I J T A
© Serials Publications
National Academy of Agricultural Science (NAAS)
Rating : 3. 03

Response of over Aged Seedlings under Different N level for Yield, N utilization Pattern and Dry Matter Partitioning of Rice under Waterlogged Situation

S. Roy Chowdhury[1], P. S. Brahmanand[1], D. K. Kundu[1], A. Kumar[1] and S. K. Ambast[1]*

Abstract: *The performance of 30, 45 and 60 day old rice seedlings was studied under waterlogged condition at three different levels of nitrogen e.g. 0,20 and 40 kg/ha N level. The reason behind use of nitrogen under waterlogged situation was to supplement deficit N level prevalent under waterlogged environment with agronomic intervention like N supplement. The performance of 60 days old rice seedling was found better at 40 kg/ha of N application level. The mud ball method of application of N showed significant increase in total N uptake under excess water situation. Better fertilizer N recovery as well as superior nitrogen use efficiency with increase in grain yield suggested efficacy of application method. Higher level of N resulted in significant increase in grain yield. The higher harvest index in aged seedling more so under higher N application suggested better N utilization by aged seedlings. The tight association harvest index with grain yield (r = 0.72* significant at p=0.05) further emphasized importance effective dry matter partitioning for higher yield.*

Key words*: over aged seedlings, panicle weight, yield, water logged areas*

INTRODUCTION

Paddy is a dominant crop in water logged ecosystem, even though its productivity is affected by adversities of waterlogged condition (Ghosh 2007). The difficulties of excess water situation particularly in low-lying areas during kharif season affects cultivation and production in about 4 million ha rice growing area in our country. Under waterlogged condition mainly standing water above surface scenario, paddy seedlings confronts two main constraints for rice crop *i.e.* survival of seedlings and maintenance of good crop stand. Many a time due to want of suitable variety with submergence tolerance and its appropriate agro-techniques hinder rice productivity in low land ecosystem. Use of over aged rice seedlings is promising in avoiding seedling mortality and low productivity in low-lying areas. Older seedlings with higher levels of carbohydrates were more tolerant to submergence (Vergara, 1985) than younger plants and showed better establishment in low-lying areas. The amount of carbohydrate in plant parts is often positively correlated with the level of submergence tolerance in rice seedlings (Palada and Vergara, 1972; Emes *et al*., 1988). Nursery grown older rice seedlings showed better seedling establishment and yield under waterlogged condition (Sharma and Panda 1989). Better performance of older seedlings with higher carbohydrate reserves than younger rice seedlings have also been reported by Chaturvedi *et al* (1995) and Mallik *et al.* (1995) in low lying waterlogged ecosystem. There has been changes in flowering time also in over aged seedlings when compared with normal aged seedlings (Viraktamath *et al* 1998). In this report we analyzed the effect of applied N on growth of overaged seedlings and their N utilization under waterlogged environment.

[1] ICAR-Indian Institute of Water Management, Bhubaneswar-751023. Odisha. India.

* Corresponding author; *E-mail: somnath_rc@yahoo.com*

MATERIALS AND METHODS

The field experiment was taken in the research farm of Directorate of Water Management, at Mendhasal during kharif season in 2007-08 under deep water condition. Rice seedling (local cultivar 'Pauli', long duration, tall) of 30, 45 and 60 days old was grown in nursery. These three different age group seedlings were used for experimental purpose. The experiment was conducted in spilt plot design with age of seedling in main plots and three levels of nitrogen i.e. 0, 20 and 40 kg/ha in subplots with three replications. The planting was done in mid-August and harvest was completed in December.

The nitrogen was given @ 0, 20 and 40kg ha^{-1} as mud ball method of application. The plot size of experiment was 10x5m with a depth of 1.5m so as to ensure different levels of applied fertilizers in different treatments in waterlogged condition. The spacing were maintained at 20x20cm and PK fertilizers was applied @ 40:40 kg ha^{-1}.The entire dosage P and K was applied during sowing time. The N was applied in three levels, @0,20 and 40kg/ ha. The application of N was split in three stages, i.e. 7 days after planting, at maximum tillering stage (58 days after transplanting) and at panicle initiation stage (93 days after transplanting) @10:5:5 and 20:10:10 kg ha^{-1} for 20 and 40kg ha^{-1} level of N respectively. The number of equal sizes mud balls was ten per plot. The crop was harvested in last week of December and yield of both grain and straw was recorded. The water level in experimental field was monitored with the help of a measuring scale. The total dry matter was recorded after drying samples in hot air oven at 70°C till constant weight and harvest index was calculated following standard formula (Yoshida *et al*. 1976). The crop was harvested at maturity. Grain yields were recorded at 14% moisture content and straw yields on an oven-dry-weight basis. Subsamples of grain and straw were dried to 70°C, ground to pass through a 0.5-mm sieve, and analysed for total N by a micro-Kjeldahl method (Nelson and Sommers, 1973). The N in grain plus N in straw were taken as the measure of total crop N uptake. The statistical analyses of data were done following Gomez and Gomez (1984).

RESULTS AND DISCUSSIONS

The water level in the field was 0.3m at the time of planting and its level increased until the month of September. The water level thereafter declined with recession of rainfall from October up to the time of harvest i.e. last week of December. The maximum water level was up to 1.05 meter in the month of September with increase in rainfall and thereafter it declined along with recession of rainfall (Fig. 1).

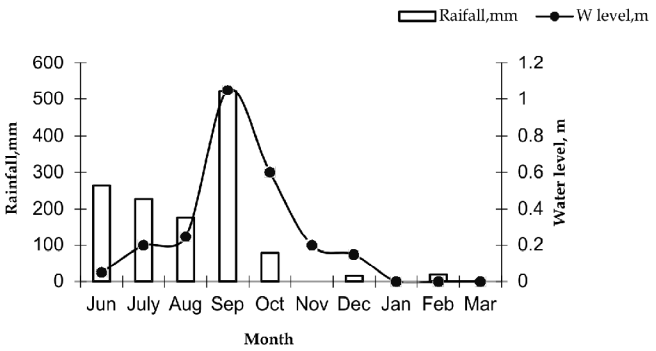

Figure 1: The rainfall received and changes in water level at the experimental site

The N application showed improvement in grain yield at 20 and 40 kg N level compared to 0 kg N, significantly so in older seedlings (Fig.2). Both the age of seedling as well the dosage of applied N showed significant influence on the yield of the crop. However their interaction effect was found non-significant. Both the 45 and 60 d old seedlings showed superior total N uptake of 55.2 kg/ha and 52.8kg/ha compared to 30 days old seedlings (Fig.3). However the 45d old seedlings showed highest N recovery percentage (32%; fig 4).The better N utilization efficiency up to 21.5 kg grain/ kg N applied was observed at N level 20 and 40 kg N (fig.5). Nitrogen (N) availability is often the main factor limiting the realization of yield potentials in rice, and, according to Cassman *et al.* (1997), yield components are closely associated with the N supply at each growth period. Moreover, active absorption and metabolism of N result in large increase in dry weight, tillering, height and leaf area. Growth and yield differences in rice under different ecosystems might, therefore, be due to differences in nitrogen uptake-limiting processes. In the central plain of Thailand, N uptake of rice crop grown under deepwater ecosystem was found most closely

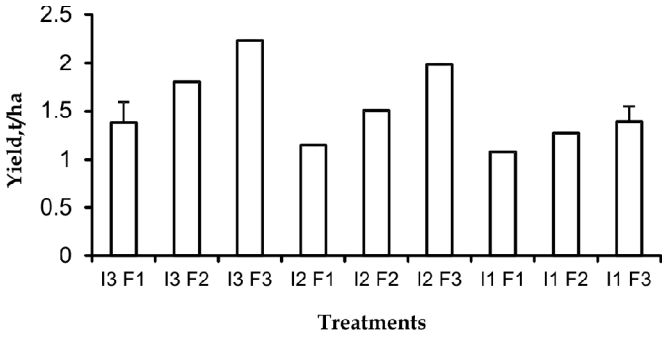

Figure 2: The grain yield in rice plants of three different age i.e.30 (I1), 45 (I2) and 60 (I3) days old at three different level of N 0 (F1), 20 (F2) and 40 (F3) kg/ha at the stage of harvest (120 days after transplanting). Each value is mean of three replications. First vertical bar lsd at p=0.05 for age of seedlings. Last vertical bar lsd for N at p=0.05. Age x N is non-significant.

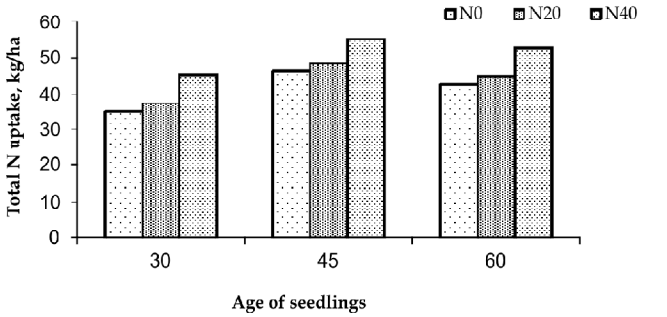

Figure 3: Pattern of total N uptake, kg/ha. in rice plants of three different age i.e.30 (I1), 45 (I2) and 60 (I3) days old at three different level of N 0 (F1), 20 (F2) and 40 (F3) kg/ha at harvest . Symbols and units are as in figure

related to grain yield through total dry mass, and 80% of total N in the crop was accumulated during the flood period (Puckridge *et al.*, 1994).

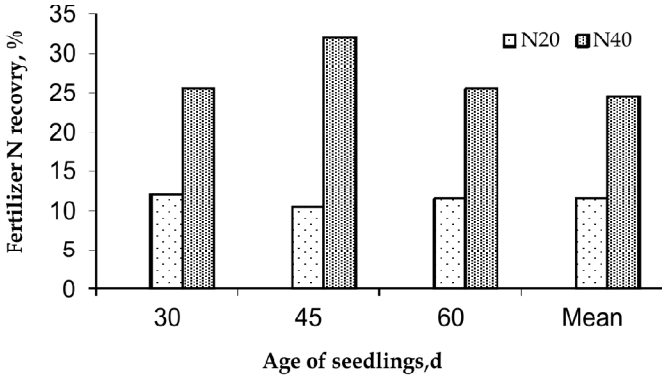

Figure 4: The trend of fertilizer N recovery (% compared to N 0 kg/ha; F1) in rice plants of three different age i.e. 30 (I1), 45 (I2) and 60 (I3) days old at 20 (F2) and 40 (F3) kg/ha at harvest. The pair of bars under symbol represents 'mean' values at levels of N i,e, 20 and 40kg/ha. Symbols are as in figure.

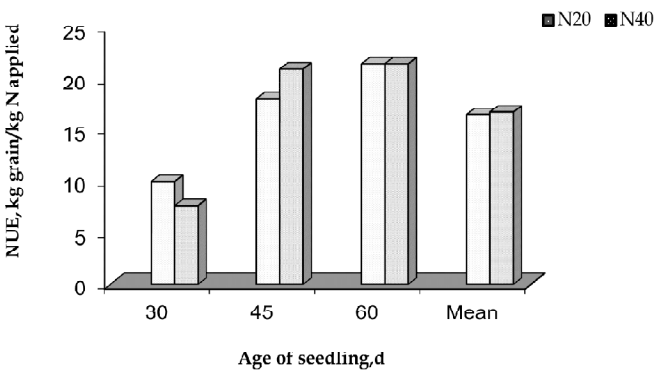

Figure 5: The nitrogen use efficiency (NUE kg grain produced/ kg N applied) in rice plants of three different age i.e.30 (I1), 45 (I2) and 60 (I3) days old at three different level of N 0 (F1), 20 (F2) and 40 (F3) kg/ha at harvest. The pair of bars under symbol represents 'mean' values at levels of N i,e, 20 and 40kg/ha. Rest symbols and units are as in figure.

Application of fertilizer N increased grain yield of rice regardless of the age of seedlings. The effect of N application was more pronounced in 60 days old seedlings than 30 days old seedling. However, effect of fertilizer N application on straw yield of rice under the waterlogged situation was not so clear. Similar response of intermediate deepwater rice to fertilizer N was earlier reported by Reddy et al. (1988). In their study, application of fertilizer N increased the plant height, number of tillers, dry-matter production and grain yield of rice. With increase in application of N fertilizer from 0 to 40 kg/ha, the N uptake of grain increased with little variation in N uptake of straw under intermediate deep water situation. In our study the grain yield was found highest in 60 days old seedling with 40 kg N (2.24 t/ha) whereas without N the grain yield in 60 day old seedlings was 1.38t/ha. The yield was observed lowest in 30 days old seedling without N (1.08 t/ha) and with increased with application of N to the grain yield in 30d old seedlings increased upto 1.39t/ha with application of N 40kg/ha rate (Fig. 2). In the present study, grain production efficiency of fertilizer N was higher (up to 21.5 kg grain/kg N compared to as low as 7.8 kg grain/kg N) when older rather than younger rice seedlings were used for crop establishment under the waterlogged ecosystem. And recovery of fertilizer N by rice under the waterlogged ecosystem increased with the dose of application. It was only 10.5 to 12.0% when applied @ 20 kg N/ha, and was

24.5 to 32.0% when applied @ 40 kg N/ha. In several N response studies of rice grown under intermediate deepwater ecosystem, the recovery of applied N was reported to range between 7 and 38% (Rao et al., 1985). The fertilizer N recovery data of the present study are therefore within the range reported by the previous researchers.

The near submergence condition in younger 30 day old seedlings might be one of the reasons for lesser response to added N compared to tall older seedlings. The harvest index also improved with age of seedling and increased level of N application from 0.25 to 0.36 from 30 days old seedling to 60 days seedling at 40 kg/ha N application (Fig. 6).

The harvest index showed close association (r = 0.72* significant at p=0.05)) with grain yield suggesting importance partitioning of dry matter for higher yield. While comparing the contribution of leaf nitrogen and yield of japonica and indica rice, Shimoda (2012) found that length of grain filling period and time of senescence are two more critical factors, compared to contribution of leaf N determining productivity in rice. Under waterlogged environment initial survival of seedlings and establishment of good crop stand are two major issues for better productivity. The older rice seedlings have been reported to give better stand and yield under waterlogged condition (Sharma and Panda 1989,Ghosh 2006) mainly due to higher carbohydrate reserves than younger seedlings (Chaturvedi *et al*1995). Faster rate of depletion of carbohydrates in younger rice seedlings makes them vulnerable under waterlogged condition (Das *et al*. 2009). The tall older seedlings can also escape submergence for a longer period than younger seedlings.

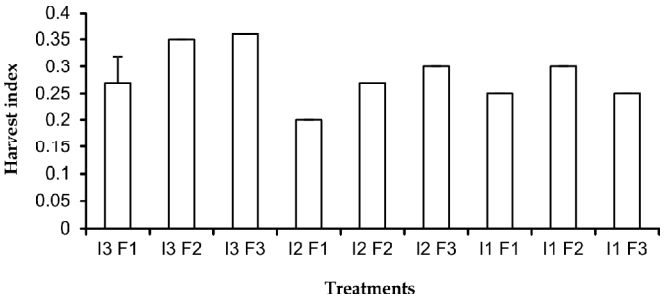

Figure 6: The harvest index in rice plants of three different age i.e.30 (I1), 45 (I2) and 60 (I3) days old at three different level of N 0 (F1), 20 (F2) and 40 (F3) kg/ha at harvest. Vertical bar lsd at p=0.05 for age of seedlings. Age x N is non-significant

Data on the grain yields and harvest index of rice vis-à-vis their N uptake from the present study revealed that applied fertilizer N contributed to both production and partitioning of dry matter under the waterlogged ecosystem. Moreover in our study under excess water condition, 60 days old seedling at 40kg N level showed better dry matter partitioning and gave highest yield .Therefore for realizing better N economy in rice cultivation under waterlogged situation, use of older (45 to 60 day old) seedlings and moderate dose of fertilizer N (40 kg/ha) are necessary.The closer association of yield and harvest index indicated that dry matter partitioning efficiency might be a critical determinant for higher yield in over aged seedlings at high N level under waterlogged scenario.

References

Cassman, K. G., S. Peng, D. C. Olk,J. K. Ladha, W. Reichardt, A. Dobermann and U Singh. (1997).Opportunities for increased nitrogen use efficiency from improved resource management in irrigated rice systems. Field Crops Res. 56: 7–39.

Chaturvedi, G.S., C.H. Mishra, O.N. Singh, C.B Pandey, V.P. Yadav, A.K Singh, J.L Dwivedi, B.B Singh and R.K. Singh.(1995). Physiological basis and screening for tolerance for flash flooding In: Ingram KT, ed. Rainfed lowland rice–agriculture research for high risk environments. Manila: International Rice Research Institute, 79–96.

Das, B. P., P.Dash and A.T.Roy. (2009). Role of total sugar and starch content of rice seedlings at different ages in variable submergence tolerance. Oryza .46: 304-09.

Emes, M.J., C.P.Wilkins, P.A. Smith, K. Kupkanchanakul, K. Hawker, W.A.Charlton, E.G. Cutter. (1988). Starch utilization by deepwater rices during submergence. In: 1987 International Deepwater Rice Workshop. Manila: International Rice Research Institute, 319–326.

Ghosh, A.(2007). Impact of stand density and levels of nitrogen on yield maximization and N utilization of rice (*Oryza sativa*) under deep water situation. Indian Journal of Agricultural Science. 77:109-110.

Gomez, K and A.A. Gomez.(1984). Statistical procedures for agricultural research. 2nd. Ed. "An International Rice Research Institute Book". .John Wiley and Sons. New York. P : 676.

Mallick, S., C.Kundu., C.Banerji, D. K.Nayak, S. D.Chatterji., P. K.Nanda., K. T.Ingram and T.L.Setter(1995). Rice germplasm evaluation and improvement for stagnant flooding. *Rainfed lowland rice-agriculture research for high risk environments,* pp 97-109. Ingram K T (Ed). International Rice Research Institute, Los Banos, Philippines.

Nelson D.W. and L.E. Sommers (1973). Determination of total nitrogen in plant material. Agron. J. 65: 109-111.

Palada M.C, B.S. Vergara.(1972). Environmental effects on the resistance of rice seedlings to complete submergence. Crop Science 12: 209–212.

Puckridge D.W., M. Kongchum, P. Thongbai, A. Sattarasart, and S.Sinoupakarn. (1994). Nitrogen uptake and yield of deepwater rice in the central plain of Thailand. Field Crops Res. 37: 193-204.

Rao M.V., B.B.Reddy, B.C.Ghosh and M.M. Panda.(1985). Nitrogen management in direct sown intermediate deepwater rice. Plant Soil 83: 243-253.

Reddy M.D., M. M. Panda, B. C. Ghosh and B. B. Reddy. (1988). Effect of nitrogen fertilizer on yield and nitrogen concentration in grain and straw of rice under semi-deepwater conditions. Journal of Agricultural Science 110: 53-59.

Sharma, A.R and M. M. Panda. (1989). Management of rainfed low land. CRRI annual report. p. 38.

Shimoda, S. (2012). Contribution of leaf nitrogen to photosynthetic gas exchange in contrasting rice (*Oryza sativa* L.) cultivars during grain filling period. Photosynthetica. 50. 387-396.

Vergara, B.S. (1985). Growth and development of deep water rice plants. IRRI Research Paper Series 103. Los Banos: International Rice Research Institute.

Viraktamath,B.C., S. Singh., C.H.N. Vijayakumar, M.S. Ramesha, and M.I. Ahmed. (1998). Effect of seedling age on flowering time in A,B and R lines. IRRN 23. 23-24.

Yoshida, S., D. Forno, J.H.Cock and K.A.Gomez. (1976). Laboratory manual for Physiological Studies of rice. 3rd ed. The International Rice Research Institute, Los Banos, Philippines. P: 46.