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Influence of foliar spray of plant growth regulators and nutrients on physiological and biochemical parameters and yield of paddy at two situations

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Abstract
A field experiment was conducted at Agricultural Research Station, Gangavati, UAS, Raichur, Karnataka, during *kharif* 2019 to study the physiological approaches to sustain the rice **(***Oryza sativa* L.) productivity under late sown situation (var. RNR-15048). The experiment was laid out in factorial RCBD with three replications, where two dates of transplanting were taken i.e. D_1 (Normal) and D_2 (Late) and six treatments along with control *viz*., T_1: NPK-19:19:19 (20000 ppm), T_2: 6-BAP (20 ppm), T_3: salicylic acid (250 ppm), T_4: mepiquat chloride (1000 ppm), T_5: borax @ (10000 ppm) and T_6: control. The results of physiological parameters obtained at 65 DAT and biochemical parameters obtained at 55 DAT indicated that D_1 (Normal DOT) showed higher values as compare to D_2 (Late DOT) in all the treatments. Among different treatments, T_1 (NPK-19:19:19 @ 20000 ppm) recorded the significantly greater results of physiological parameters *viz*., photosynthetic rate (9.20 µ mol CO_2 m^{-2} s^{-1}), transpiration rate (2.10 m mol H_2O m^{-2} s^{-1}), SPAD value (28.42), NDVI value (28.42) and biochemical parameters such as chlorophyll content ‘a’(2.64 mg g^{-1} fr. wt.), ‘b’(0.85 mg g^{-1} fr. wt.) and total (3.49 mg g^{-1} fr. wt.). Whereas the next best treatment was T_2 (6-BAP @ 20 ppm) over rest of the treatments. The highest grain yield plant^{-1} (21.55) were recorded in T_1 (NPK-19:19:19 @ 20000 ppm) than other treatments. It was concluded that D_1 (Normal DOT) was the best situation and among foliar application of different agrochemicals T_1 (NPK-19:19:19 @ 2.0%) was found to be the best treatment, it was ideal and economically feasible at 35,45 DAT and at 55 DAT.

Keywords: Influence, spray, regulators, physiological, biochemical, parameters, situations

Introduction

Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world’s population. The slogan “Rice is life” comes from the understanding that rice based cropping system are essential to everyone directly or indirectly for the food security, livelihood improvement, cultural heritage and sustainable development for the global peace. Rice plays a major role in national economy in many developing countries. Rice (*Oryza sativa* L.) is the major source of food for nearly half of the world’s population. Rice based cropping system are essential to everyone directly or indirectly for the food security, where it provides 30-75 per cent of the total calories to more than 3 billion Asians (Khush, 2014) [10]. Rice is cultivated round the year in one or the other part of the country in various ecologies spread over 46.2 m ha with a production of 117.32 million tons with productivity of 2585 kg ha^{-1} (Anon., 2019) [1]. In Karnataka, rice is cultivated in the command areas of cauvery, Tungabhadra Project (TBP) and Upper Krishna Project (UKP) where transplanting is predominant method of establishment. Foliar application of nutrients was helps in avoiding the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better nutrient translocation of these nutrients from the leaves to the developing seeds. (Manonmani and Srimathi, 2009) [12]. Growth regulaters are known to enhance the source-sink relationship and stimulate the translocation of assimilates thereby helping in effective flower formation. The application of inorganic nutrients in combination with plant growth regulator will also enhances the nutrient availability, in turn increases the productivity (Chandrasekhar and Bangarusamy, 2003) [3]. Spraying of 3.0% NPK (19:19:19) without basal dose of fertilizer application recorded highest seed yield as compared to only basal dose of application (Das and Jana, 2015) [4]. The relevant study on mepiquat chloride showed that as it decreases plant height and the occurrence of lodging and likewise enhanced yield more than the control (Mukherjee, 2020) [14]. Some findings open a new window for the role to exogenous application of salicylic acid in providing tolerance to the plants against various pathogens (Singh *et al.* 2015) [20].

Material and Methods

The experiment was laid out in factorial RCBD design with three replications, six treatments including control and two dates of transplanting i.e. normal and late seasons of transplanting in rice. Foliar application of different agrochemicals at 35,45 and 55 days after transplanting was done to improve physiological and biochemical parameters and yield. The observations were recorded 10 days after each spray and at harvest. The data on following observations was recorded during the course of study by using standard procedures. The physiological parameters includes photosynthetic rate, transpiration rate SPAD value and NDVI value. The biochemical parameters includes chlorophyll content 'a', 'b' and total.

Results and Discussion

The data on photosynthetic rate, transpiration rate and grain yield with different treatments and at different times of transplantation is presented in table 1 as well as the interactions between these treatments and their interactions with each other.

At 65 DAT, photosynthetic rate was showed significant differences among the treatments at different situations. The treatment T_1 (NPK-19:19:19 @ 20000 ppm) showed the highest photosynthetic rate (9.62 µ mol CO_2 m^{-2} s^{-1}) among treatments & the least photosynthetic rate (6.25 µ mol CO_2 m^{-2} s^{-1}) was observed in T_6 (control) in normal date of transplanting among the treatments & same trend was observed in late date of transplanting. The treatments T_2 (6-BAP @ 20 ppm) (9.17 µ mol CO_2 m^{-2} s^{-1}) & T_4 (mepiquat chloride @ 1000 ppm) (8.63 µ mol CO_2 m^{-2} s^{-1}) were on par with each other. There was no significant difference in the interaction between dates of transplanting and agrochemicals and also between dates of transplanting on photosynthetic rate.

Photosynthesis provides the raw material and energy, required for growth and all other biochemical processes. It is known that thousands of reactions including are undergoing in the plants simultaneously which ultimately decide the growth and development and the final yield. These results are in agreemented with the findings of Murty *et al.* (1995) [15] who reported that foliar application of SA at low concentration at different growth stages of showed positive association with photosynthetic rate. Farooq *et al.* (2009) [6] showed that SA application improved the integrity of cellular membrane and facilitated the rice plant to sustain photosynthesis and general metabolism improves drought tolerance. Similar results also showed by Naeem *et al.* (2017) [16].

At 65 DAT, there were substantial changes in transpiration rates between the treatments in various conditions. T_1 (NPK-19:19:19 @ 20000 ppm) had the highest transpiration rate (2.24 m mol H_2O m^{-2} s^{-1}) among treatments, while T_6 (control) had the lowest transpiration rate (0.48 m mol H_2O m^{-2} s^{-1}) in the normal date of transplanting, and the similar pattern was seen in the late date of transplanting. T_2 (6-BAP @ 20 ppm) (1.67 m mol H_2O m^{-2} s^{-1}) and T_4 (mepiquat chloride @ 1000 ppm) (1.41 m mol H_2O m^{-2} s^{-1}) treatments were comparable. The interaction between transplanting dates and agrochemicals, as well as the interaction between transplanting dates and transpiration rate, was not significant.

The ability of land plants to transpire is critical to their survival. Because the openings of stomata during the day enable gaseous exchange, it aids in the absorption of carbon dioxide (CO_2) from the environment during photosynthesis. Transpiration provides a major cooling impact, preventing the plant from being overheated. These findings are consistent with those of Srivastava *et al.* (1996) [21], who found that transpiration rate and chlorophyll content are useful factors for choosing drought tolerant cultivars, and that lower stomatal opening was indicated by Jahan *et al.* (2014) [9].

In grain yield $plant^{-1}$, D_1 (normal DOT) had a significantly higher (20.93) grain yield while D_2 had a significantly lower (18.46) grain yield (late DOT).On the grain yield $plant^{-1}$, there was no significant difference between the different agrochemicals, nor was there any interaction between the dates of transplanting and the agrochemicals. The carbohydrates in rice grains originate from photosynthesis which is predominantly carried out in leaves (sources). Therefore, grain filling and rice yield depend on the efficient transport of carbohydrates from the leaves to seeds (sinks).

The infrastructure of plant is decided by morphological parameters coupled with more photosynthetic activity which lead to higher biomass production and also efficient partitioning of dry matter in to reproductive parts. These results are in agreemented with the findings of Vaiyapuri and Sriramachandrasekharan (2003) [22] who revealed that, salicylic acid sprayed @ 0.1% registered the highest grain yield. Venkatakrishnan and Balasubramaniam (1996) [23] opined that the highest mean seed yield of sunflower due to combined application of along with 0.2% borax spray. Higher dose of IAA @ 50ppm applied to the rice by Pandey *et al.* (2001) [17] which showed significant increase in the plant height and produced highest grain yield.

The data on SPAD value and NDVI value with the different treatments in different dates of transplanting and their interactions presented in table 2 as influenced by the two environmental conditions.

At 65 DAT, significantly higher (25.63) SPAD value was observed in D_1 (normal DOT) and lower (21.68) SPAD value was observed in D_2 (late DOT). Then, SPAD value is superior over other treatments followed by T_1 (NPK-19:19:19 @ 20000 ppm) (30.63), T_2 (6-BAP @ 20 ppm) (28.26) & T_4 (mepiquat chloride @ 1000 ppm) (27.64). The least (17.43) SPAD value was observed in T_6 (control) in normal date of transplanting among the treatments & same trend was observed in late date of transplanting. There was no significant difference in the interaction between dates of transplanting and agrochemicals on SPAD value.

The SPAD determines the relative amount of chlorophyll presence by measuring the absorbance of the leaf in two wavelength regions. The SPAD value will increase in proportion to the amount of nitrogen present in the leaf. The higher SPAD value indicates a healthier plant. These results are in agreemented with the findings of Hayat *et al.* (2008) [8] who reported that the tomato receiving salicylic acid (SA) possessed maximum value for SPAD chlorophyll content and significantly ($P<$ 0.05) higher than that of control. Same results were observed with Richardson *et al.* (2002) [18].

D_1 (normal DOT) had a much higher (0.20) NDVI value at 65 DAT, while D_2 had a significantly lower (0.15) NDVI value (late DOT). T_1 (NPK-19:19:19 @ 20000 ppm) (0.26), T_2 (6-BAP @ 20 ppm) (0.23), and T_4 (mepiquat chloride @ 1000 ppm) are then superior to other therapies (0.22). T_6 (control) had the lowest (0.11) NDVI value among the treatments in the usual date of transplanting, and the same tendency was seen in the late date of transplanting. The interaction between transplanting dates and agrochemicals had no significant effect on NDVI value.

The NDVI, which is a mix of red and NIR reflectance measures, is one of the most regularly used vegetation indices. It has been widely used to assess plant greenness, which is related to the quantity of chlorophyll present in plant leaves. The NDVI values represent the canopy's reflectivity in different wavebands. These findings are consistent with those of Lukina *et al.* (1999) [11] and Harrell *et al.* (2011) [7], as well as Anyamba and Tucker's findings (2005) [2].

The data on chlorophyll content 'a', 'b' and total with the different treatments in different dates of transplanting and their interactions presented in table 3 as influenced by the two environmental conditions. At 55 DAT, chlorophyll content 'a' showed significant difference among the treatments at different situations. The treatment T_1 (NPK-19:19:19 @ 20000 ppm) showed the highest chlorophyll content 'a' (2.67 mg g^{-1} fr. wt.) among treatments & the least chlorophyll content 'a' (1.06 mg g^{-1} fr. wt.) was observed in T_6 (control) in normal date of transplanting among the treatments & same trend was observed in late date of transplanting. The treatments T_2 (6-BAP @ 20 ppm) (2.58 mg g^{-1} fr. wt.) & T_4 (mepiquat chloride @ 1000 ppm) (2.50 mg g^{-1} fr. wt.) were on par with each other.There was no significant difference in the interaction between dates of transplanting and agrochemicals and also between dates of transplanting on chlorophyll content 'a'.

At 55 DAT, chlorophyll content 'b' showed significant differences among the treatments at different situations. The treatment T_1 (NPK-19:19:19 @ 20000 ppm) showed the highest chlorophyll content 'b' (0.87 mg g^{-1} fr. wt.) among treatments & the least chlorophyll content 'b' (0.38 mg g^{-1} fr. wt.) was observed in T_6 (control) in normal date of transplanting among the treatments & same trend was observed in late date of transplanting. The treatments T_2 (6-BAP @ 20 ppm) (0.83 mg g^{-1} fr. wt.) & T_4 (mepiquat chloride @ 1000 ppm) (0.80 mg g^{-1} fr. wt.) were on par with each other. There was no significant difference in the interaction between dates of transplanting and agrochemicals and also between dates of transplanting on chlorophyll content 'b'.

At 55 DAT, total chlorophyll content differed significantly across treatments in various conditions. T_1 (NPK-19:19:19 @ 20000 ppm) had the highest total chlorophyll content (3.54 mg g^{-1} fr. wt.) among treatments, while T_6 (control) had the lowest total chlorophyll content (1.44 mg g^{-1} fr. wt.) in normal transplanting date, and the same pattern was seen in late transplantation date. T_2 (6-BAP @ 20 ppm) (3.41 mg g^{-1} fr. wt.) and T_4 (mepiquat chloride @ 1000 ppm) (3.29 mg g^{-1} fr. wt.) treatments were comparable. The interaction between transplanting dates and agrochemicals, as well as the effect of transplanting dates on total chlorophyll content, was not significant.

It was discovered in this experiment that agrochemicals had a significant impact on chlorophyll content. Both chlorophyll 'a' and 'b' were higher in the plant with the highest grain production among the chlorophyll components. The total chlorophyll content determines the photosynthetic capacity of the genotypes and effects photosynthesis rate, dry matter production, and yield. These findings corroborate those of Shabana *et al.* (2008) [7], who found that foliar application of SA resulted in a considerable increase in chlorophyll 'a' and 'b' concentration in rice leaves. Same results were observed with Motagally and Zohri (2016) [13] and Deswal and Pandurangam (2018) [5].

Table 1: Influence of agrochemicals on photosynthetic rate, transpiration rate at 65 days after transplanting and grain yield plant^{-1} (g) of paddy at two situations

Treatments	photosynthetic rate (μ mol CO_2 m^{-2} s^{-1})			transpiration rate (m mol H_2O m^{-2} s^{-1})			Grain yield plant^{-1} (g)		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1- Foliar application of NPK-19:19:19 @ 20000 ppm	9.62	8.78	9.20	2.24	1.97	2.10	22.92	20.18	21.55
T_2- Foliar application of 6-BAP @ 20 ppm	9.17	8.20	8.68	1.67	1.33	1.50	22.49	19.71	21.10
T_3- Foliar application of salicylic acid @ 250 ppm	6.60	5.56	6.08	0.59	0.51	0.55	19.53	17.27	18.40
T_4- Foliar application mepiquat chloride @ 1000 ppm	8.63	7.10	7.87	1.41	1.16	1.28	21.81	19.55	20.68
T_5- Foliar application of borax @ 10000 ppm	7.66	6.74	7.15	0.73	0.60	0.67	19.87	17.43	18.65
T_6- Control	6.25	5.42	5.83	0.48	0.42	0.45	18.94	16.66	17.80
Mean	7.98	6.96	-	1.18	1.00	-	20.93	18.46	-
	D	T	D x T	D	T	D x T	D	T	D x T
S. Em (±)	0.40	0.68	0.97	0.12	0.20	0.28	0.69	1.19	1.68
CD @ 5%	NS	2.02	NS	NS	0.59	NS	2.01	NS	NS

Table 2: Influence of agrochemicals on SPAD value and NDVI value of paddy at two situations at 65 days after transplanting

Treatments	SPAD value			NDVI value		
	D_1	D_2	Mean	D_1	D_2	Mean
T_1- Foliar application of NPK-19:19:19 @ 20000 ppm	30.63	26.20	28.42	0.26	0.22	0.24
T_2- Foliar application of 6-BAP @ 20 ppm	28.26	24.08	26.17	0.23	0.19	0.21
T_3- Foliar application of salicylic acid @ 250 ppm	24.22	20.95	22.58	0.16	0.12	0.14
T_4- Foliar application mepiquat chloride @ 1000 ppm	27.64	23.56	25.55	0.22	0.18	0.20
T_5- Foliar application of borax @ 10000 ppm	25.57	21.23	23.40	0.20	0.14	0.17
T_6- Control	17.43	14.20	15.82	0.11	0.08	0.10
Mean	25.63	21.68	-	0.20	0.15	-
	D	T	D x T	D	T	D x T
S. Em (±)	0.96	1.67	2.36	0.01	0.02	0.02
CD @ 5%	2.85	4.93	NS	0.03	0.05	NS

Table 3: Influence of agrochemicals on chlorophyll content 'a', 'b' and total (mg g^{-1} fresh weight) of paddy at two situations at 55 days after transplanting

Treatments	chlorophyll 'a'content			chlorophyll 'b'content			Total chlorophyll content		
	D_1	D_2	Mean	D_1	D_2	Mean	D_1	D_2	Mean
T_1- Foliar application of NPK-19:19:19 @ 20000 ppm	2.67	2.61	2.64	0.87	0.83	0.85	3.54	3.44	3.49
T_2- Foliar application of 6-BAP @ 20 ppm	2.58	2.52	2.55	0.83	0.78	0.80	3.41	3.30	3.35
T_3- Foliar application of salicylic acid @ 250 ppm	1.21	1.17	1.19	0.55	0.53	0.54	1.76	1.70	1.73
T_4- Foliar application mepiquat chloride @ 1000 ppm	2.50	2.44	2.47	0.80	0.75	0.78	3.29	3.19	3.24
T_5- Foliar application of borax @ 10000 ppm	1.58	1.53	1.56	0.61	0.57	0.59	2.19	2.11	2.15
T_6- Control	1.06	1.02	1.04	0.38	0.34	0.36	1.44	1.36	1.40
Mean	1.93	1.88	-	0.67	0.63	-	2.61	2.52	-
	D	T	D x T	D	T	D x T	D	T	D x T
S. Em (±)	0.07	0.11	0.16	0.02	0.03	0.05	0.07	0.12	0.17
CD @ 5%	NS	0.33	NS	NS	0.10	NS	NS	0.36	NS

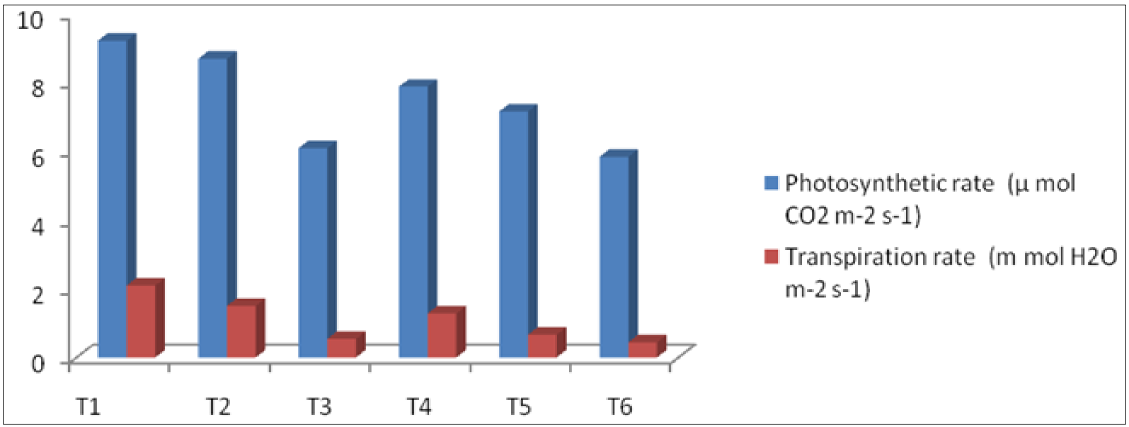

Fig 1: Influence of agrochemicals on photosynthetic rate and transpiration rate at 65 days after transplanting of paddy at two situations

Conclusion

The conclusion drawn from this investigation that, more photosynthetic rate in D_1 (Normal DOT) as compare to D_2 (Late DOT) in all the treatments. T_1 (NPK-19:19:19 @ 20000 ppm) spray showed significantly higher value for both dates of transplanting as compared to the T_6 (Control) and the next best treatment was T_2 (6-BAP @ 20 ppm) among the different agrochemicals. The same trend was observed with other physiological parameters like transpiration rate, SPAD value and NDVI value. The biochemical parameters such as chlorophyll content 'a', 'b' and total were also consistent with the above conclusion between different situation & among different treatments.

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