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Original Research Article

Effect of Drought Stress on Yield and Yield Components of Rice (*Oryza sativa* L.) Genotypes

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Keywords

Rice, Drought, Stress, Growth and Yield

A B S T R A C T

A pot experiment was conducted with rice genotypes Swarna sub1, Nagina 22, NDR 102, NDR 97 and Susk Samrat during kharif season 2015-16 at the student instructional farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P). Drought treatment was given for 7 days at reproductive stage. The screening of rice genotypes was done on the basis of plant height, tiller number per plant, days to 50% flowering, leaf area , test weight, chlorophyll content and grain yield per plant. The rice genotypes Nagina22, NDR 102 and Susk Samrat showed less percent reduction in yield and yield components comparatively Swarna sub1. Therefore, on the basis of yield and yield component Nagina 22 showed high tolerance in compare to other genotypes.

Introduction

Rice is the important primary and staple food for more than two-third of the world's population (Dowling et al. 1998). About 7.5 % of total rice production comes from irrigated lowlands (Bouman and Tung, 2001). Abiotic stresses especially drought can affect the physiological status of an organism and have adverse effects on growth, development, and metabolism (Chutia and Borah 2012). Drought is an abiotic stress which affects plants at various levels and stages of their life period. This abiotic stress not only affects plant water relations through the reduction of water content, turgor, and total water, but it also affects stomatal closure, limits gas exchange, reduces transpiration, and disturbs photosynthesis (Razak *et al.* 2013). Negative effects of water deficit on mineral nutrition and metabolism decrease the leaf area and alter assimilate partitioning among the plant organs (Zain *et al*. 2014).

Drought is a meteorological term and is commonly defined as the inadequacy of water availability including period without significant rainfall that affects the crop growth (Hanson *et al.,* 1995) and soil moisture storage capacity and it occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation. Drought has been recognized as the primary constraint to rainfed rice production (Datta *et al.*, 1975). Generally drought stress occurs when the available water in the soil is reduced and atmospheric conditions cause continuous loss of water by transpiration or evaporation. Drought stress tolerance is seen in almost all plants but its extent varies from species to species and even within species.

Drought stress is considered to be a moderate loss of water, which leads to stomatal closure and limitation of gas exchange. Desiccation is much more extensive loss of water, which can potentially lead to gross disruption of metabolism and cell structure and eventually to the cessation of enzyme catalyzed reactions (Jaleel *et al.,* 2007d). Drought stress is characterized by reduction of water content, diminished leaf water potential and turgor loss, closure of stomata and decrease in cell enlargement and growth. Severe water stress may result in the arrest of photosynthesis, disturbance of metabolism and finally the death of plant (Jaleel *et al.,* 2008c). Drought is a major abiotic stress that adversely affects the rice growth, mostly in the rainfed ecosystem that ultimately affects the biomass production and yield. Rice needs to adapt a series of physiological mechanisms with complicated regulatory network to fight and cope up with the unfavourable conditions due to drought stress.

Drought stress is characterized by reduction of water content, diminished leaf water potential, turgor pressure, stomatal activity and decrease in cell enlargement and growth. Severe water stress may result in the arrest of photosynthesis, disturbance in metabolism and finally the death of plant (Jaleel, *et al.,* 2008c). It reduces plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters (Farooq, *et al.,* 2008,). Water stress is a limiting factor in agriculture production by preventing a crop from reaching the genetically determined theoretical maximum yield (Begg and Turner, 1976). In plants, a better understanding of the morphological and physiological basis of changes in water stress resistance could be used to select or create new varieties of crops to obtain a better productivity under water stress conditions (Nam *et al.,* 2001). The reactions of plants to water stress differ significantly at various organizational levels depending upon intensity, duration of stress, plant species and its growth stages (Jaleel *et al.,* 2008b**).**

Materials and Methods

A pot experiment was conducted with rice genotypes swarna sub1 ,Nagina 22, NDR 102, NDR 97 and susk samrat during kharif season 2015-16 at the student instructional farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P). Drought treatment was given for 10 days at 35 days old seedling and 10 days reproductive stage. Data related to yield and yield components of five plants were recorded and average out to one as a per plant. Plant height was recorded at the maturity from base of plant to base of panicle of five plants and average out to one. Tiller number of five plants were recorded separately and average out to one as a per plant at the time of maturity. The leaf area was recorded as width x length x 0.57 factor of five plants and average out to one as a leaf area per plant. Chlorophyll content was recorded by Chlorophyll meter as total chlorophyll content as SPAD value. Grain yield of five plants randomly recorded and average out to one as grain yield per plant (g). Test weight was recorded by randomly counting 1000 seeds and weighted in gram as test weight per plant.

Results and Discussion

Drought stress reduced the plant height irrespective rice genotypes (fig. 1). High reduction in plant height was recorded in Swarna Sub 1 (49.31%) while low reduction in Nagina 22 (17.56%), Susk Samrat, NDR 97(19.99%) and NDR102 (28.55%). The drought stress reduces the metabollic activitiy due to lack of water. Such condition due to reduce turgor pressure affects the cell division and cell elongation activities of plant and resultantly plant height reduces. Similar results were reported by Yeo *et al. (*1999) who observed that water deficit reduced yield in *Oryza Sativa.*

Drought stress reduces the tiller number per plant in all rice genotypes (Fig2). Maximum reduction in tiller number is recorded in Swarna Sub 1 (25.82%) while minimum in Nagina 22(8.76%).The number of tillers reduces due to reduced growth and photosynthesis processes of plant (Quampah *et al., 2011*).

Leaf area of rice genotypes significantly reduced irrespective of genotypes (Fig3). The high reduction in leaf area was recorded in Swarna Sub 1 (49.08%) while low in Nagina 22(18.70%) Susk Samrat (28.22%), NDR 97 (22.40%) and NDR 102 (20.60%). Negative effects of water deficit on mineral nutrition and metabolism decrease the leaf area and alter assimilate partitioning among the plant organs (Zain *et al*., 2014).

Days to 50% flowering significantly affected in rice genotypes due to drought stress (Fig 4). Maximum reduction in days to 50% flowering was recorded in Swarna Sub 1 (18.56%) which minimum in Nagina 22 (9.67%). Drought stress enhances the phasic change from vegetative to reproductive stage. Susceptible plant flowering early while resistant plants maintains it more or less about normal condition upto same extent (Fukaai et al 1999).

The total chlorophyll content varied in rice genotypes (Fig.5). Drought stress reduced the total chlorophyll content. Highest reduction in chlorophyll content was recorded in Swarna Sub-1 (33.33%) and lowest in Nagina 22 (7.93%). Energetic status of the chloroplast increases as a consequence of the water stress which has a direct relationship to that of increased amount of total chlorophyll and Chla and Chlb among the stressed induced verities (Ranjbar-fordoei *et al.* 2000).

Fig.1 Effect of drought stress on plant height (cm) of rice genotypes

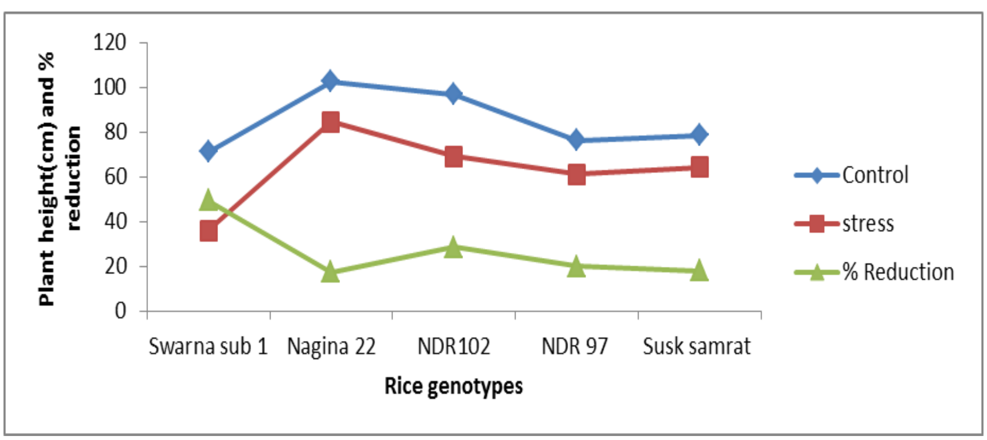


Fig. 2: Effect of drought stress on tiller number of rice genotypes

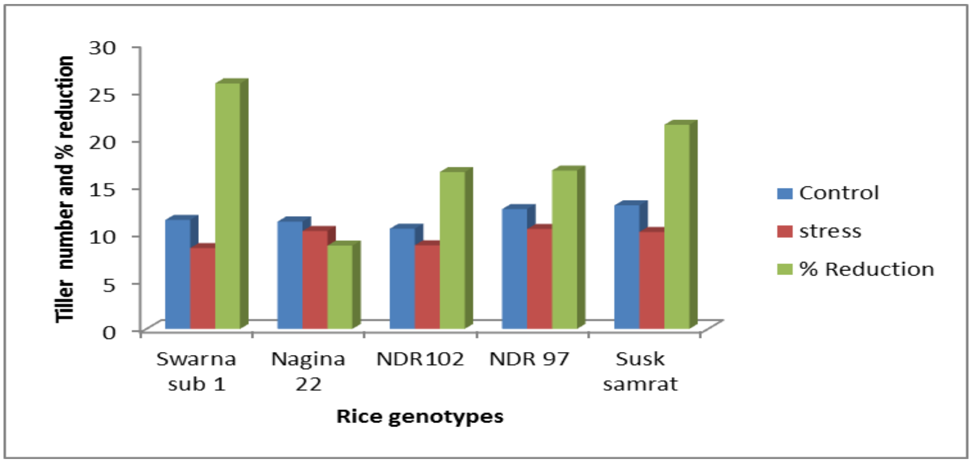


Fig.3 Effect of drought stress on leaf area (cm^2) of rice genotypes

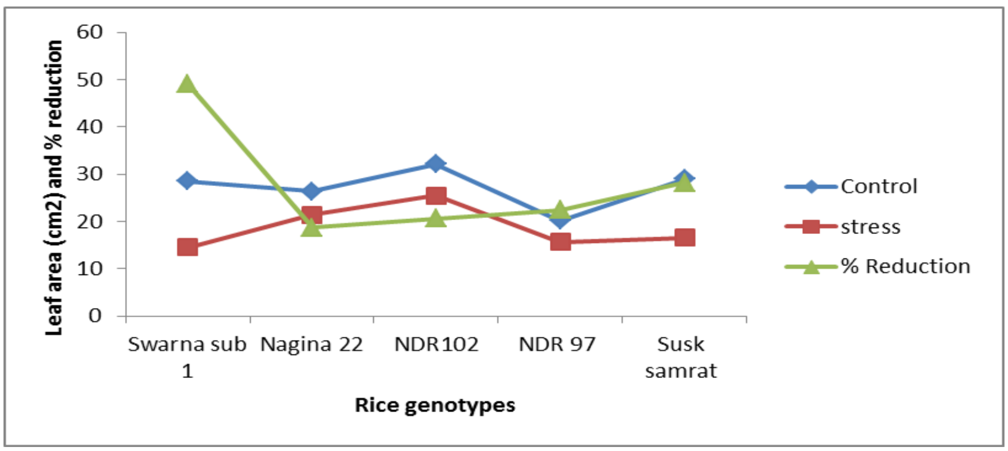


Fig. 4: Effect of drought stress on days to 50% flowering of rice genotypes.

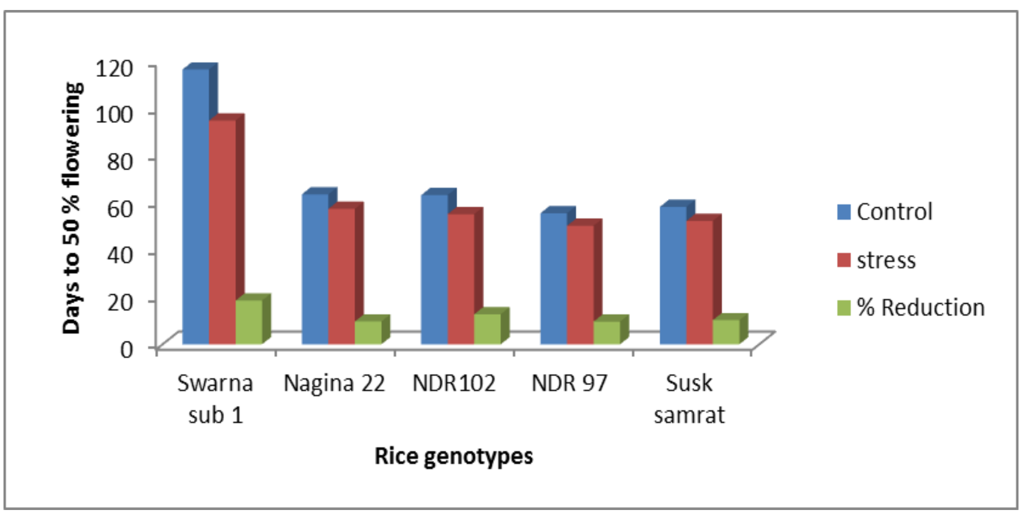


Fig. 5: Effect of drought stress on total chlorophyll content (SPAD) of rice genotypes

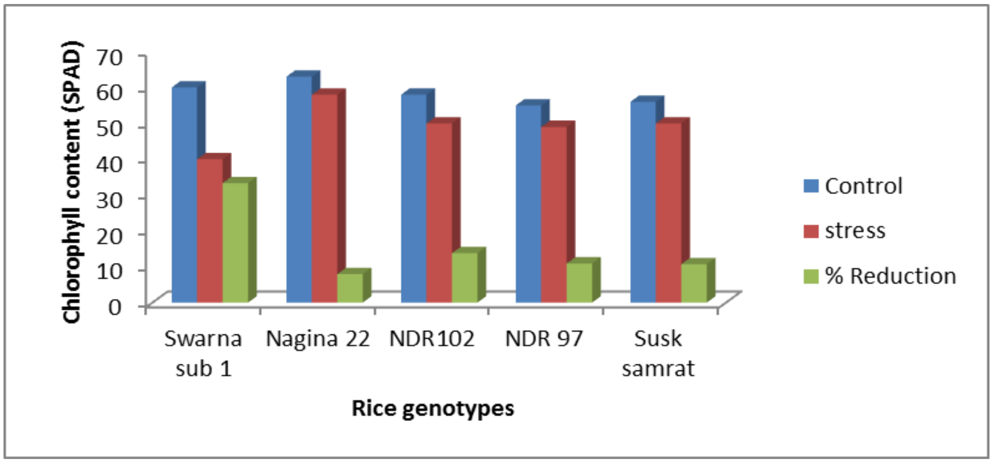


Fig. 6: Effect of drought stress on test weight (g) of rice genotypes

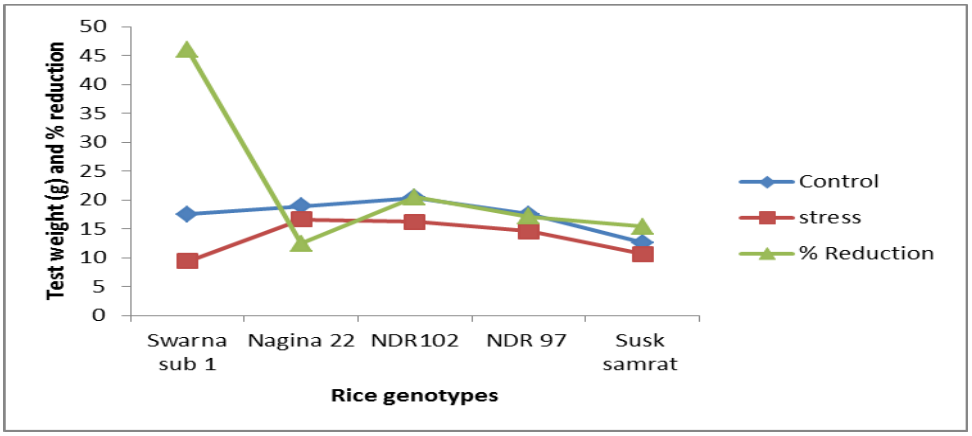
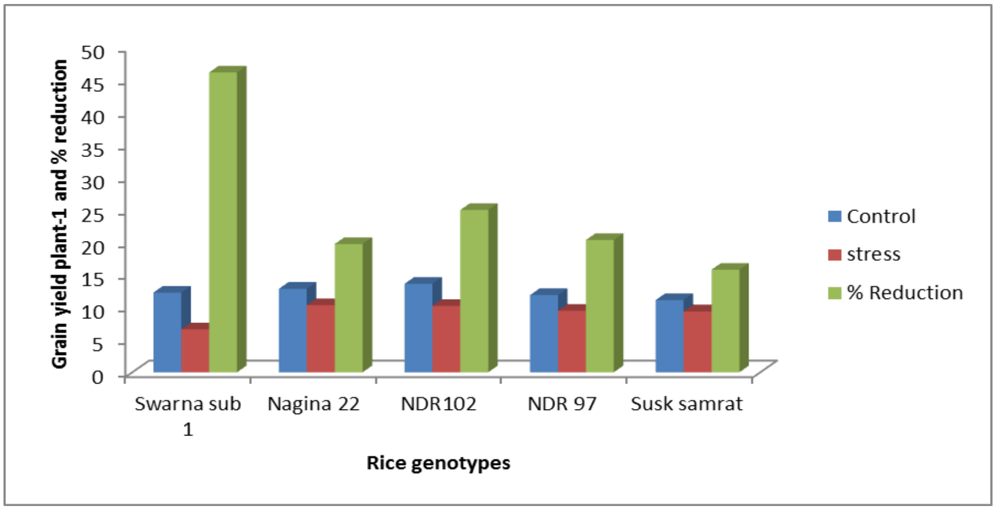


Fig. 7: Effect of drought stress on grain yield (g) of rice genotypes



Rice genotypes showed genetic high variability in test weight of Swarna Sub1 (46%),NDR 102 (20.47%), NDR 97(17.08%) and low reduction showed in Nagina 22(12.44% (fig.6). Grain size, shape and ultimately weight reduces under water stress regimes. In reduces water content in plant limit the reproductive development and grain growth. (Pantuwan *et al.*, 2000).

There was genetic variability noted in grain yield of rice genotypes (fig 7).grain yield of rice genotypes varies under control and stress condition. Drought stress significantly reduced the grain in Swarna Sub 1 (46.07%) which low reduction was recorded in Nagina 22 (19.71%) NDR 97 (20.32%) and NDR 102 ((24.94%). Drought stress significantly decrease the grain yield /plant in reproductive stage. Drought stress reduces the rice growth and severely affects different traits, such as seedling biomass, stomatal conductance, photosynthesis, starch metabolism, and plant water relations (Sarkarung *et al*. 1997 and Quampah *et al.* 2011). Pantuwan *et al.* (2000) reported that grain yield of some rice varieties was reduced by up to 81 % under drought condition and this reduction depended on timing, duration, and severity of the plant water stress

Conclusion

Drought stress highly reduced yield and yield components of rice genotypes. Nagina 22 and NDR 97 showed less reduction under drought stress over Swarna Sub1. Swarna Sub1 was highly susceptible to drought stress.

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