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PERFORMANCE OF TWO WHEAT *(TRITICUM AESTIVUM)* GENOTYPES IN RESPONSE TO WATERLOGGING AT DIFFERENT GROWTH STAGES UNDER NON-SALINE AND SALINE SOIL CONDITIONS

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A pot culture study was conducted on growth and yield performance of two wheat genotypes (Pato and SA RC-6) in response to waterlogging under non-saline (2.96 d Sm') and saline (15 d Srn") soil conditions in a wire house. Desired salinity of 15 d Sm'l was developed by mixing required amount ofNaCI salt in the soil before filling the pots. The treatments within each set comprised of watcrlogging imposed for a period of 21 days at different growth stages, i.e., tillering. booting and grain tilling alone or in different combinations. At maturity, data regarding grain yield and different yield components were recorded. The maximum reduction in grain yield was observed when waterlogging was imposed at tillering and then at grain tilling stage followed by the decrease due to a spell of waterlogging at grain tilling stage alone and at booting stage alone, respectively, Also. salinity increased the effect ofwaterlogging at all growth stages, but the trend remained the same as was observed under non-saline soil conditions.

Key words: Genotypes, growth stage. salinity, *Triticum aestivum*, waterlogging, wheat

INTRODUCTION

Salt-affected and waterlogged soi Is are a common feature of irrigated agriculture of the world. According to an estimate, 25°'0 of the world' s irrigated and 60% of the cultivated land is affected by sal inity (Suarez and Rhoades, 1991). The area of salt-affected land in Pakistan is estimated at about 6.67 mha (Khan. 199X). about half of which is under the canal command.

Poor drainage affects perhaps as much as one half of the world's irrigated land (Donman and Houston. 1967), Flood irrigation on dense soils with low permeability rate and high soil temperature can also rapidly deplete soil oxygen and damage crops (Hodgson. 1982). In Pakistan, the temporary tlooding or permanent waterlogging has affected an area of Q, 17 mha (Rafiq. I()9()) and 1.16 mha of the land is subjected to the dual mcu.uicc of salinity and waterlogging (Qureshi, 1(93).

Salinitv is inimical to plant growth through numerous complex interactions including specific ion toxicities, osmotic effects and/or induced nutrient deficiencies (Wyn Joncs. 1981). A strong negative correlation between the Na and Cl" concentrations in leaf sap and fresh weight of a number of wheat genotypes has been shown by Qureshi and Aslam (19XY) and Saqib et al. (1999). Oxygen deficiency or hypoxia is a major component of damage under waterlogged conditions (Trought and Drew, 1980).

Soil environment becomes particularly adverse for plant growth where salinity and waterlogging occur together. Salinity and waterlogging interact to allow large and rapid accumulation of toxic Na and Cl" in the shoots of many plants including wheat (Akhtar et al., 1994; Saqib et al., 1(99). In most of the cases. waterlogging is intermittent and its time of start with respect to g'ywth stage of the plant and duration is quite variable, Therefore, the effects of waterlogging and saline waterlogged conditions on plants and their intensities will largely depend on the growth stage of plant.

Earlier, a number of experiments have been conducted to study plant response against salinity and waterlogging with waterlogging developed at specific stages usually at tillering and booting stages (Nawaz, 1993: Akhtar et al., 1994: Saqib et al., 1999), while no information is available on comparative effect of salinity and waterlogging at different growth stages. The present study is therefore planned to compare the response of wheat to waterlogging developed at different growth stages under non-saline and saline soil cond itions.

MATERIALS AND METHODS

This study was conducted under natural conditions in a wire house at Saline Agriculture Research Centre. University of Agriculture, Faisalabad, Pakistan. The wire house has glass roof with no control of temperature, humidity and light as the sides were open having only a wire net to control birds, The study was started in November 2000 and was ended in April 2001.

There were two sets of treatments i.e.. non-saline (ECe=2.96 dS m') and saline (ECe=15 dS m'). The soil was collected from a normal field (non-saline) and filled in earthen pots @ 12 kg per pot. The desired salinity in pots of saline treatment was developed by mixing required amount of NaCI in the soil before filling in the pots. The recommended doses of NPK (Nitrogen, Phosphorous and Potassium) fertilizers !iT 120: 60: 60 kg ha^{-1} were applied as urea, single super phosphate and potassium sulfate, respectively. Half the N and whole of the P and K doses were applied before sowing while remaining half of N was applied at booting stage. The pots were irrigated with tap water having ECO.90 dS m¹. At "waiter" (soil moisture level when it is ready for ploughing) conditions the soil was pulverized and the seeds oftwo wheat genot) pes viz.. Pato and SARC-6 were sown. The treatments within each set (non-saline and saline) comprised of six timings of waterlogging: (I). Control (Normal irrigation. Cont), (2). Waterlogging at tillering stage (Till), (3). Waterlogging at booting stage (Boot), (4). Walerlogging at grain filling stage (GF). (5). Waterlogging at tillering and hoot ing stages er B 1. (6). Waterlogging at tillcring and grain filling stages (I, Gl-). Waterlogging was developed b) stagnating water for 2 I days in respective treatment pots a(respective stages. Other than the period of waterlogging. pots were irrigated like control pots as and when required. The experiment was replicated five times in a cornpletel-, randomized factorial statistical arrangement.

At maturity plants were harvested and threshed manually and data regarding grain yield. 100 grains weight, number of spikes and spike lets. spike length. plant height. tillering capacity and stl'<l\\ weight were recorded. The data were analyzed statistically following the methods described by Steel and Torric (1980). Standard error was computed to compare the significance of differences among treatment means.

RESULTS

Grain yield and 100 grains weight

Under non-sa Iine soi I cond it ions. a sign ificant decrease in grain yield of hoth the genotypes (Pato and SARC-6) was observed when waterlogging was imposed at grain filling stage alone or in combination with a waterlogging event at tillering stage (Iig. I). However. grain yield of Pato was also reduced Sigil iJiclllly when \\aterlogging was developed at tillering b()()llllg stages while SARC-6 observed a non-significant reduction in this treatment. Salinity alone caused a significant reduction in grain yield of Paro while a non-significant reduction in grain yield of SARC-6. The imposition of \\aterlogging under saline conditions at different stages caused a further significant decrease in grain yield of Pato and the lowest grain yield of this genotype was observed in treatment where waterlogging was developed at tillering and grain filling stages. The grain yield of SARC-6 was. however. decreased significantly under saline conditions onl) when waterloggillg was developed at booting or grain fillillg stages alone or ill combination with a waterlogging event at tillering stage. Pato gave a higher grain yield than S!\RC-6 in most of the treatments except where \\aterlogging \\as imposed at tillering or booting stages alone or ill combin.uion under saline soil conditions.

A significant reduction in 100 grains weight of Pat o was observed when waterlogging was developed at grain filling stage alone or in combination with waterlogging at tillering under non-saline conditions and at booting or grain filling stages a/one or in combination with waterlogging at tillering stage under saline soil conditions (Fig. 2). However, the 100 grains weight of SARC-6 was reduced significantly when waterlogging was developed at grain filling stage alone or in combination with waterloggillg at tillering stage under both non-saline and saline soil conditions. The lOO grains weight of SARC-6 was also significantly higher than that of Pato in most of the treatments.

Spikes and spikelets

The imposition of waterlogging at different grO\\th stages under non-saline conditions did not decrease the numhcr of spikes per plant except waterlogging treatment at tillering hooting stages that significantly reduced the number ()I' spikes per plant of both the genotypes viz. Paio <IJlUSARC,6 (Fig. 3). Salinity alone and in combination \ı ith \\aterlogging events at different growth stages caused a significant reduction in number of spikes per plant of S!\RC-6. However, only waterlogging treatments at tillering. booting and tillering + booting stages under saline soil conditions caused a significant reduction in number of spikes per plant of Pato.

The spike length and number of spike lets per spikl' 01 both the genotypes were not decreased significnnr}, due to an) of waterlogging events under non-saline or saline soil conditions (data not shown). Also both the genot) pes varied non-significantly regarding these two parameters in different treatments.

Plant height, tillering capacity and straw weight

Si\RC-6 showed a significantly more plant height than Pato under all the treatments (Fig. of). None 01 ıIll' \\<lll'rlogging treatments under non-saline conditions caused a slgnilieanl reduction in plant height or any of the genotypl'S. Rather waterlogging developed at booting stage alone or in combination with a waterlogging event at tillering stage increased the plant height of SARC-6 significantly. Salinir, alone as well as in combination of different \\<Ilerlogging events caused a significant reduction in planr height of Paio However, under saline conditions, the plant llL'ight or Si\J{C', 6 was not reduced significantly in the treatments where waterlogging was developed at booting stage or grain filling stage.

None of the waterlogging events under non-saline conditions caused a significant reduction in number of tillers per plan: of any of the wheat genotypes (Fig. 5). On the other hand. salinity alone and in combination with wdterlogging dl tillering, tillering " booting and tillering grain filling stagl's caused a significant reduction in number or tillers per plant of both the wheat genotypes. However. waterlogging at grain filling stage alone and at booting stage only did not cause a significant reduction in number of tillers per plant of <Ill) or the wheat genotype.

Under non-saline conditions, none of the waterlogging events caused a significant reduction in stra« weight or an: of the wheat genotypes (Fig. 6). However. salinir, alone and in combination with waterlogging at all the gJ'O\\!h stages eau sed a significant reduction in straw weight or both the wheat genotypes. Different waterlogging treatments under saline soil conditions varied non-significantly with salinir, Fig 1 Effect of salinity and waterlogging on grain yield of wheat genotypes as influenced by growth stage

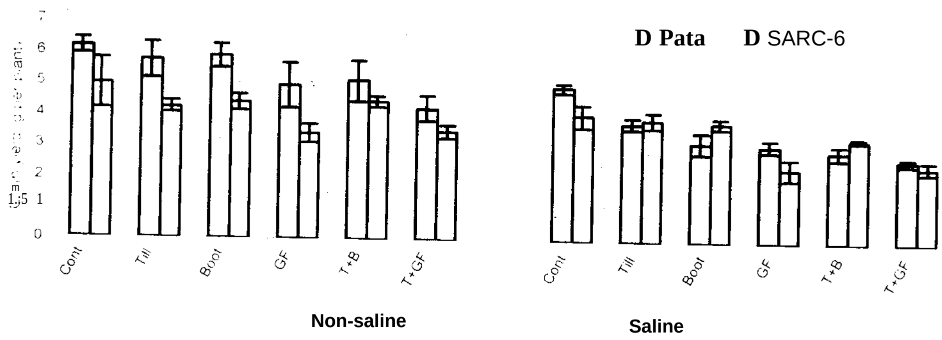


Fig. 2 Effect of salinity and waterlogging on 100 grains weight of wheat genotypes as influenced by growth stage

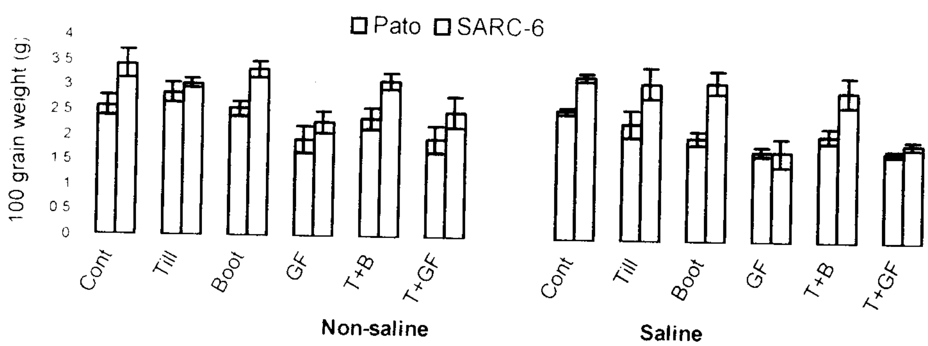


Fig. 3 Effect of salinity and waterlogging on spikes per plant of wheat genotypes as Influenced by growth stage

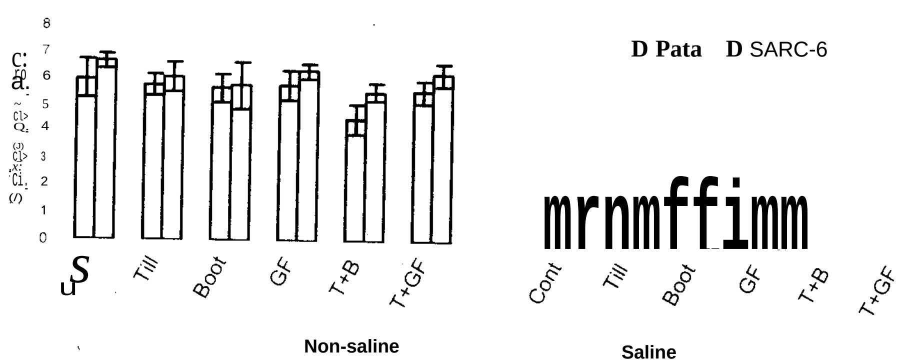


Fig. 4 Effect of salinity and waterlogging on plant height of wheat genotypes as influenced by growth stage

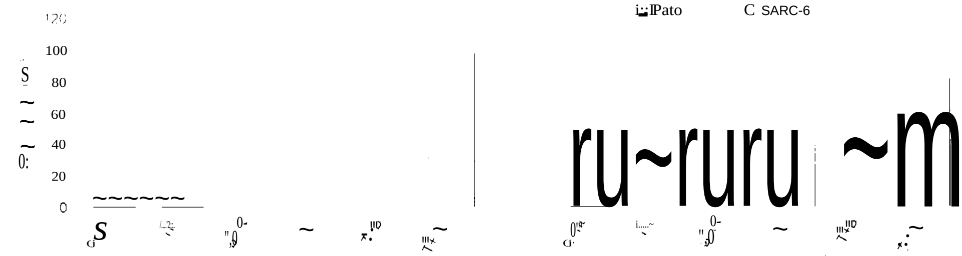


Fig. 5 Effect of salinity and waterlogging on tillers per plant of wheat genotypes as influenced by growth stage

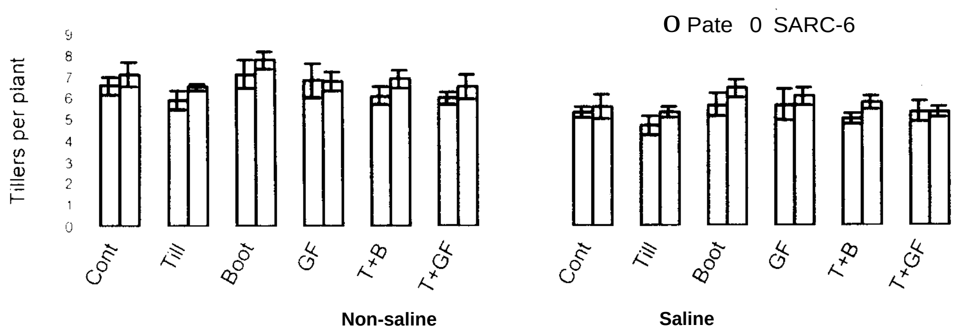


Fig. 6 Effect of salinity and waterlogging on straw weight of wheat genotypes as influenced by growth stage

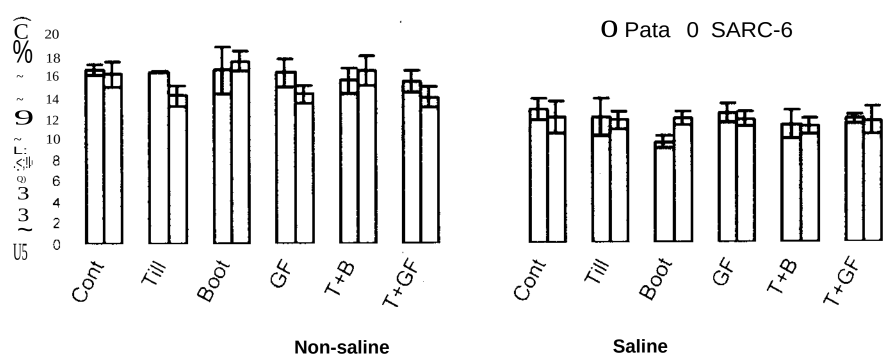
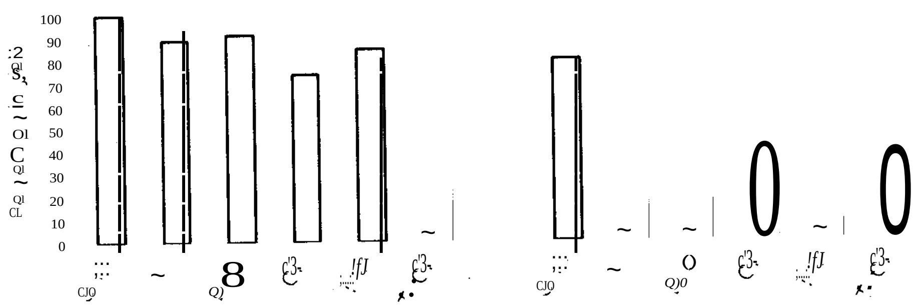


Fig. 7 Grain yield in different treatments as percent of control



alone except the treatment with waterlogging at booting stage where the straw weight of Pato was significantly less than that observed in case of salinity alone treatment. The two genotypes ,t1so varied non-significantly in most of treatments except waterlogging at tillering under non-saline conditions where straw yield of Pato was significantly higher than that of SA RC-6 and waterlogging at booting stage under saline conditions where opposite was true.

DISCUSSION

In non-saline soil conditions, on genotypic mean basis (Fig. 7), reduction in grain yield was the highest in tillering + grain filling treatment (30%) followed by grain filling treatment (26(~o) and tillering :' booting treatment (15%) in a descending order. A spell of waterlogging at grain filling stage in tillcring + grain filling and grain filling alone treatments also caused a maximum reduction in 100 grains weight (Fig. :2) but did not decrease any other yield component significantly. However. the tillering + booting stage waterlogging also caused a significant reduction in number of spikes per plant (Fig. 3).

Waterlogging of a soil initiates a number of physical and chemical changes in a soil that results in changed ionic behavior (Ponnamperurna, 1(84). The concentration of O_2 is rapidly reduced that limits energy dependent growth of plant roots (Yartapetian and Jackson, 1(97). However, in short term waterlogging (for a few days), the deficiency of oxygen is more important than nutrient deficiencies and ionic toxicities. So, the plants that are able to adapt to a less lethal process of anaerobic respiration and can manage internal root aeration through well developed aerenchyrna will be usually less affected by short term waterlogging spells and vice versa (Nawaz, 1(93).

The grain development mainly depends on vegetative parts of the plant for the photosynthates and other organic and inorganic molecules. Translocation of dry matter from leaves, culm and head occurs at grain filling stage (Waldren and Flowerday, 1(79) for grain development. These translocation processes in the plants are energy demanding and may be badly affected due to decreased energy supply in waterlogged conditions (Drew and Lynch. 1(80). The waterlogging at grain filling stage did not significantly affect the yield components except 100 grains weight. So its effect on grain development that lead to decreased 100 grains weight was the only and most drastic that caused a significant reduction in grain yield.

Waterlogging at booting stage also significantly reduced the number of spikes per plant. With this treatment. the reduction in grain yield was mainly due to reduced number of spikes per plant. The waterlogging at an early growth stage like tillering has a little effect on growth and yield of wheat. However, when combined with a waterlogging spell at reproductive stage, both combined to cause a greater reduction in the grain yield than resulted from a single spell at reproductive stage.

Salinity affects plant growth by reducing the uptake of water and nutrients. It also reduces root pressure driven xylem transport of water and solutes (Marschner, 1(95) A decrease in turgor of the leaf cells (Neuman et al. 1(88) and a decrease in cell wall extensibility (Neurnan, 19(3) thus occurs that leads to growth inhibition. Being the dominant ions in a saline substarate, Na and er are taken up at higher rates and these cause salt injury to plants (Serrano et al. 1(99). Due to these effects, salinity alone reduced the grain yield and all the other yield components.

Salinity and waterlogging interact to cause a damage greater than that can result due to either salinity or waterlogging alone (Akhtar et al., 1994; Saqib et al., 1(99) because oxygen deficiency under waterlogged conditions halts the processes of salt exclusion and compartmentation, important salinity tolerant mechanisms in crop plants (Qureshi and Barrett-Lennerd, 1(98). The selectivity for K over Na is also reduced due to energy shortage (Barrett-Lennard. 1(86) that leads to higher Na' and lower K concentrations in leaves.

In this stud: ;il-,«. the development of watcrlogging at different grollth stages under saline conditions caused a higher reduction in grain yield and most or the yield components as compared to effects or respective waterlogging events under non-saline conditions. As in case or non-saline conditions, tillering - grain filling stage treatment also caused the maximum reduction in grain yield (5'-1°,,: fig. 7) under saline soil conditions followed by 51% in grdin lilling alone and '-13"" in tillcring , booting stage treatment.

Conclusive I:. \\e can say that growth stage or a plant at the time or waterlogging is very important in determining the effect on the growth and final grain yield. Also the occurrence or sal inity and waterlogging increase the effect of waterlogging at all stages, but the trend almost remains the xamc. The maximum reduction in grain yield may occur when \\aterloggllg is imposed at grain filling stage followed b: booting ,Idge and lillering stage watcrlogging, respcctivclv

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