature also plays an important role in increasing the spikelet sterility (Shah *et al.*, 2011).

Keeping above in view, the present investigation was undertaken to study the package of practices and feasibility of aerobic rice system in aerobic situation during summer season.

MATERIALS AND METHODS

The experiment was laid out in observational plots with three replications. Total number of plots (P₁, P₂, P₃ and P₄) was four in each replication and total number of plots was twelve in this experiment. The plot size was 10 X 8 m. The rice variety was Puspa (IET 17509). The date of direct sowing in un-puddled field was 7th February, 2012. Direct seeding of dry treated seed (carbendazim @ 2g per kg seed) with spacing of 20 X 15 cm was done. The recommended fertilizer dose was N, P₂O₅, K₂O @ 80, 40, 40 kg ha⁻¹. 25% of recommended dose of nitrogen, full dose of phosphorus, 75% of potash

and zinc sulphate ($ZnSO_4$) @ 20 kg ha⁻¹ were applied as basal. Remaining dose of nitrogen in two splits was applied. 50% nitrogen at active tillering stage and 25% nitrogen along with 25% Potash at Panicle initiation stage were applied. Harvesting was done on 04.06.2012.

Need based seven numbers of irrigations were applied according to physiological growth stages of rice plant and observing soil condition, particularly when hair line cracks developed on the soil surface. To control rice gundhibug during milky stage and stem borer, carbosulfan 6G and carbofuran 3G was applied at 10 days interval.

Plant height (from ground level to the tip of the flag leaf) was taken at ripening stage based on randomly selected ten plants. The 5 m² area in the middle of each plot was harvested for recording grain yield. Ten rice hills outside the harvested area were selected and harvested separately for recording yield parameters, viz. number of tillers per hill, length of panicle and panicle weight etc. Meteorological data (Tables 2 and 3) was taken from State Agricultural Farm (SAF), Office of the Assistant Director of Agriculture, Bankura, West Bengal.

The characteristics of red and laterite soils are poor in calcium, organic matter content, available phosphate and in bases. Land is undulating and has many tiny rivulets. These rivulets are dry except during rainy season. The upland soils are mostly eroded red-gravelly with a very low water holding capacity. Crust formation in the upland soils is serious problem. The top soils are poor in iron due to leaching and accumulation takes places in deep subsoil. This experiment was conducted in upland. The texture of experimental soil was sandy loam with acidic in nature (pH: 5.2) and 0.13 ds m⁻¹ EC,

0.51% organic carbon, 33 kg ha⁻¹ available P₂O₅, 183 kg ha⁻¹ available K.

RESULTS AND DISCUSSION

It was revealed from the experiment that good crop stand was obtained with Puspa (IET 17509) variety. The average value of plant height was 91.6 cm. The average value of number of tillers hill⁻¹ was 16.8. Low grain yield (1 t ha⁻¹) was resulted from this experiment. The average value of number of unfilled grains per panicle was 81 (Table 1). High atmospheric temperature was prevailed during flowering period, grain formation and grain ripening stages. As a result of which, more number of grains in a panicle became chaffy and ultimately produced low grain yield of aerobic rice. It was mainly due to floret sterility. As very hot wave and dry weather conditions prevailed during the end of April to May, 2012 (Table 2 and 3), the condition improved the spikelet sterility. The similar trend was also noticed by Nakagawa *et al.* (2003). Exposure to 41°C for 4 hour at flowering caused irreversible damaged and plants became completely sterile (IRRI, 1976). The low aerobic rice grain yield was due to prevail of high atmospheric temperature during the study that affected almost all the growth stages of rice from emergence to ripening and harvesting. This was agreed with findings of Yin *et al.* (1996) and Shah *et al.* (2011). Spikelet sterility was greatly increased at temperature higher than 35°C (Matsui *et al.*, 1997a). It was also observed that soil became dry and hard within a very short period after application of irrigation. The soils of red and laterite areas were sandy loams (very light textured), low in water holding capacity, poor in organic matter content and presence of tiny rivulets.

Table 1. Grain yield and ancillary characters of rice in aerobic situation during summer, 2012.

Plot	Plant height (cm)	No. of effective tillers m ⁻²	No. tillers per hill	Panicle length (cm)	Panicle weight (g)	No. of filled grains panicle ⁻¹	No. of Unfilled grains panicle ⁻¹	Grain yield (t ha ⁻¹)
P ₁	87.2	354.5	14.5	21.2	0.98	35.6	68.2	0.88
P ₂	95.8	372.1	18.7	23.7	0.91	26.7	86.1	0.95
P ₃	92.0	402.8	21.5	22.6	1.05	38.5	90.5	1.08
P ₄	91.4	325.6	12.6	21.4	1.10	40.2	79.3	1.12
Average	91.6	363.7	16.8	22.2	1.01	35.2	81.0	1.00

Table 2. Meteorological data during summer season, 2012.

Months	Max. temp. (Av.)	Min. temp. (Av.)	Rainfall (mm)	Total number of rainy days
February, 2012	30.21 ^o C	18.5 ^o C	11.9	2
March, 2012	36.53 ^o C	19.66 ^o C	13.6	1
April, 2012	41.54 ^o C	23.64 ^o C	82.1	5
May, 2012	40.41 ^o C	24.70 ^o C	61.5	5
June, 2012	38.70 ^o C	27.39 ^o C	123.4	8

High temperature coincide with anthesis and flowering period at 1st and 2nd week of May, 2012 (Source: State Agricultural Farm, Bankura, West Bengal)

Table 3. Maximum and minimum temperature during the month of May, 2012 during the study.

Dates	Max. Temp. (Av.)	Min. Temp. (Av.)
13.05.2012	39.5 °C	25.3 °C
14.05.2012	41.0 °C	27.5 °C
15.05.2012	44.0 °C	29.2 °C
16.05.2012	43.0 °C	26.2 °C
17.05.2012	44.0 °C	28.2 °C
18.05.2012	45.5 °C	28.2 °C
24.05.2012	44.0 °C	27.7 °C
25.05.2012	46.0 °C	29.6 °C
26.05.2012	46.0 °C	27.0 °C

High temperature coincide with grain formation and grain ripening stages of rice plant
(Source: State Agricultural Farm, Bankura, West Bengal)

Conclusion

The present study concluded that low grain yield of rice in aerobic situation during summer season, 2012 was mainly due to high temperature during flowering period, grain formation and grain ripening stages. Spikelet sterility at high temperature was the main reason for lower grain yield during summer season.

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