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Preliminary studies on rice varieties adaptability to aerobic irrigation

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Abstract. An experiment was carried out in 1994 on a Vercelli sandy-loam soil to evaluate the performance of fifty rice genotypes under nonflooded irrigation. Plant height, days to heading and ripening, and yield were measured. There were three irrigation applications by flushing during the cultivation season. Total water applied was 800 m^3 per hectare. Rainfall during the 1994 growing season totalled 3,500 m^3 per hectare and was well distributed. Total water supply (rainfall plus irrigation) was calculated to be 4,300 m^3 per hectare. The nonflooded aerobic culture influenced the growth and cycle duration of different genotypes. The commercial indica type *Panda* performed well and was the top-yielding variety. Several varieties showed yield losses due essentially to reduced filled grains and reduced fertile florets. Earlier maturing varieties would appear to be more adapted to the aerobic irrigated culture.

I – Introduction

Cultural methods for rice (*Oryza sativa L.*) production include both the flooded and the upland cultural systems, with a large predominancy for the former in temperate areas (e.g., in Europe). However, besides requiring large quantities of water, this system may increase the difficulties in applying pesticides and fertilizers and in using machinery and may, consequently, be more costly.

Permanent flooded conditions during the cultural cycle provide a continuous and adequate supply of water, allow nonaquatic weeds control, facilitate the use of granular insecticides and herbicides, reduce losses of ammonium fertilizer, and enhance the availability of nutrients (such as phosphorus, iron, manganese) following reduction of the soil due to the exclusion of oxygen by the flood water (Shapiro, 1958; Ponnamperuma, 1965; Patrick et al., 1985).

The conventional flooding technique is very high water consuming. Brown et al. (1978) have indicated that 48% (570 mm) of the applied irrigation water (1,180 mm) is lost through evapotranspiration (ET). The remainder is lost due to runoff and infiltration. Water represents a major and necessary production cost for rice growers.

The flooding technique is used as a management tool, not as a specific requirement of the rice plant.

On the other hand, rice producers often have to face increasing competitive uses of water. In addition, pollution affects more and more the water quality.

With the traditional rice system, under temperate conditions (the case of Italy), the direct water broadcast sowing method cannot prevent some damaging effects of adverse environmental conditions on the plantlets establishment.

The main constraints affecting rice growing under temperate conditions at the initial stage are:
– cold weather;
– crustaceans and worms activity in submerged soil;
– wind effect (which may hamper or slow the crop establishment);
– strong competition of aquatic weeds (such as *Heterathera, spp.*);
– algae populations development;
– water shortage.

Drilling and aerobic cultivation (dry rice) are the ideal alternative methods of planting as they allow to overcome the damaging effects above.

De Datta (1975) indicates that rice is grown under upland conditions in three continents. The upland cultural system depends solely on the rainfall and upland production occurs in areas where the rainfall seldom, or never, causes flooded conditions.

Upland yields of more than 7 t/ha^{-1} have been recorded, indicating that rice does not require flooded conditions for high yields (De Datta, 1975). To this purpose, different methods can be used. Initial research indicates sprinkler irrigation as an alternative irrigation method. Sprinkler irrigation can contribute substantially to lower water consumption.

An efficient system using sprinkler irrigation in order to prevent plant stress in the critical periods should sustain optimum rice yields. However, reports on several areas have shown highly variable results (Ferguson and Gilmour, 1977, 1978; Westcott and Vines, 1986; McCauley, 1990). Following these results, further research to compare the effects of normal flood irrigation and sprinkler irrigation (or any other suitable method) on rice yield and quality is requested.

In some cases, an alternative suitable method may be furrow irrigation. Preliminary rice production studies using furrow irrigation, rather than flooding, have shown promising results. Furrow irrigation may offer a method of producing additional rice per unit of irrigation water and applying fluid fertilizers (Wells et al., 1991).

The objective of the pesent study was to evaluate the response of several rice cultivars and new selected lines to dry cultivation with the flushing irrigation method applied in the groundwater-irrigated area of northern Italy (Po Valley).

II – Materials and methods

Experiments were conducted in 1994 on a loam-sandy soil in the experimental field of the *Sezione Specilizzata per la Risicoltura*, near Vercelli, to detect the performance of major commercial rice cultivars and new lines in dryland conditions with minimal irrigation by flushing. The compared genotypes included common, medium and long grains cultivars and lines developed in Italy under flooded culture.

The experiment was a complete randomized block design with four replications for each of the 15 genotypes compared. The plots measuring 10 m x 1,5 m were separated by 0,6 m and consisted of eight rows 0,18 m apart. Rice varieties were drill seeded, on 29 April 1994, 2 cm deep on a completely dry soil. This method gave uniform seedling emergence for all the plots in 10–13 days. Water was supplied by the flushing method from a gravity-feed irrigation system.

The irrigation treatments were designed so that the rainfall (plus irrigation) were enough to maintain 20% at least of soil moisture and assured no water stress. The irrigation treatments consisted of shallow flood, the soil was flooded during a night by flushing. Irrigation was resorted to when the soil moisture was between 20 and 22%. Since the rainfall in 1994 was adequate, three seasonal water treatments in all were necesary.

Standard cultural procedures were adopted. Phosphorus (60 kg/ha P_2O_5) and potassium (105 kg/ha K_2O) were applied as recommended before planting. Nitrogen was used, as urea, for four separate applications: the first application was made at preplant stage and incorporated with straw by ploughing. The successive applications were made by hand broadcast at the beginning and at late tillering, and at panicle differentiation stages. The total nitrogen amount applied was 170 kg/ha, about 20% more than the standard used in flooded culture.

Weeds were controlled chemically, as required by successive applications of standard rice herbicides mixture (Propanil + Bensulfuron methyl). Recorded observations included: heading date, plant height at harvest, ripening date. All plots were harvested by plot combine. The grain was dried, cleaned and weighed. Yields were calculated on the basis on 14% moisture. An adequate grain sample was taken from the yield plot to determine the head rice yield (percent whole milled grain).

III – Results and discussion

The rainfall in 1994 was adequate throughout the germination and seedling emergence stages, so that no supplemental water was necessary. The rainfall during the 1994 growing season totalled 3,500 m^3 per hectare and was well distributed. Total water applied (rainfall plus irrigation) was calculated to be 4,300 m^3 per hectare. These rates are very low compared with the water applied to a conventional flooded culture consuming about 13–15 m^3 in this rice area. However, we have to consider the favourable climatic conditions (favourable air relative humidity, with no wind, in the growing season). This area is moreover characterized by a quite superficial underground water table (about 0,8 m in dry soils) which, with all probability, influences the rice growth.

IV – Growth and development

The growth and development of the rice varieties were apparently normal, except for the biomass formation that was slightly reduced as is shown from a plant height lower than the standard type of culture. In particular, the different rice varieties showed more reduced and superficial roots due to the water stress affecting the soil.

Nonflooded conditions had practically no effect on seedling emergence. However, after this stage, rice development was slightly affected by stresses due to insufficient water supply and inadequate moisture. All the varieties showed a longer cycle duration but reached complete ripening, except for a line derived from the *Inta x Panda* cross.

Generally, more early varieties were of good performance and were more adapted to dry conditions. Earliness may be used as a suitable criterion for selecting improved varieties.

V – Heading date

Heading dates were recorded for each cultivars plot and the average values are shown in *Table 2* as days for heading. *Ago* (98,25 dd) and *Inta x Panda* selected line (130,50 dd) headed among the first and last, respectively, which indicates that stresses from nonflooded conditions which may have occurred influenced differently the time from planting to heading in relation to the cultivars. In general, aerobic cultivation resulted in a delay of the heading time. Cultivars with early or medium heading dates performed better.

VI – Ripening

Ripening dates based on morphological observations were recorded and shown in *Table 2* as days to ripening. However the percentage of grain moisture content gives better information about the ripening time and the more suitable harvest date. The average values of grain moisture content at harvesting time are also presented in *Table 2.*

Generally, the cycle duration before ripening stage was more affected than the heading stage according to different cultivars. Several genotypes showing low moisture at harvesting time performed very well. The top-yielding *Panda* proved good maturing qualities and was among the earlier varieties. Very long duration varieties showed significant yield reduction compared with the top-yielding variety which indicated a poor adaptability to dry conditions.

VII – Rice yield

Average rice yields for the various cultivars are shown in *Table 2* and *Figure 1.* Due to the low water treatment, several genotypes exhibited yield losses indicating insufficient adaptability to non flooded culture. But some cultivars performed well under dry conditions. *Panda,* developed for its long grain (Long B) commercial Indica type, was the top-yielding cultivar and produced 6 t/ha, i.e. not less than the standard culture. It appears to be more resistant to water stress in dry conditions. Other long grain rices (such as *UPLA 64a, Koral, Inta x ISC 209, Pegaso, Dorella*) peformed also well under dry conditions. Medium *Loto, Cripto,* very high yielding cultivars with flood irrigation and long grain cultivars *Graddo, Giada, ISC 402/2*, showed significant yield reduction ranging from 1,678 kg/ha$_{-1}$ to 2,599 log ha$_{-1}$ under dry conditions, compared with the top-yielding variety. Selected line from *Inta x Panda* cross appeared to be extremely sensitive to moisture stress. Its yield was very low under dry conditions due essentially to high florets sterility, non complete grain filling and very long cycle duration.

VIII – Conclusions

Experiments carried out in 1994 furnished preliminary results suggesting potential alternate aerobic rice cultivation under nonflooded conditions. The lower amount of water supplied using the aerobic method reduced plant growth and prolonged the cycle duration according to the different cultivars. Nonflooded conditions also influenced the varieties' yielding response.

The major yield reduction would appear to be due to incomplete grain filling and high florets sterility. However, good performing rices may be among earlier maturing cultivars. The varied cultivar responses to stresses from non flooded conditions show, in conclusion, a potential for genetic improvement.

Aerobic rice production may be adapted to non traditional rice areas where soil flooding is problematic or water cost prohibitive.

The advantages of dry rice methods are: a) reducing water consumption; b) economizing the costs of machinery usage; c) reducing the constraints at planting time; d) improving the rice stand establishment.

References

• **Brown K.W., Turner F.T., Thomas J.C., Deuel L.E., and Keener M. E.** (1978). Water balance of flooded rice paddies. *Agric. Water Manage.*, 1:277-291.
• **De Datta S.K.** (1975). Upland rice around the world. In: *Major research in upland rice.* IRRI. Los Baños, Laguna, Philippines, p. 254.
• **Ferguson J. A. and Gilmour J.T.** (1977). Center-pivot sprinkler irrigation on rice. *Ark. Farm Res.*, 2:12.
• **—** (1978). Water and nitrogen relations of sprinkler irrigated rice. *Ark. Farm Res.*, 3:2.
• **McCauley G.N.** (1990). Sprinkler vs. flood irrigation in traditional rice production regions of Southeast Texas. *Agron. J.*, 82:677-683.
• **Patrick W.H., Jr., Mikkelsen D.S. and Wells B.R.** (1985). Plant nutrient behavior in flooded soil. In: O. P. Englested (ed.), *Fertilizer Technology and Use*, 2nd ed., SSSA. Inc. Madison. WI, pp. 197-227.
• **Ponnamperuma F.N.** (1965). Dynamic aspects of flooded soils and the nutrition of the rice plant. In: *The mineral nutrition of the rice plant*. IRRI. The J. Hopkins Press, Baltimore, pp. 295-328.
•**Shapiro R.E.** (1958): Effects of flooding on availability of phosphorus and nitrogen. *Soil Sci.*, 85:190-197.
• **Wells B.R., Kamputa D., Norman R J., Vories E. D. and Baser R.** (l991). Fluid fertilizer management of furrow irrigated rice. *J. Fertil. Issue*, 8:14-19.
• **Westcott M.P., and Vines K.W.** (1986). A comparison of sprinkler and flood irrigation for rice. *Agron. J.*, 78:637-40.

Fig 1. RICE VARIETIES PERFORMANCE UNDER DRY CULTURE . YEAR 1994

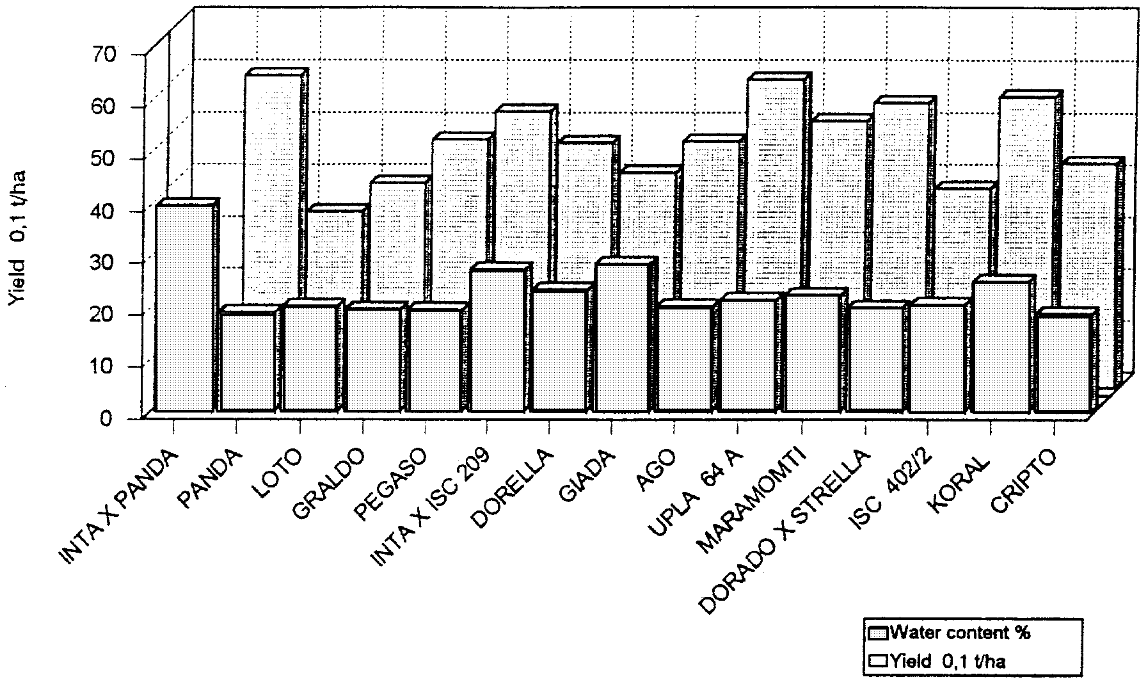

Table 1. Treatments applied to nonflooded dry rice with supplemental irrigation by flushing. Year 1994

Treatments	Water m^3 par ha
Fertilization : Straw + 4 split "N" applications : Total N: 170 kg/ha P_2O_5 : 60 kg/ha K_2O : 105 kg/ha	
Sowing time : 29 april 1994	
Irrigation (by flushing): 3 times	800 m^3
Rainfall	3 500 m^3
Total applied water	**4 300 m^3**

Table 2. Performance of 15 rice genotypes under aerobic nonflooded cultivation. Year 1994

Cultivars	**Yield** (t/ha)	**Days to heading**	**Days to ripening**	**Grain moisture at ripening** (%)
Panda	5,99	108,50	154,75	19,02
UPLA 64A	5,92	110,50	152,75	21,48
Koral	5,60	110,75	160,50	24,91
Dorado x Strella	5,48	111,25	129,00	19,80
Inta x ISC 209	5,32	114,25	159,75	27,25
Maramonti	5,13	108,75	159,00	22,30
Pegaso	4,77	103,25	153,25	19,42
Ago	4,73	98,25	151,50	20,24
Dorella	4,71	106,75	151,50	23,41
Cripto	4,32	98,75	152,00	18,67
Giada4,13	4,13	119,75	162,25	28,32
Graldo	3,93	109,50	154,75	19,53
ISC 402/2	3,84	100,75	153,75	20,43
Loto	3,40	104,25	149,50	20,17
Inta x Panda	1,18	130,50	182,00	39,58
LSD (< 0.05)	1,31	2,86	18,63	—
Mean	**4,56**	**109,05**	**155,08**	**22,97**