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Effect of drought stress and nutrient solution electrical conductivity (EC) on dry matter partitioning of rice plants

K.P. Halder[1], S.W. Burrage[2] and M.S. Islam[1]
[1]Farm Management Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh
[2]Imperial College of Science, Technology and Medicine (Wye-Campus), University of London, UK

Abstract

The effect of intermittent water stress and nutrient solution EC on dry matter partitioning in leaf, stem, root and panicle of rice were studied. The rice plants were grown in NFT. Results revealed that in the unstressed situation 51.2% of the dry matter was translocated to panicles in the EC 3.0 plants and 40.8% in the EC 2.0 plants. Under drought stress situation especially during the reproductive phase only 24.6-34.1% of the dry matter was transferred to the panicle, most of the dry matter (37.1-45.8%) was concentrated in the stem. The EC 2.0 plants had a greater proportion of dry matter in the roots than the EC 3.0 plants..

Keywords: Drought stress, Solution EC, Dry matter partitioning and Rice

Introduction

The availability of water in the growing medium influences the partitioning of photosynthates into different organs of a plant. Wardlaw (1990) reported that partitioning of photosynthates and its effect on dry matter distribution is influenced by several factors such as drought, mineral nutrient availabilities and temperature. Under a drought stress situation, root growth is often less inhibited than shoot growth (Blum *et al.*, 1983) and more carbohydrate is translocated to roots. Penning de Vries *et al.* (1989) found that dry matter partitioning between root and shoot was altered depending on moisture availability in the growing medium. They found dry matter partitioning was not significantly influenced by moderate moisture stress but under severe stress at the vegetative stage dry matter translocation to roots was increased by 50%, which would, otherwise move to shoots.

Information regarding dry matter partitioning of rice into leaf, stem, panicle and root is not adequate when plants were drought stressed and grown under different level of nutritional status in the growing medium. Therefore, for better understanding of drought stress effects on dry matter distribution in rice, this experiment was conducted in nutrient film technique (NFT) and stressed period was considered until the plant received a set amount of solar radiation (1.20 MJm^{-2}).

Materials and methods

The trail was conducted in the glasshouse unit of the Imperial College, Wye- Campus, University of London, UK during May to October 2000. Rice (*Oryza sativa* L. *cv.* BR 24) seeds were germinated in an incubator at constant temperature of 30^{0}C for 48 hours. After germination, the individual seeds were placed in small wetted rock wool cubes (2.54 x 2.54 x 3.80 cubic mm). The cubes were placed in trays in a glasshouse at a temperature of 26 ^{0}C day and night. After 5 days, when the seedlings had reached 3–4 cm height, they were given equal amount of the mixture of 1% stock solution A and 1% stock solution B of Wye nutrient solution (Varley and Burrage, 1981). After 10 days when the seedlings had reached 15-16 cm height, they were chosen for uniformity and transferred to larger rock wool cubes (10 x 10 x 6.5 cubic mm). Then the larger rock wool cubes were transferred to the NFT system (Fig. 1).

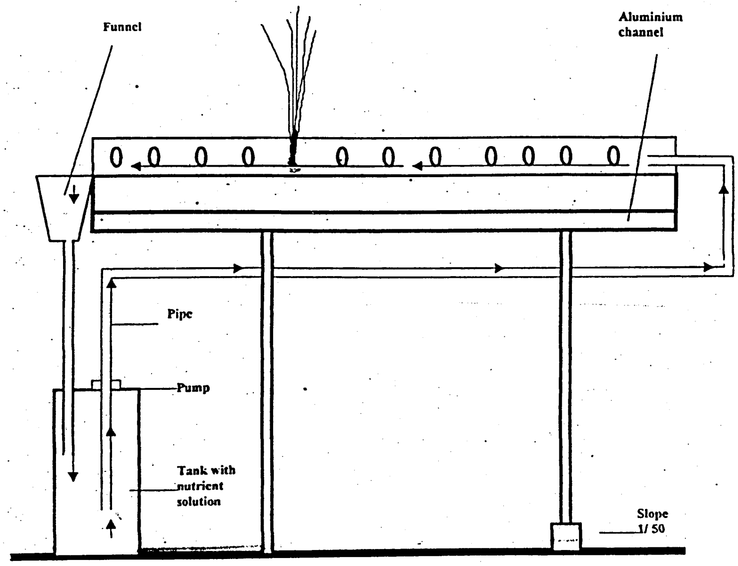

Fig. 1: Basic unit of NFT system

Each gully contained 12 plants. The solution p^H was maintained at 5.5-6.5 by using 5% acid mixture of nitric and orthophophoric acid (3:1). The plant spacing was 20 cm within the row and 20 cm between rows. Day and night temperatures were set at 26 ^{0}C and 21 ^{0}C respectively. Ventilation of the cubicle was set at 29 ^{0}C.

Water stress was imposed in relation to solar radiation received by the plant because the water loss by a plant through transpiration depends upon the availability of solar energy received. To develop a controlled stress on plants, water was withheld from the plant until the plant received 1.20 MJ m^{-2} solar radiation. The water stress treatments were adjusted by controlling the period between recirculation of the nutrient solution by means of a computer connected to a tube radiometer. The total radiation received within the glasshouse was integrated and the pumps were switched on for 15 minutes after a fixed amount of energy (1.20 MJ m^{-2} solar radiation), according to the treatment, had been received inside the glasshouse. Four water stress treatments (CC= Continuous circulation of nutrient solution throughout the life cycle; VS= Water stress was imposed 15 days after transplanting to panicle initiation stage; RS= Water stress was imposed from panicle initiation (PI) to maturity of the crop; WS= Water stress was imposed from 15 days after transplanting to maturity of the crop) and two level of nutrient solution EC (3.0 mS cm^{-1} and EC 2.0 mS cm^{-1}) were used. The treatments were laid out in a randomized complete block design (Factorial) and replicated four times. Plant samples from each replication were randomly selected at the maturity of the crop. The collected plants were separated into leaf, stem (stem + leaf sheath), panicle and root. The plant material was oven dried at 75 ^{0}C to a constant weight and dry weight (DW) was determined. The collected data were analyzed by following the Genstat computer software programme (Genstat Committee, 2000).

Results and discussion

It was observed that regardless of water stress, the EC 3.0 plants produced significantly ($P<0.05$) more dry matter than EC 2.0 plants except VS plants (Fig. 2). This result partially agreed with the finding of De Kreij and Van (1988). They found when roses grown in rock wool in an irrigation solution EC above 1.9 mS cm^{-1} gave a higher dry matter content than roses grown with an EC 1.5 mS cm^{-1} solution. The CC plants produced the highest dry weight and WS plants produced the lowest dry weight. There was no significant difference between VS and RS plants.

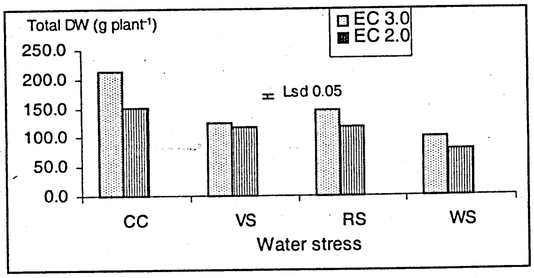

Fig. 2: Interaction effect of water stress and nutrient solution EC on dry matter production in rice plants. Lsd 0.05 value indicates difference between different water stress treatments under same level of EC; and different EC level under same water stress treatment.

In CC and VS plants the panicle made up the greatest proportion of dry weight followed by stem, leaf and root (Fig. 3). In the RS and WS plants the stem supplied more of the DW followed by panicle, leaf and root. In the unstressed situation (CC plants) the panicles of EC 3.0 plants had a greater proportion of the DW than in the EC 2.0 plants. In WS plants same trend was also observed. In VS and RS plants there was no significant difference between EC 3.0 and EC 2.0 plants. In general stress during different growth phases tended to decrease the panicle DW and increase the stem DW.

There were no consistent patterns in leaf and root DW. Brevedan and Hodges (1973) reported that when a plant is supplied with sufficient nutrient and ample water more photosynthates produced by photosynthesis will be transferred from source to sink. Their findings support the observation in this experiment; in plants grown with sufficient water (CC plants) 51.2% of the photosynthates were translocated to panicles in the EC 3.0 plants, 40.8% in the EC 2.0 plants. But when water supply was restricted especially during the reproductive phase only 24.6-34.1% of the dry matter was transferred to the panicle, most of the dry matter was concentrated in the stem (37.1-45.8%) suggesting that materials were not being translocated from source (stem) to the sink (panicle) when the plant was stressed. It was found that plants grown in EC 2.0 had a greater proportion of dry matter in the roots than the EC 3.0 plants indicating that dry matter allocation to the roots increased under nutrient limitation. This result is partially comparable with the findings of Ismail *et al.* (1994), McDonald and Davies (1996) who reported that N and P deficit plants or when plants experience a reduction in N supply, the growth of shoots is reduced more than that of roots probably due to a higher export rate of photosynthates to the roots. It may be concluded that the dry matter partitioning to the different plant parts depend on different levels of nutritional status in the growing medium under drought stressed condition at different growth phases of plant.

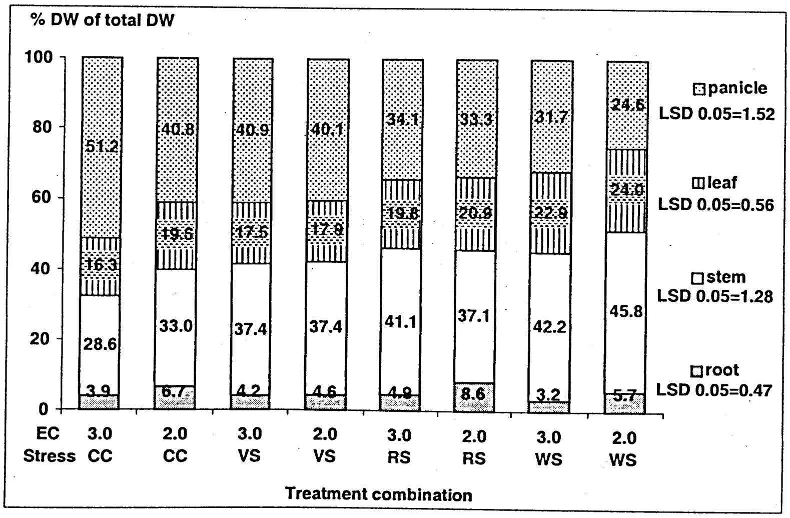

Fig. 3: Interaction effect of water stress and nutrient solution EC on percent distribution of dry matter in different plant parts of rice. LSD 0.05 value indicates difference between different water stress treatments under same level of EC; and different EC level under same water stress treatment.

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