Modulating effect of PGRs on Growth and Biochemical traits in rice*(Oryza sativa* L.*)* under salt stress

ABSTRACT

An investigation was conducted to study the effect of plant growth regulators on rice (variety Sarju-52) grown under sodic conditions, during the *kharif*season 2018 at the students' instructional farm of ANDUA&T, Kumarganj, Ayodhya. The experiment was laid out in randomized block design with nine treatments and three replications, with different concentrations and modes of application of plant growth regulators (PGRs). The PGRs were applied as follows- seed priming of GA_3 @25 ppm & 50 ppm and SA @ 10ppm & 25 ppm, and foliar application of GA_3 and SA, each @ 100 ppm & 200 ppm at 30 (DAT), along with untreated control. Seed priming was done for 12 hours in different concentrations of PGRs. Thirty five days old seedlings were transplanted to the field from the nursery. Observations were recorded on various growth parameters such as plant height, number of tillers, dry biomass/hill, relative water content and biochemical parameters like chlorophyll, and TSS, at 30, 60 and 90 DAT and at maturity (harvesting stage). Both seed priming and foliar application of PGRs positively influenced the growth characters, chlorophyll content, and total soluble sugars. Moreover, foliar spray of GA_3 @200 ppm was found to have a more pronounced effect in improving the yield of the variety studied, among all the treatments, under sodic conditions. It can be concluded that foliar spray of GA_3 @ 200 ppm is effective in improving the growth and yield of rice grown under salt stress.

Keywords: GA_3, Salicylic acid, TSS, chlorophyll content, salt stress tolerance

INTRODUCTION

There are altogether 24 species of genus Oryza of which 21 are wild and two viz., **(*Oryza sativa L.)*** and **(*Oryzaglaberrima L.)*** are cultivated. **(*Oryza sativa L.)***is grown in all rice growing areas, but **(*Oryzaglaberrima L.)*** is confined to the West Africa only . Thus it indicates that there might have been two centers of origin of our cultivated rice; South-eastern Asia (India, Myanmar and Thailand) and West Africa. Rice has shaped the culture, diets and economic of thousand millions peoples. For more than half of the peoples "rice is lifeline". For its importance position, the United Nation designated year 2004 as the "International Year of rice. Importance of rice is an important staple food crop for more than 60 per cent of the world people. Rice is a critical source of food for more than 3 billion people annually. In 2017 approximately 680 million tons of rice is grown yearly [3] and rice were consumed worldwide, according to the USDA, ready to eat products eg. Popped rice, puffed rice, rice flakes, canned rice and fermented products are produced. Rice husk is used as animal feed, for paper making and as fuel source.

Soil sodicity/salinity has become a severe threat to ensure global food security. The total world wide area of the salt affected land is about 190 million ha and about 48 million ha in South and Southeast Asia In India, sodic soils have occupied 3.77 million ha salt affected area. Sodic soils are essentially located in the Indo-Gangetic plain, arid and semiarid region in western and central India and the peninsular region (Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, telangana, Chhattisgarh, Jharkhand, Odisha)in the southern India. Rice, which plays an important role in providing food to the major of the world population, is cultivated in a wide range of ecosystems. In India, 45 million hectare of land is under rice cultivation.

Salt stresses adversely affect natural productivity and causes significant crop loss worldwide. Excessive salts in the soils may alter its physical and chemical properties, including soil structure and hydraulic conductivity. High exchangeable sodium and pH decrease soil permeability, available water capacity and infiltration rates through swelling and dispersion of clays as well as slaking of soil aggregates.

Sodicityreduces the ability of plants to take up water and this causes reductions in growth rate, along with a suite of metabolic changes identical to those caused by water stress, whereas the water available in the salt affected soil is contaminated with anions and cations, inducing osmotic stress. In Punjab, Haryana, Uttar Pradesh and Bihar these are distributed significantly in the upper, middle and lower Gangetic plain region. Increasing sodicity/salinity had significant impact on food production and more agricultural lands are expected to become salt affected due to climate change effect. In India, 42.7 million ha of land is under rice cultivation. Salt stresses adversely affect natural productivity and causes significant crop loss worldwide. Excessive salts in the soils may alter its physical and chemical properties, including soil structure and hydraulic conductivity **[11]**.

Uttar Pradesh is largest rice growing state only after West Bengal in the country, rice is cultivated in 45 million hectare which is with a production of 120 million tones (Financial year 2020-2021) and productivity is 2550 kg/ha of our country and Uttar Pradesh in grown over an area of 5.62 million hectare with production and productivity of 12.95 million tones and 2295 quintal ha-1. Rice is the major crop in Uttar Pradesh and is grown in about 5.90million hectare which comprises of 13.5% of total rice area and cropping intensity is 153% in India. Uttar Pradesh has favorable and suitable climate, broad areas of fertile soils, sunshine and adequate water resources. The state ranks 2rd in the country in production of rice **[7]**

Salinity stress is the most major factors limiting the germination and productivity of crop plants because mostly crop plants are susceptible to salinity caused by higher concentration of salt in the soil and constitutes a issue concerned a significant segment of the plant, mainly in region with dry and hot climates**.[5]**Exogenously applied growth regulators can alter the content of endogenous phyto-hormones. The biosynthesis of plant hormones is regulated by both developmental and environmental **[18]**. Gibberellic acid (GA3) is the most important growth regulator, which breaks seed dormancy, promotes germination, increases inter nodal length, plant hypocotyl growth and cell division in the cambial zone and increases the size of leaves. GA3 stimulates hydrolytic enzymes that are impotent for the degradation of the cells surrounding the radicle and thus speeds germination by promoting seedling elongation growth of cereal seeds**Afzal I[1].** They are extensively used to manipulate flower formation and fruit set in different plants**.** Maximum germination percentage was recorded in KNO3 (3%) and GA3 (150 ppm) while hydro priming influenced least on germination percentage **[10].**

Salicylic acid (SA) is a water-soluble antioxidant compound that can also use regulate plant growth. It also has a role in abiotic stress tolerance such as drought and salt tolerance in wheat. Ameliorative effect of SA on growth of crop plants under abiotic stress conditions may have been due to its role in nutrient uptake, water relations, stomatal regulation, photosynthesis and growth . Salicylic acid (SA) is an endogenous growth regulator and belongs to a group of phenol compounds. It participates in the regulation of physiological processes and also provides protection against biotic and abiotic stress such as salinity. the positive effects of Salicylic Acid for salt tolerance have been studied in many crops such as bean, tomato and maize **[9]**.

Seed priming techniques have been used to increase germination, improve germination uniformity, improve seedling establishment and stimulate vegetative growth in more field crops under stressed conditions. Also, reported that priming by salicylic acid and gibberellins have been used to increase germination characteristics in rye seeds **[10].** Priming has also been shown to induce nuclear DNA synthesis in the radicle tip cells in several plant species including: tomato, pepper, maize In addition, the hormone-priming increased the germination percentage and enzymes activities in plants **[2].**

Comment [DAL1]: Very long Introduction!

Materials and Methods

The present investigation entitled **"Modulating effect of PGRs on Growth and Biochemical traits in rice *(Oryza sativa L.)*undersalt stress *"***was carried out in *kharif*season, during 2018 at the student instructions farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya,

(U.P.), India. In the present study, Variety sarju-52 under salt stress condition was taken as experimental materials to find out the response of PGRs on growth and biochemical changes contributing traits of rice in RBD with three replications and nine treatments.Healthy seeds of rice variety Sarju-52 were soaked in the solution of various concentration of GA3 (25ppm and 50 ppm) & salicylic acid (10ppm and 25ppm) distilled water for hydro-priming, for 12 hours along with untreated control. After that seeds were taken out from the solution and distilled water and dried for one hour in shade then seed showing in nursery. Various foliar application of GA3 (100ppm and 200ppm) and salicylic acid (100ppm and 200ppm) were applied as foliar application at 30 DAT. Growth parameters viz. plant height, number of tillers hill-1 and dry biomass plant-1 and Relative water content. Bio-chemical parameters viz. Chlorophyll content, Total soluble sugar of crops were also observed were found superior with foliar application of GA_3 200ppm followed GA_3 100ppm.

OBSERVATIONS RECORDED:

1. Growth and growth analysis: Growth related observations were recorded at four stages of crop growth i.e. 30th, 60th and 90DAT and harvesting stage. Five plants under each treatment were tagged initially which were used for growth measurement.

A)**Plant height (cm):** Plant height was measured in cm from soil surface up to tip of the plant with the help of a meter scale. Measurement was done on the plants which were initially tagged for this purpose and average height was collected from the replicated data.

B) Number of tillers plant^{-1}: Number of tillers per plant under each treatment was recorded by counting at the appropriate stage. The plants already tagged for this purpose were used and an average tillers plant^{-1}were computed.

C)Dry Biomass plant $^{-1}$ (g): Five plants were uprooted from each treatment and roots were removed with the help of a blade. The samples were cleaned and then oven dried at 70±5^{0}C till a constant weight was achieved. The weight was recorded with the help of an electronic balance and average biomassplant $^{-1}$ was recorded.

D) Relative water content (RWC %): The relative water content (RWC) was determined by the method described by Turner and Beg (1981). Leaf discs were cut from the leaves, weighed and saturated by floating on distilled water in petridish for six hours. The discs were surface dried and weighed. After that discs were kept in oven at 70±5^0 C for 24 hours. After drying, weight of discs was calculated with the help of electronic balance. RWC was calculated by the following

formula: - $$RWC\,(\%) = \frac{\text{Fresh weight - Dry weight}}{\text{Saturated weight - Dry weight}} \times 100$$

2. BIOCHEMICAL STUDIES:

All the biochemical measurements was done in leaf sample.

A) Chlorophyll content (SPAD Value): Chlorophyll content was measured with the help of Plant efficiency analyzer (Model X 55/M-PEA) the values were expressed as SPAD value.

B) Total soluble sugar content (mg g^{-1} dry weight): The total soluble sugar content in shoot was estimated by the method of Yemm and Wills (1954)

Reagents:

Ethanol (80%)

Anhtrone (0.2%)

Glucose

Anthrone reagent: 200 mg Anthrone in 100 ml concentrated H_2SO_4

Procedure:

100 mg dried plant sample was homogenized in 10 ml of ethanol (80% concentration) centrifuged at 4000 rpm for 20 minutes. Supernatant was collected and residue was re-extracted with 10 ml of 80% ethanol and again centrifuged at 4000 rpm for 20 minutes. Supernatant was collected and both the supernatants were combined and made up to final volume of 20 ml. 0.1-0.2 ml supernatant was dried in a test tube on water bath and cooled to room temperature. One ml of distilled water was added to each test tube and mixed thoroughly. 4 ml of anthrone reagent was added along the wall of the test tube and mixed slowly and heated on water bath at 100^0C for 10 minutes and cooled rapidly under running cold water. Absorbance was measured at 620 nm against the reagent blank. The amount of total carbohydrate present in the extract was calculated using a standard curve prepared from graded concentration of glucose.

Results and Discussion

Plant height

All treatments showed increasing trend in plant height as compared to control with advancement of stages (Fig.1) As effectiveness of mode of application of PGRs response of foliar application on plant height was found more pronounced that seed soaking treatment. At 30 DAT, maximum plant height was recorded with treatment T3 (seed soaking GA3 @ 50 ppm) which is 8.61 % higher than control whereas at 60& 90 DAT, maximum per cent increase in plant height were obtained with T7 (GA3 @ 200ppm) i.e. 27.65 % and 28.03 % respectively. This finding is according to**,** [15] reported in rice and in mustard [17].GA3 is one important plant hormones that regulate various processes of plant growth and development, which is particularly important in stem elongation. GA3 application, the heightwas increased significantly under salinity condition.[12]

Plant tiller

Seed soaking and foliar application enhanced tillers production plant^{-1} as compared to control and varies with growth stages (Fig.2). As effectiveness of mode of application of PGRs response of foliar application on plant height was found more pronounced that seed soaking treatment. At 30 DAT, maximum tillers plant^{-1} was recorded with treatment T3 (seed soaking 50ppm GA_3) which is 23.77%, whereas at60& 90 DAT, maximum per cent increase in tillers plant^{-1} were obtained with T7 (GA3 @ 200ppm) ie.34.99% and 31.10% respectively. This finding is in accordance with the finding of [14], [15]**.** Plant hormones play important role in regulating the tiller occurrence[8].

Plant dry weight

The maximum plant dry weight was recorded with treatment T3 (seed soaking @ 50ppm GA3) at 30DAT (Fig.3).which is 43.08% higher over control and at 60& 90 DAT, maximum per cent increase in plant dry weight were obtained with GA_3 (GA_3@200ppm) i.e. 18.81 % & 30.82 % at 60 & 90DAT respectively. Similar observation was also reported by [14],[17],[6],[8].The increase in plant dry weight due to foliar spray GA_3 indicated that the photosynthetic activity and efficiency of the leaves have been increased which contributed to dry matter production. [10], [17][13].

Relative water content

All the treatments have positive significant effect on relative water content (RWC%) of rice grown under sodic condition on (Fig.4)The effect of spraying of PGRs on leaves, RWC was found to be more obvious as the effectiveness of the method use of PGRs (GA3 and SA). At 30 DAT seed soaking treatments, were found more effective than control. Maximum relative water content was obtained with seed soaking with GA3 50 ppm 70.50% at par with GA3 @ 25 ppm while 60 and 90 DAT, maximum percent increase in relative water content was achieved with foliar application of GA3 @ 200 ppm 13.57% and 9 6.44% respectively Similar observation were also made by [10] [14] RWC tend to decline when transpiration exceeds waterabsorption under drought condition leading to decrease in cell turgor. Maintenance of high RWC under drought due to relatively more growth of the roots than shoots and/or abscisic acid induced reduction in stomata opening tends to maintain cell turgidity, chlorophyll content and photosynthesis [16].

Bio-chemical studies

chlorophyll content - It is clear from data presented in (Fig.5) that activating effectiveness of PGRs is phasic events which regularize the plant growth and development. High salt concentration degrade the chlorophyll content of the plant at all growth stage. Exogenous application of PGRs either seed soaking or foliar application mitigates the adverse effect of salt stress. Sharp decline of chlorophyll content affect 60 DAT was noticed in all treatments. Extent of reduction in chlorophyll content at 60 DAT was observed in foliar application of GA3 @ 200 ppm followed by GA3 100 ppm and SA @ 200 ppm in comparison to other treatments. This finding is according to [14][10]. Which could be predicate as the ability of varieties to maintain higher chlorophyll content and the optimistic response to GA3. Under sodic condition limited water availability (physiological drought) usually causes a reduction in chlorophyll content. Being positively correlated with yield relatively high chlorophyll content may contribute to the plant productivity under stress condition ([16],[12] [4]).

Total soluble sugar

All treatments recorded rise total soluble sugars as compared to control at varies growth stages (Fig.6). As effectiveness of mode of application of PGRs response of foliar application on soluble sugars was found more pronounced that seed soaking treatment maximum total soluble sugars was recorded with treatment T3 (seed soaking 50ppm GA3) which is 8.66% higher than control. Whereas at 60& 90 DAT, maximum per cent increase in total soluble sugars were obtained with T7 (GA3 @ 200 ppm) *i.e.* 22.26% and 19.39% respectively. Similarly [14], [10] reported that- foliar application of GA3 @ 200 ppm had significantly increase level sugar content.

Conclusions:

This experiment can be concluded that foliar application of PGRs were found more effect method than seed soaking. Seed priming treatment in nursery did not show longer effect to counter act the adverse effect of sodicity on plant growth of rice. Whereas, foliar application of various concentration of GA_3 and SA have significantly improve the crop yield. Among the treatments GA_3@ 200 ppm (foliar application) was found most effective concentration to improve plant growth and yield. Its needs further variation at farmer field.

Table No 1.Modulating effect of PGRs on Growth traits in rice *(Oryza sativa L.)*undersalt stress

	Treatments	Plant height			Number of tillers Plant-1			Dry biomass hill-1 (g)			Relative water content (RWC %)		
		30 DAT	60 DAT	90 DAT & Harvesting	30 DAT	60 DAT	90 DAT & Harvesting	30 DAT	60 DAT	90 DAT & Harvesting	30 DAT	60 DAT	90 DAT& Harvesting
T_1	Control	51.20	70.62	71.86	6.86	7.06	7.53	2.84	10.79	21.96	69.27	71.47	68.94
T_2	GA3 @25ppm seed soak	54.09	74.33	76.26	8.46	8.60	8.80	4.49	12.86	24.38	70.27	74.69	71.59
T_3	GA3 @ 50ppm seed soak	54.93	75.66	77.96	9.00	9.23	9.40	4.99	13.82	24.98	70.50	75.42	72.13
T_4	SA @10ppm seed soak	52.80	71.60	72.96	7.46	7.80	8.06	3.21	11.57	22.35	69.59	72.67	70.00
T_5	SA @25ppm seed soak	54.30	73.66	74.73	8.20	8.56	9.13	3.91	12.27	23.51	69.87	73.61	71.17
T_6	GA3 @ 100ppm FS at 30 DAT	50.70	93.13	95.80	6.26	10.46	10.53	2.24	17.31	28.94	69.34	80.17	75.08
T_7	GA3 @ 200ppm FS at 30 DAT	50.76	97.06	99.86	6.40	10.86	10.93	2.74	18.81	30.82	69.52	82.70	75.96
T_8	SA @ 100ppm FS at 30 DAT	50.13	82.26	90.80	7.06	9.46	9.76	2.54	15.21	25.96	69.46	76.83	73.34
T_9	SA @ 200ppm FS at 30 DAT	50.40	88.66	92.13	6.73	9.80	9.90	2.62	16.15	27.95	69.36	78.29	73.94
	SEm±	0.46	0.78	1.14	0.51	0.27	0.22	0.14	0.33	0.44	0.22	0.30	0.22
	CD at 5%	1.37	2.32	3.41	1.56	0.80	0.67	0.41	1.00	1.31	0.65	0.91	0.66

SA:- Salicylic Acid

FS:-Foliar spray

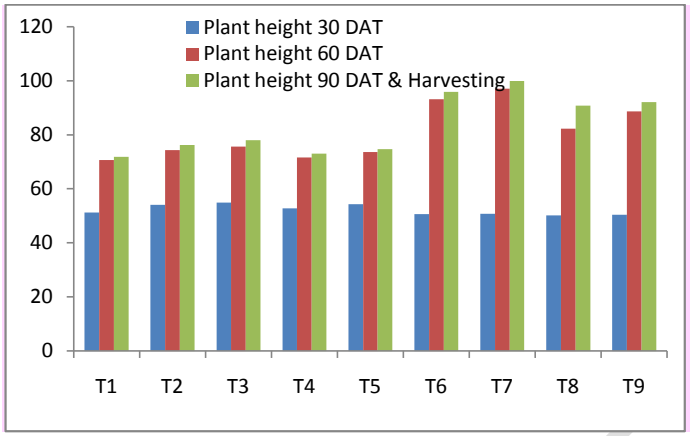
Table No 2- Modulating effect of PGRs on Biochemical traits in rice *(Oryza sativa L.)*undersalt stress

	Treatments	Chlorophyll content (SPAD Value)			Total soluble Sugar		
		30 DAT	60 DAT	90DAT & Harvesting	30 DAT	60 DAT	90 DAT & Harvesting
T_1	Control	10.35	11.37	6.22	77.95	105.22	91.90
T_2	GA3 @25ppm seed soak	11.27	13.02	7.55	84.44	120.19	105.26
T_3	GA3 @ 50ppm seed soak	11.45	13.37	7.50	85.31	125.27	105.29
T_4	SA @10ppm seed soak	10.49	12.27	6.77	82.68	110.41	101.66
T_5	SA @25ppm seed soak	11.05	12.84	7.35	83.28	121.94	101.83
T_6	GA3 @ 100ppm FS at 30 DAT	10.37	14.59	8.03	77.46	132.02	111.32
T_7	GA3 @ 200ppm FS at 30 DAT	10.53	15.38	8.25	78.43	135.53	114.01
T_8	SA @ 100ppm FS at 30 DAT	10.19	13.79	7.72	78.73	127.35	108.98
T_9	SA @ 200ppm FS at 30 DAT	10.25	14.17	7.90	78.01	130.13	109.87
	SEm±	0.19	0.10	0.12	0.54	0.65	0.63
	CD at 5%	0.58	0.29	0.35	1.61	1.94	1.89

SA:- Salicylic Acid

FS:- Foliar spray

Fig.1 & Fig.2 - Modulating effect of PGRs on Plant height and Number of tillers Plant^{-1} traits in rice *(Oryza sativa L.)*undersalt stress



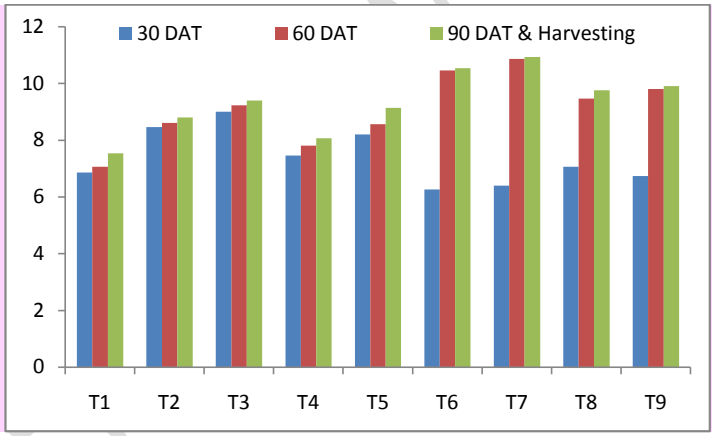
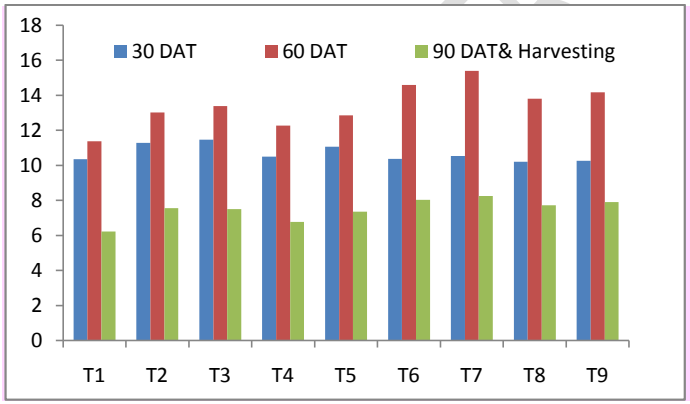


Fig.1- Plant height **Fig.2 - Number of tillers Plant^{-1}**

Fig.-3 & Fig.-4 Modulating effect of PGRs on Dry biomass hill^{-1}(g) and Relative water content (RWC %) traits in rice *(Oryza sativa L.)*undersalt stress



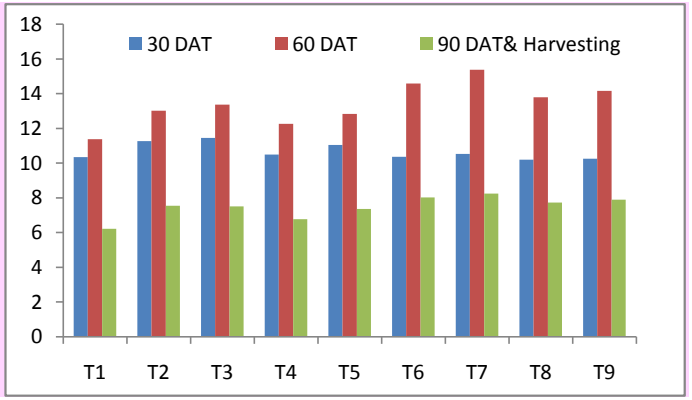
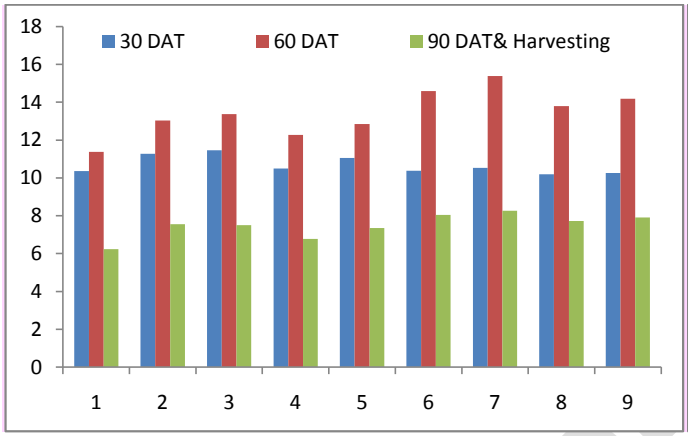


Fig.3- Dry biomass hill^{-1}(g)Fig.4- Relative water content (RWC %)

Fig.-5 & Fig.-6 Modulating effect of PGRs on Chlorophyll content (SPAD Value) and Total soluble Sugar traits in rice *(Oryza sativa L.)*undersalt stress



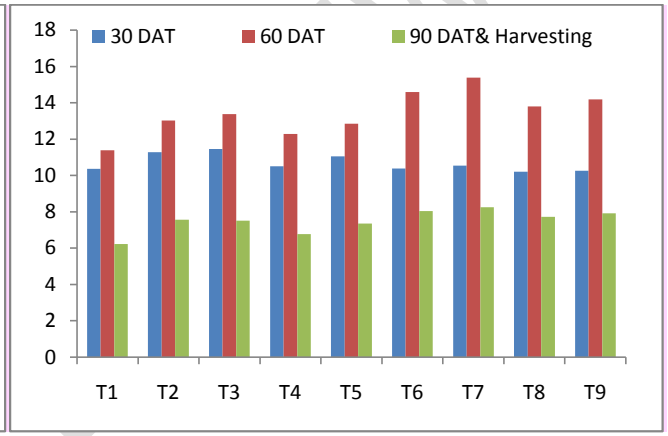


Fig.5- Chlorophyll content (SPAD Value) **Fig.6 - Total soluble Sugar**

Comment [DAL2]: How did you these resultats???

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