ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 4 (4): 311-314, 2005
ISSN 1812-5379

Effect of Integrated Crop Management Practices on Rice (*Oryza sativa* L.) Root Volume and Rhizosphere Redox Potential

[1]B. Jayakumar, [1]C. Subathra, [1]V. Velu and [2]S. Ramanathan
[1]Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India 641 003
[2]Director of Research, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India 641 003

Abstract: This study was conducted at wetlands, Tamil Nadu Agricultural University, Coimbatore (11°N and 77°E) during Navarai (Dec-May) season of 2003-'04 in Noyyal series, clay soil (Vertic ustochrept), to explore the effects of certain of the Integrated Crop Management (ICM) practices involving two genotypes (CORH 2 and ADT 46), three establishment methods (direct seeding, 14 days old young seedlings-SRI mat nursery and 28 days old conventional seedlings), two manuring (inorganics alone and INM) and two weeding practices (manual weeding and mechanical weeding) on rice (*Oryza sativa* L.) crop root volume and rhizosphere redox potential. The results revealed that there was a progressive and conspicuous increase in the root volume and dry matter production with the advancement of crop growth stages. Hybrid CORH 2 recorded higher root volume and DMP than the variety ADT 46 at AT, PI and FF stages. Planting of SRI mat nursery seedlings (14 days old) registered higher root volume when compared to the other establishment methods (direct seeding and 28 days old seedlings). The manuring practices viz., inorganics alone (G_0) and INM (G_1) failed to influence the root volume and DMP. Mechanical Weeding (W_2) recorded higher root volume than the manual Weeding (W_1) and the same mechanical weeding better aerated the rhizosphere region by increasing the redox values.

Key words: Direct seeding, SRI seedlings, mechanical weeding, inorganics alone, INM

INTRODUCTION

Rice (*Oryza sativa* L.) should be called, the stuff of life as it constitutes the staple food of more than half of the people in the world. Neither root nor its influence on biomass production has been given much attention in the green revolution. When plant breeders sought to increase the harvest index, they did not include measurement of roots as part of total biomass when calculating the index[1]. Repeated use of rotating hoe with its wheels that aerate the top horizon of the soil leads to better development of the rice ecosystem through the possibility of rice roots' extended growth under the influence of oxygen[2-4].

Transplanting young seedlings, singly and with wider spacing plus growing them in aerated soil not continuously saturated, produces larger root. The aeration status is measured by redox potential (Eh). The Eh range in waterlogged soils extends from approximately -300 to +700 mV. The changes in Eh are more pronounced when organic substances are added to soils low in organic matter[5]. Incorporation of green manures recorded lower Eh values than did chemical fertilizers[6]. The oxidising power of the roots protects the plant against reducing substances like ferrous iron or hydrogen sulfide, which may reach phytotoxic concentrations in water logged soils[7,8]. The rice plants grown in aerobic conditions showed better growth and longer roots than anaerobically grown plants revealing the sensitivity of rice roots to external supply of oxygen and diffusion of oxygen into the rhizosphere, oxidising various reducing substances in the close vicinity of the roots[9]. Measurement of redox with spatial resolution showed that rice roots could increase the redox potential in a reduced soil[10]. The oxidising power of the root was concentrated at the root tip and the redox potential in the rhizosphere of the primary root tip increased from -250 to 100 mV, whereas at 1 mm distance from the root surface the redox potential remained nearly constant[11]. The higher oxidising activity of roots is said to correlate with its resistance to *Akiochi* disease and the low activity with its susceptibility[12]. The plants with larger rhizosphere will be significantly better protected from absorbing large amounts of reduced products and the oxygenation of small lateral roots is higher than the primary roots[13]. A clump of three rice plants grown under conventional condition (mature seedlings, closely spaced, three per hill

Corresponding Author: Mr. B. Jayakumar, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore, India 641 003

grown in standing water) required an average of 28 kg force to be pulled up. Whereas rice plants grown under SRI conditions (young seedlings widely spaced one per hill, no standing water) required an average of 52 kg for uprooting[14,15]. Research on the physiological effects of SRI methods on the rice plant done at National Rice Research Institute, China indicated that the root dry weight was 45% greater for SRI plants compared to same variety conventionally grown and the roots extended 10-15 cm deeper[16]. Indeed, roots themselves have received little attention in the literature. SRI experience suggests that this neglect was unfortunate. When the roots promoted through appropriate plant, soil, water and nutrient management practices can help plants to obtain much higher yields from existing genetic endowments, without need to employ chemical inputs. With this view, the present investigation was aimed to study the influence of selected Integrated Crop Management (ICM) practices on root volume, rhizosphere redox potential and in turn on total biomass production of rice.

MATERIALS AND METHODS

A field experiment was conducted at wetlands, Tamil Nadu Agricultural University, Coimbatore (11°N and 77°E) during Navarai (Dec- May) season of 2003-'04 in Noyyal series, clay soil (Vertic ustochrept), to explore the effects of certain of the integrated crop management (ICM) practices involving two genotypes (CORH 2 and ADT 46), three establishment methods (direct seeding, 14 days old young seedlings-SRI mat nursery and 28 days old conventional seedlings), two manuring (inorganics alone and INM) and two weeding practices (manual weeding and mechanical weeding) on root volume and rhizosphere redox potential of rice. There were 24 treatment combinations replicated thrice in Factorial Randomized Block Design. The sowing for direct seeding, SRI mat nursery seedlings (14 days old seedlings) and conventional nursery (28 days old seedlings) was made on the same day so as to ensure the uniform age of the crop. In INM plots, GLM @ 6.25 t ha^{-1} was incorporated one week ahead of the direct seeding. The weeding practices were imposed on 15 DAT and 30 DAT. The LCC measurements were taken on weekly interval in order to assess the nitrogen status of leaf and nitrogen applied @ 35 kg ha^{-1} as and when the LCC critical value fell below 4. Phosphorous @ 60 kg P_2O_5 ha^{-1} as SSP, $ZnSO_4$ @ 25 kg ha^{-1} and gypsum @ 500 kg ha^{-1} were applied as basal. Potassium was applied @ 60 kg K_2O ha^{-1} as MOP in three equal splits. The soil of the experimental field was with a pH of 7.96, EC of 0.68 dS m^{-1}, organic carbon content of 0.56%, low available N (271 kg ha^{-1}), high available P (54 kg ha^{-1}) and high available K (740 kg ha^{-1}). The plant samples were collected during critical crop growth stages viz., Active Tillering (AT), Panicle Initiation (PI) and First Flowering (FF) stage. The plants were dried in the oven then the roots and above ground biomass were separated. The root volume was measured by water displacement method and expressed as CC per hill. The above ground biomass (DMP) was weighed separately and expressed as kg ha^{-1}. As the investigation related to rhizosphere region, sturdy efforts were taken to embellish the oxidation and reduction status of the soil, redox potential was measured with a platinum electrode attached to a portable pH-ORP meter. *In situ* redox measurements were taken in all the plots after each weeding (15th and 30th DAT) by placing the electrode at 10 cm depth of the rhizosphere region. The redox meter was calibrated with the standard solution of $FeSO_4$ and FAS[17]. The redox status was recorded in each plot at four different spots and was averaged to derive a single redox value and the data were subjected to statistical scrutiny.

RESULTS AND DISCUSSION

The results of Table 1 and 2 and Fig. 1 and 2 revealed that there was a progressive and conspicuous increases in the root volume and dry matter production with the advancement of crop growth stages. The comparison of root volume and Dry Matter Production (DMP) indicated that both were dependent on each other as the root volume increases the DMP also increased and vice versa. This is in corroboration with the findings of Uphoff[1] who observed the synergistic effect between root growth and shoot growth, each enabling other to grow larger and function better. As could be expected, hybrid CORH 2 recorded higher root volume and DMP than the variety ADT 46 at all the crop growth stages. This might be due to the nature of hybrids to produce more dry matter than the varieties[18-20].

At all the stages of crop growth, planting of SRI mat nursery seedlings (14 days old) registered higher root volume when (Fig. 2) compared to the other establishment methods (direct seeding and 28 days old seedlings). Similar trend reflected in the DMP also. This was due to the careful and horizontal rather plunged planting method adopted for SRI seedlings, which enhanced the root volume[21]. While comparing the root volume and DMP of direct seeding with 28 days old seedlings both were comparable at all the crop growth stages. This is in contradiction with Prabhakar and Narsa Reddy[22] who observed early accumulation of biomass and profuse root system under direct seeded flooded rice.

Table 1: Effect of genotypes, establishment methods, weeding and manuring practices on rice root volume (CC per hill)

Particulars	Crop growth stages		
	AT	PI	FF
Genotypes			
V_1-CORH 2	9.9	17.2	20.8
V_2-ADT 46	8.7	14.3	18.4
CD (0.05)	0.5	0.7	0.7
Establishment methods			
P_1-Direct seeding	8.7	15.2	19.5
P_2-14 days old seedlings	10.9	17.5	21.4
P_3-28 days old seedlings	8.3	14.4	17.9
CD (0.05)	0.9	1.1	1.2
Manuring practices			
G_0-Inorganics alone	9.3	15.6	19.8
G_1-INM	9.3	15.8	19.4
CD (0.05)	NS	NS	NS
Weeding practices			
W_1-Manual weeding	6.8	14.8	15.8
W_2-Mechanical weeding	8.3	16.6	18.2
CD (0.05)	0.5	0.7	0.7

Table 2: Effect of genotypes, establishment methods, weeding and manuring practices on rice dry matter production (kg ha^{-1})

Particulars	Crop growth stages		
	AT	PI	FF
Genotypes			
V_1-CORH 2	1428	4079	10338
V_2-ADT 46	1265	3903	9092
CD (0.05)	55	106	285
Establishment methods			
P_1-Direct seeding	1333	4018	9637
P_2-14 days old seedlings	1420	4048	9951
P_3-28 days old seedlings	1286	3908	9557
CD (0.05)	96	NS	NS
Manuring practices			
G_0-Inorganics alone	1321	3951	9751
G_1-INM	1371	4032	9679
CD (0.05)	NS	NS	NS
Weeding practices			
W_1-Manual weeding	1338	3961	9398
W_2-Mechanical weeding	1354	4021	10032
CD (0.05)	NS	NS	285

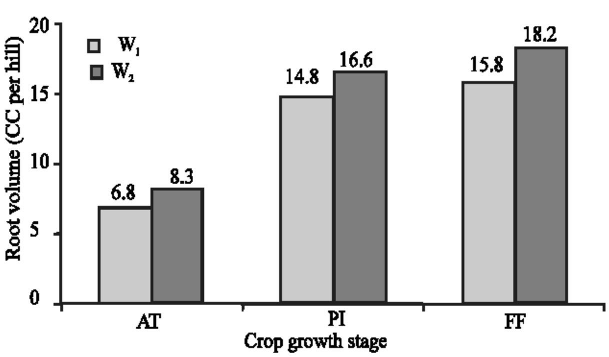

Fig. 1: Influence of weeding practices on root volume at critical crop growth stages

The manuring practices viz., inorganics alone (G_0) and INM (G_1) failed to influence root volume and DMP at all the crop growth stages. This is in contradiction with the findings of Sheeba and Kumarasamy[23] who reported higher total dry matter in the treatments that received either FYM or GLM than the unmanured plot. Among the weeding practices mechanical Weeding (W_2) recorded higher root volume than the manual weeding. This is due to the aeration of top horizon of the soil and the regeneration of newer roots due to the pruning effect by the mechanical weeder[16]. This finding has also got support from Armstrong and Webb[2] who observed the possibility of rice roots extended growth under the influence of oxygen. This is confirmed by the redox measurements observed in the same study. The Fig. 3 revealed that mechanical weeding better aerated the rhizosphere region of rice by increasing the Eh values from -139 to -128 mV and +176 to +184 mV. Those increased Eh values resulted from the cumulative of aeration caused by mechanical churning of soil (short term effect) by mechanical weeder and enhanced root growth, in turn higher oxidizing power (long term effect) under mechanical weeding. This finding got support from Ando *et al.*[9], Elessa and Fischer[11] and Reddy and Patrick[10] who were observed the oxidising power of rice roots under reduced soil condition.

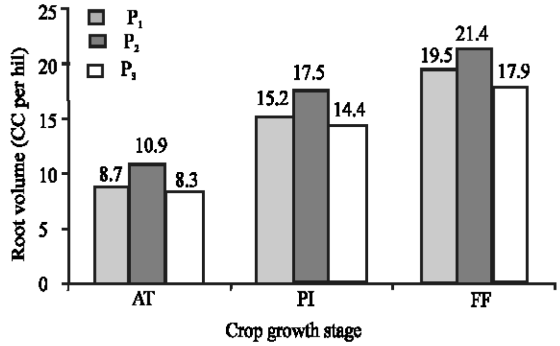

Fig. 2: Influence of establishment methods on root volume at critical crop growth stages

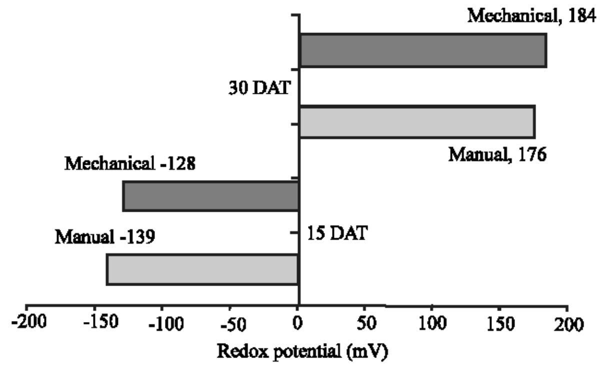

Fig. 3: Influence of weeding practices on rhizosphere redox potential

Finally, transplanting SRI seedlings (14 days old) singly and with wider spacing plus growing them in aerated soil (mechanical weeding) produced larger root system. Thus individual practices of SRI are each beneficial but real pay off is collectively produced through greater root development[1,8,13,14].

ACKNOWLEDGMENTS

The authors are indebted to Dr. V. Balasubramanian and Dr. Ronald J. Buresh, IRRI, Philippines for their financial assistance and continuous encouragement to carry out the investigation.

REFERENCES

1. Uphoff, N., 2003. Possible gains achieved with the System of Rice Intensification (SRI). Paper Presented on International Symposium on Transitions in Agriculture for Enhancing water productivity. Tamil Nadu Agricultural University, Killikulam, India. September, 22-25.
2. Armstrong, W. and T. Webb, 1985. A critical oxygen pressure for root extension in rice. J. Exp. Bot., 36: 1573-1582.
3. Randriamiharison, 2002. Research results on the system of rice intensification in Madagascar. Country Report of the International Conference on the System of Rice Intensification (SRI), Chinese National Hybrid Rice Research Centre, Sanya, China, April 1-4.
4. Shao-bua, W., C. Weixing, J. Dong, D. Tingbo and Z. Yan, 2002. Physiological charcteristics and high-yield techniques with SRI rice. In: http://ciifad. cornell.edu/sri.
5. Nagarajah, S., M.C.G. Robielos and H.U. Neue, 1986. Effect of *Sesbania rostrata* and *Azolla microphylla* and rice straw on soil solution kinetics of a flooded quoll. The Philipp. J. Crop Sci., 11: 1.
6. Dekamedhi, B. and S.K. De Datta, 1995. Effect of green manure and prilled urea on the changes of electro chemical properties of soil under lowland rice. J. Ind. Soc. Soil Sci., 43: 572-577.
7. Tadano, T. and S. Yoshida, 1978. Chemical changes in submerged soils and their effect on rice growth. In: Soils and Rice, IRRI, LosBanos, Philippines, pp: 399-420
8. Van Breemen, N. and F.R. Moorman 1978. Iron Toxicity. In: Soils and Rice, Los Banos, Philippines, pp: 781-800.
9. Ando, T., S. Yoshida and I. Nishiyama, 1983. Nature of oxidizing power of rice roots. Plant Soil, 72: 57-71.
10. Reddy, K.R. and W.H. Patrick, 1986. Denitrification Losses in Flooded Rice Fields. In: Nitrogen Economy of Flooded Rice Soils. De Datta, S.K. and W.H. Patrick, (Eds.). Matinus Nijhoff Publishers, Dordrecht, The Netherlands, pp: 99-116.
11. Elessa, H. And W.R. Fischer, 1992. Plant induced changes in the redox potentials of the rice rhizosphere. Plant Soil, 143: 55-60.
12. Armstrong, W., 1969. Rhizosphere oxidation in rice: An analysis of intervarietal differences in oxygen Flux from the roots. Physiol. Plant., 22: 296-303.
13. Armstrong, W., 1970. Rhizosphere oxidation in rice and other species: A mathematical model based on the oxygen flux component. Physiol. Plant, 23: 623-630.
14. Barison, J., 2002. Nutrient-use efficiency and nutrient uptake in conventional and intensive (SRI) rice cultivation systems in Madagascar. M.Sc Thesis, Cornell University, Ithaca, NY.
15. Joelibarison, 1998. Perspective de development de la region de Ranomafano: Les mechanisms physiologiques du riz sur de bas- fonds: Cas du SRI Memoire de fin d 'etudes. Antananarivo: Ecole superieure des sciences Agronomiques University of Antananarivo.
16. Longxing, T., W. Xi and M. Shaokai, 2002. Physiological effects of SRI methods on rice plant. In Assessments of the Systems Rice Intensification: Proceedings of an International Conference, Sanya, China, April 1-4, 2002, Uphoff, N., *et al*. (Eds.), Ithaca, NY: Cornell International Institute for Food, Agriculture and Development, pp: 132-139.
17. Hesse, P.R., 1971. A Text Book of Soil Chemical Analysis. William Clowes and Sons Limited, London, pp: 436-459.
18. Ganesh, S.S., 2001. Studies on the integrated effect of organic and inorganic nitrogen sources for hybrid rice. M.Sc. Thesis, Tamil Nadu Agriculture University, Pajancoa, Karaikal, India.
19. Subbaiah, S.V., R. Mahendra kumar, S.P. Singh. and M.S. Ramesha, 2002. Studies on Nitrogen and Phosphorus response in transplanted hybrid rice (*Oryza sativa* L.) J. Agric. Res, Manage., 1: 113-119.
20. Yamauchi, M., S.S. Viramani and B.S. Vergara, 1985. Harvest index and straw weight of some experimental F_1 rice hybrids. IRRN., 10: 19-21.
21. Nisha, P.T., 2002. Physiological response of rice hybrids CORH 2 and ADTRH 1 to integrated crop management techniques. M.Sc Thesis, Tamil Nadu Agric. Univ. Coimbatore, India.
22. Prabhakar, S.V.R.K. and S. Narsa Reddy, 1997. Rice productivity as affected by dates of seeding and methods of planting. Andhra Agric. J., 44: 30-32.
23. Sheeba, S. and K. Kumarasamy, 2001. Residual effects of inorganic and organic manuring on certain soil properties and yields of rice crop. Madras Agric. J., 88: 430-434.