SHORT COMMUNICATION

EVALUATION OF MORPHOPHYSIOLOGICAL TRAITS ASSOCIATED WITH DROUGHT TOLERANCE IN RICE

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Sixteen local rice germplasm lines of close phenology were studied for selected root and shoot traits. These traits were evaluated for yield stability under reproductive stage drought in rice. It was observed that well-developed root system as measured in terms of root pulling resistance helps in maintaining higher plant water status and yield stability. Delay in flowering seems to be due to low plant water status and was linked with drought susceptibility.

***Key Words* : Drought tolerance, flowering, rice, root pulling resistance.**

Almost half of the rice is grown under rainfed conditions, where drought at some stage leads to partial or total crop failure. Several root characteristics have been associated with drought avoidance in rice (Nguyen *et al.* 1997, Babu *et al.* 2003) however, large sampling errors were found as the main limitation associated with detection of genetic variation for root system parameters (Pantuwan *et al.* 1997). Root pulling resistance (RPR vertical force required to pull the root from the soil) can be used as an integrated measurement of total root system (O'Toole and Soemartono, 1981). It was associated with ability to maintain higher plant water status under severe drought stress (Ekanayake *et al.* 1985) however, Pantuwan *et al.* (2002 b) pointed out that in lowland rice larger root system favours faster depletion of available soil moisture resulting in lower panicle water potential at flowering stage. Drought stress that develops prior to flowering generally delayed the flowering of genotypes, and such a delay was associated with drought susceptibility in rice (Pantuwan *et al.* 2002 a). The current paper examines the contribution of RPR, flowering delay and plant water status in building yield of rice under drought.

Studies were conducted with local germplasm lines of close phenology under irrigated and rainfed conditions. RPR was measured from irrigated plots at flowering stage. A modified root pulling machine was used to measure root pulling resistance as described by O'Toole and Soemartono (1981). Flowering delay was recorded by comparing flowering in irrigated and water deficit plots. Relative water content (RWC) was estimated in water deficit sites when irrigated controls were at flowering stage. RWC was estimated at midday in uppermost fully expanded leaves (Barrs and Weatherly 1962). Grain yield data of rainfed site was used for estimating relationship with RPR, flowering delay and RWC.

Flowering was delayed from four to thirteen days among lines under rainfed conditions (Table 1). The lines with longer delay in flowering suffered drought stress for longer duration and vice versa. It was observed that flowering delay is governed by plant water status under drought condition (r = -0.69**) and negatively associated with grain yield (r = -0.61*). RPR at flowering stage varied from 50.35 kg to 95.35 kg among lines (Table 1). It was positively associated with relative water content and grain yield (r = 0.57* and 0.59* respectively) under rainfed site. This indicates that lines having high root pulling resistance keep the aerial plant parts well supplied with water through higher water extraction from drying

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Table 1. Days to flower, grain yield, relative water content and root pulling resistance of different lines.

Lines	Irrigated site grain yield (g/m^2)	Rainfed site grain yield (g/m^2)	Days to flower (rainfed site)	Mean flowering delay in rainfed (days)	Relative water content (%)	Root pulling resistance (kg)
Banspor	530.9	98.6	102	7.5	71.7	77.5
Chhota Kabri	247.3	80.8	104	9.5	73.2	66.5
Chapti Gurmatiya	278.6	100.9	99	4.5	76.7	77.0
Bhejari	568.1	139.2	104	9.5	70.7	75.3
Anjania	437.5	85.5	103	8.5	68.2	72.9
Cross-116	437.5	124.4	102	7.5	77.1	95.3
Kanak Chudi	292.2	77.7	105	10.0	63.7	79.7
Luchai	416.6	42.7	106	11.0	65.2	73.1
Jhilli	536.2	49.4	109	13.0	69.2	61.9
Bhata Phool	385.3	84.3	108	12.0	69.7	71.7
Bhatha Gurmatia	525.3	161.7	104	8.5	80.2	83.9
Bakhala Sal	452.6	53.7	108	11.5	67.2	74.0
Rani Kajar	390.1	66.9	110	13.0	66.7	61.6
BAS-370	435.1	30.5	108	11.5	66.7	50.3
Batroo	510.1	112.9	103	5.0	76.9	90.2
Mokado	428.6	32.7	109	11.0	70.7	81.7
Mean	429.5	83.9	105.5	9.5	70.8	74.5
LSD (5%)	82.8	27.5	2.97	-	7.1	10.5

soil. The current results are similar to Ekanayake *et al.* (1985) that plants with higher RPR had the ability to maintain higher leaf water potential under severe drought stress and opposite to the findings of Pantuwan *et al.* (2002 b). Relative water content was strongly associated with grain yield (r = 0.72**) under rainfed condition (Fig. 1). This indicates that maintenance of higher water status under drought plays an important role in building grain yield. It implies that well-developed root system helps in maintaining higher plant water status along with shorter delay in flowering which ultimately reflects in yield stability under drought conditions.

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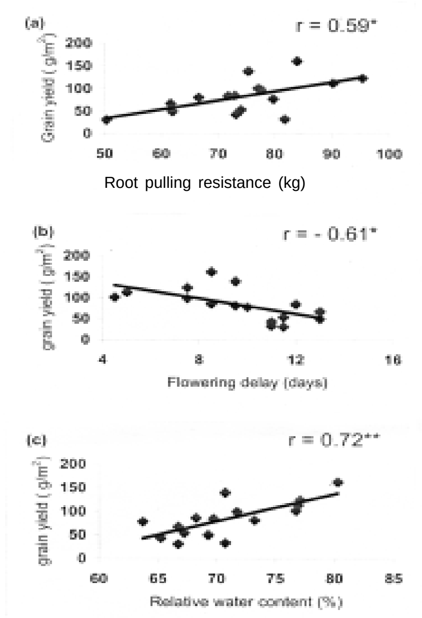

Fig. 1. Relationship of grain yield under drought stress with (a) root pulling resistance (b) flowering delay and (c) RWC

REFERENCES

Babu, R.C., Nguyen, B.D., Chamarerk, V., Shannugasundaram, P., Chezhian, P., Jeyaprakash, P., Ganesh, S.K., Palchamy, A., Sadasivam, S., Sarkarung, S., Wade, L.J., and Nguyen, H.T. (2003). Genetic analysis of drought resistance in rice by molecular markers: Association between secondary traits and field performance. *Crop. Sci.* **43:** 1457-1469.

Bars, H.D. and Weatherly, P.E. (1962). A re-examination of the relative turgidity technique for estimating water deficits in leaves. *Aust. J. Bios. Sci.* **15:** 415-418.

Ekanayake, I.J., Garrity, D.P., Masajo, T.M. and O'Toole, J.C. (1985). Root pulling resistance in rice: Inheritance and association with drought tolerance. *Euphytica* **34:** 905-913.

Nguyen, H.T., Babu, R.C. and Blum, A. (1997). Breeding for drought resistance in rice: Physiology and molecular genetics considerations. *Crop. Sci.* **37:** 1426-1434.

O'Toole, J.C. and Soemartono (1981). Evaluation of a simple technique for characterizing rice root system in relation to drought resistance. *Euphytica* **30:** 283-290.

Pantuwan, G., Fukai, S., Cooper, M., O'Toole, J.C. and Sarkarung, S. (1997). Root traits to increase drought resistance in rainfed lowland rice. In : S. Fukai (eds.) Breeding Strategies, for Rainfed Lowland Rice in Drought Prone Environments. pp. 170-179. ACIAR, Canberra, Australia.

Pantuwan, G., Fukai, S., Cooper, M., Rajatasereekul, S. and O'Toole, J.C. (2002 a). Yield response of rice (*Oryza sativa* L.) genotypes to drought under rainfed lowlands. 2. Selection of drought resistant genotypes. *Field Crop Res.* **73:** 169-180.

Pantuwan, G., Fukai, S., Cooper, M., Rajastasereekul, S. and O'Toole, J.C. (2002 b). Yield response of rice (*Oryza sativa* L.) genotypes to drought under rainfed lowlands. 3. Plant factors contributing to drought resistance. *Field Crop Res.* **73:** 181-200.