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Stimulatory effect of different agrochemicals on growth, photosynthetic pigments and yield of rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during *kharif* season 2017 at Agriculture Research Station Gangavati, UAS, Raichur, Karnataka, to study the stimulatory effect of different agrochemicals on growth parameters, photosynthetic pigments and yield of rice (var. GNV10-89). The experiment was laid out in a randomized complete block design with three replications and 10 treatment along with control as follows: T_1: 25 % extra nitrogen (N) soil application, T_2: NPK (19:19:19) @ 1.0 %, T_3: triacontanol (2.0 ml l^{-1}), T_4: GA_3 (50 ppm), T_5: nitrobenzene (20 ppm), T_6: salicylic acid (500 ppm), T_7: 6-BAP (20 ppm), T_8: borax (0.2 %), T_9: T_3 + T_8 foliar applications and T_{10}: control. The results with respect to growth parameters and photosynthetic pigments were differed significantly by foliar as well as soil application of different agrochemicals at 65 and 85 days after transplanting (10 days before and 10 days after panicle initiation). Foliar spray of NPK (19:19:19) @ 1.0 % recorded the significantly higher chl. a (2.47 mg g^{-1} fr.wt.), chl. b (0.82 mg g^{-1} fr.wt.) and chl. a + b (3.29 mg g^{-1} fr.wt.) than rest of the treatment. The treatment NPK (19:19:19) @ 1.0 % recorded maximum number of green leaves per hill (69.8), higher panicle length (25.4 cm), leaf area duration (44.6 days), filled spikelets per panicle (232.9) and the highest grain yield (8709.8 kg ha^{-1}) as compared to rest of the treatment.

Keywords: different agrochemicals, growth parameters, photosynthetic pigments and yield

Introduction
Rice (*Oryza sativa* L.) is the most important staple food grain crop of the world which constitutes the principle food for about 60 per cent of the world's population. It is mostly eaten steamed or boiled, but it can also be dried and ground into flour. It can be used to make beer and liquors. Rice straw is used to make paper and can also be woven into mats, hats and other products. Rice based production system provides the income and employment for more than 50 million households. One third of Asia's rice production is consumed in China and one fifth in India. In Karnataka rice is grown under a variety of soils and wide range of rainfall and temperature. Only around 44 per cent of the total acreage is under irrigation while the rest is under the regime of monsoon. Rice is cultivated in places where the rains are as heavy as 3000 mm and in others where it is just 600 mm. In some areas only one crop is grown and in certain other areas three crops are raised. The unique feature of rice culture in the state is that either sowing or transplanting is seen in all seasons of the year. In this state it is highly challenging for the researchers to work with the problems of diversified rice cultivation. High concentration of chlorophyll a, b and a + b recorded by foliar spray of growth regulators such as GA_3 spraying at early tillering + panicle initiation stage was found more superior over other treatments and it improved significantly higher chlorophyll content and made 17.68 per cent higher photosynthetic contribution after flowering (Das *et al.*, 2011; Medhi and Baruh, 2001) [4, 9]. Triacontanol (TRIA) is a natural component of plant epicuticular waxes. It has been found to enhance the growth and yield of many important cereal crop, growth promoting effects of TRIA are associated with increased photosynthetic CO_2 uptake ultimately increased chlorophyll content (Ries *et al.*, 1977) [15]. The chlorophyll content of 15 days old rice seedling treated with TRIA @ 10 µ g l^{-1} exhibited the significantly higher chlorophyll content of about 25 per cent over control (Chen *et al*., 2002) [2]. High concentrations of chlorophyll a, b and a + b were obtained in black gram sprayed with 150 ppm of salicylic acid (Muthulakshmi and Lingakumar, 2016) [12]. The agrochemical used in this experiment include nutrient (macro and micro) and plant growth regulators. Appropriate quantity of nutrient in required proportions at right time applied through right method increased the yield levels. Growth regulators play vital role in coordination of many growth and metabolic processes in plant, which regulates the amount, type and direction of plant growth and have the ability to influence the growth from

seed germination to senescence either by decline in the photosynthesis or by enhancing the accumulation of more photosynthates, grain development and ultimately grain yield, Hence it is important to identify the suitable growth regulators and nutrients which are used in the present investigation for improving grain filling percentage and enhancing the grain yield of rice variety GNV-10-89. Foliar application of salicylic acid on lowland rice at various concentrations along with the recommended dose of NPK registered the highest grain yield (Vaiyapuri and Sriram Chandrasekaran, 2003; Shabana *et al*., 2008; Muhal *et al.*, 2014) [17, 16, 11]. Fertilizer dose of major nutrients (NPK) in rice increased the grain yield (11.5 %) due to increase in recommended dose of NPK (Dakshina *et al*., 2014; Rahman *et al*., 2014) [3, 14]. The foliar application of different levels of NPK revealed the significantly increased capsule number per plant and seed yield per plant (Khalid and Shedeed, 2015) [6].

Material and Methods

A field experiment was carried out at Agricultural Research Station (ARS), Gangavati, University of Agriculture Sciences, Raichur, during *kharif* season 2017 to study the influence of different agrochemicals on growth parameters, photosynthetic pigments and yield of rice variety GNV-10-89. The experimental site is situated in the Northern Dry Zone of Karnataka between 15'15'40" North latitude and 76'31'40" East longitude at an altitude of 419 meter above mean sea level. The experiment was laid out on medium black soil and the status of the soil indicates low in available N, medium in available P_2O_5 and high in available K_2O.

This study was performed based on randomized complete block design and 3 replication with 10 treatment including control. The first treatment imposition was done at 10 days before panicle initiation (65 Days after transplanting) as the varietal character showed panicle initiation starts from 75 to 80 days after transplanting and second treatment imposition was at 10 days after panicle initiation (85 Days after transplanting). The foliar as well as soil application different agrochemicals and RDF (NPK- 150:75:75 kg ha^{-1}) was common for all the treatment. The following treatments: T_1 - 25 % extra N soil application as top dressing, T_2 - Foliar application of NPK (19:19:19) @ 1.0 %, T_3 - Foliar application of triacontanol (2.0 ml/l), T_4 - Foliar application of GA_3 (50 ppm), T_5 - Foliar application of nitrobenzene (20 ppm), T_6 - Foliar application of salicylic acid (500 ppm), T_7 - Foliar application of 6-BAP (20 ppm), T_8 - Foliar application of borax (0.2 %), T_9 - Foliar application of T_3 + T_8 and T_{10} - Control.

Observations with respect to growth parameters, photosynthetic pigments and yield of rice (var. GNV10-89) were recorded at 10 days after treatment imposition *i.e.,* 95 days after transplanting. The data on following growth parameters were recorded *viz.,* number of green leaves per hill, leaf area duration, panicle length, number of filled spiklets; photosynthetic pigments (a, b and a + b) and grain yield. Comparisons were made using one-way analysis of variance (ANOVA) as given by Panse and Sukhatme (1985) [13]. The standard error of mean (S.Em±) was worked out and the critical differences were considered to be significant at $P<$ 0.05 per cent.

Results and Discussion

The influence of foliar as well soil application of different agrochemicals on photosynthetic pigments *i.e.,* chlorophyll a, b and a + b content at different growth stages of rice *i.e.,* 75 and 95 days after transplanting (DAT) (Figure 2).At 75 DAT the treatment of T_2 (NPK- 19:19:19 @ 1.0 %) recorded the highest chlorophyll a content (2.36 mg g^{-1} fr. wt.), chlorophyll b (0.78 mg g^{-1} fr. wt.) and a + b (3.14 mg g^{-1} fr. wt.) as compared to rest of the treatments and lower chlorophyll a (0.93 mg g^{-1} fr. wt.), chlorophyll b (0.31 mg g^{-1} fr. wt.) and a + b (1.24 mg g^{-1} fr. wt.) was observed in T_{10} (control). Whereas at 95 DAT chlorophyll a, b, and a + b was increased significantly in all the treatments but among all the treatments T_2 (NPK- 19:19:19 @ 1.0 %) recorded the highest chlorophyll a (2.47 mg g^{-1} fr. wt.), chlorophyll b (0.82 mg g^{-1} fr. wt.) and chlorophyll a + b (3.29 mg g^{-1} fr. wt.). The lower chlorophyll a (1.07 mg g^{-1} fr. wt.), chlorophyll b (0.35 mg g^{-1} fr. wt.) and a + b (1.42 mg g^{-1} fr. wt.) was observed in T_{10} (control) presented in Table 1.These results are in conformity with the findings of Shabana *et al.* (2008) [16] and Das *et al.* (2011) [4] in rice.

At 95 DAT, the number of green leaves decreased as the growth advanced, due to ageing up of leaves. At this stage the highest (69.8) number of green leaves was recorded in T_2 (NPK-19:19:19 @ 1.0 %) among all the treatments, followed by T_7 (6-BAP- 20 ppm) (63.4). The lower (24.7) number of green leaves was noticed in T_{10} (control) followed by T_8 (borax- 0.2 %) 35.3 depicted in Table 2 and Figure 4. Similar results were obtained by Ali *et al.* (2014) [1] it might be due to combined application of growth regulators *i.e.,* BA reduces the ageing of leaves and maintains greenness of leaves for longer period.

At 75-95 DAT the significantly higher leaf area duration (LAD) depicted in Table 2 and Figure 1 was noticed in the treatment of T_2 (NPK-19:19:19 @ 1.0 %) 44.6 days. But it was on par with foliar spray of T_7 (6-BAP- 20 ppm) (42.3 days) and T_1 (25 % extra N soil application as top dressing) (40.4 days). However, the lower LAD was recorded in T_{10} (control) (18.2 days).These results are in conformity with the findings of Morandi *et al.* (1984) [10] and Kulkarni (1993) [7]. They reported that LAD was increased by foliar spray of plant growth regulators in sunflower.

The length of panicle and number of filled spikelets per panicle was increased due to foliar and soil application of different agrochemicals (Table 2 and Figure 3). The significantly higher panicle length (25.4 cm) and number of filled spikelets per panicle (232.9) was recorded in foliar spray ofT_2 (NPK- 19:19:19 @ 1.0 %). However, the lower panicle length (12.0 cm) and less number of filled spikelets per panicle (172.7) were observed in T_{10} (control). These results are in accordance with that of Manzoor *et al.* (2006) [8]. Who reported that the panicle length (29.75 cm) and number of spikelets (130.2) per panicle were increased due to increase in the concentration of nitrogen fertilizerand these werehigher at 225 kg N ha^{-1}.

The carbohydrates in rice grains originate from photosynthesis that is carried out predominantly in leaves (sources). Therefore, grain filling and rice yield depend on the efficient transport of carbohydrates from the leaves to seeds. In most plants, sucrose is the main carbohydrate transported long distance in the veins to support the growth and development of roots, flowers, fruits, and seeds. The data on grain yield per hectare (Table 2) indicated that the treatment of T_2 (NPK- 19:19:19 @ 1.0 %) recorded the significantly higher (8709.8 kg ha^{-1}) as compared to all other treatments. However, the significantly lower (7080.3 kg ha^{-1}) yield was recorded in T_{10} (control) and rest of the treatments was differed significantly. These results are in conformity with the findings of Dakshina *et al.* (2014) [3]. Who reported that higher dose of major nutrients (NPK) might have facilitated to increase grain yield. The foliar spray of NPK was the suitable application for maximum yield of blackgram (Rahman *et al.*, 2014) [14] and Das and Jana (2015) [5] who also reported the effect of water soluble fertilizer NPK (19:19:19) spray on growth and yield of pulses showed the significantly higher seed yield.

Table 1: Effect of different agrochemicals on chlorophyll a, b and total chlorophyll conetent at 75 and 95 days after transplanting of rice

Treatments	75 Days after transplanting			95 Days after transplanting		
	Chl. a (Mg g^{-1} fr.wt.)	Chl. b (Mg g^{-1} fr.wt.)	Total chlorophyll (Mg g^{-1} fr.wt.)	Chl. a (Mg g^{-1} fr. wt.)	Chl. b (Mg g^{-1} fr.wt.)	Total chlorophyll (Mg g^{-1} fr.wt.)
T_1 - 25 % extra N soil application as top dressing	2.10	0.70	2.81	2.13	0.71	2.84
T_2 - Foliar application of NPK (19:19:19) @ 1.0 %	2.36	0.78	3.14	2.47	0.82	3.29
T_3 - Foliar application of triacontanol (2.0 ml/l)	1.57	0.52	2.09	1.65	0.55	2.20
T_4 - Foliar application of GA_3 (50 ppm)	1.50	0.51	2.01	1.62	0.54	2.16
T_5 - Foliar application of nitrobenzene (20 ppm)	1.83	0.61	2.44	2.03	0.67	2.71
T_6 - Foliar application of salicylic acid (500 ppm)	1.17	0.39	1.56	1.34	0.44	1.78
T_7 - Foliar application of 6-BAP (20 ppm)	2.23	0.74	2.97	2.35	0.78	3.13
T_8 - Foliar application of borax (0.2 %)	1.41	0.47	1.88	1.51	0.50	2.01
T_9 - Foliar application of $T_3 + T_8$	1.70	0.55	2.25	1.83	0.61	2.44
T_{10} - Control	0.93	0.31	1.24	1.07	0.35	1.42
Mean	1.68	0.56	2.24	1.80	0.59	2.39
S.E.m (±)	0.11	0.05	0.28	0.13	0.27	0.21
C.D. at 5 %	0.32	0.15	0.84	0.40	0.79	0.63

N - Nitrogen, GA_3- Gibberellic acid, 6-BAP – Benzylaminopurine

Table 2: Effect of different agrochemicals on growth and yield of rice

Treatments	Green leaves $hill^{-1}$ at 95 DAT	LAD (75-95 days)	Panicle length (cm)	Filled spikelets $panicle^{-1}$	Yield (kg ha^{-1})
T_1 - 25 % extra N soil application as top dressing	57.1	40.4	21.2	231.2	8419.9
T_2 - Foliar application of NPK (19:19:19) @ 1.0 %	69.8	44.6	25.4	232.9	8709.8
T_3 - Foliar application of triacontanol (2.0 ml/l)	44.0	33.8	17.6	202.1	8080.0
T_4 - Foliar application of GA_3 (50 ppm)	47.7	31.6	16.7	201.7	7890.2
T_5 - Foliar application of nitrobenzene (20 ppm)	50.1	37.2	19.8	222.4	8350.1
T_6 - Foliar application of salicylic acid (500 ppm)	38.7	23.4	15.3	190.5	7540.4
T_7 - Foliar application of 6-BAP (20 ppm)	63.4	42.3	21.5	231.8	8509.9
T_8 - Foliar application of borax (0.2 %)	35.3	28.9	16.0	198.0	7730.0
T_9 - Foliar application of $T_3 + T_8$	51.9	35.1	18.7	203.1	8219.7
T_{10} - Control	24.7	18.2	12.0	172.7	7080.3
Mean	48.2	33.5	18.4	208.6	8053.0
S.E.m (±)	2.30	1.30	0.42	0.80	0.80
C.D. at 5 %	6.90	3.80	1.26	2.40	2.40

N - Nitrogen, GA_3- Gibberellic acid, 6-BAP –Benzylaminopurine, DAT- Days after transplanting

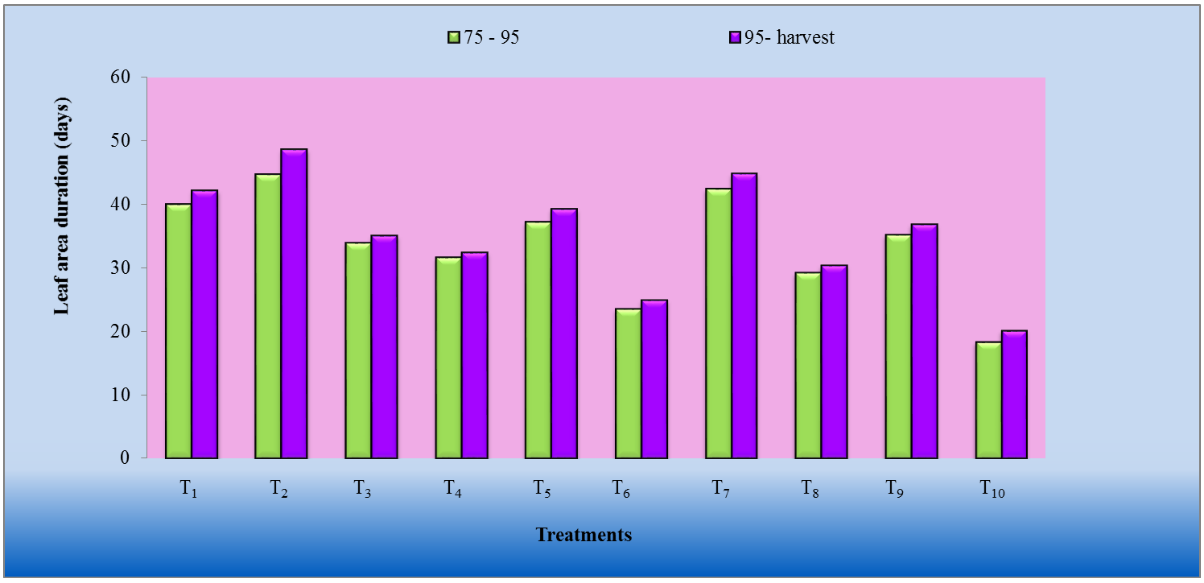

Fig 1: Effect of agrochemicals on leaf area duration (LAD, days) at different growth stages of rice

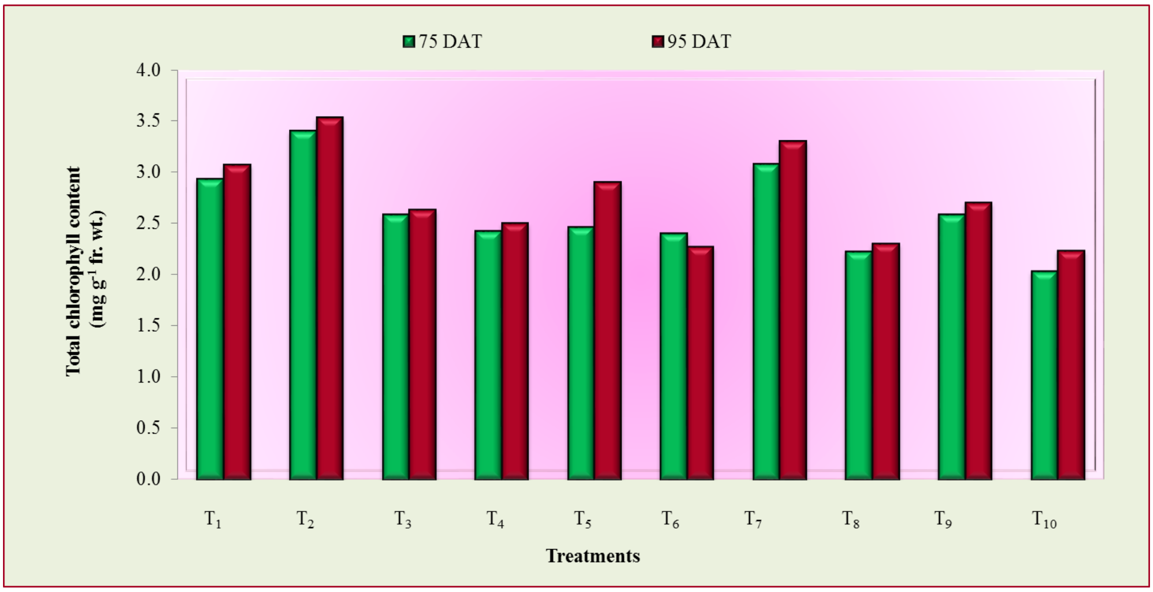

Fig 2: Effect of agrochemicals on total chlorophyll content (mg g^{-1} fr. wt.) at 75 & 95 days after transplanting of rice

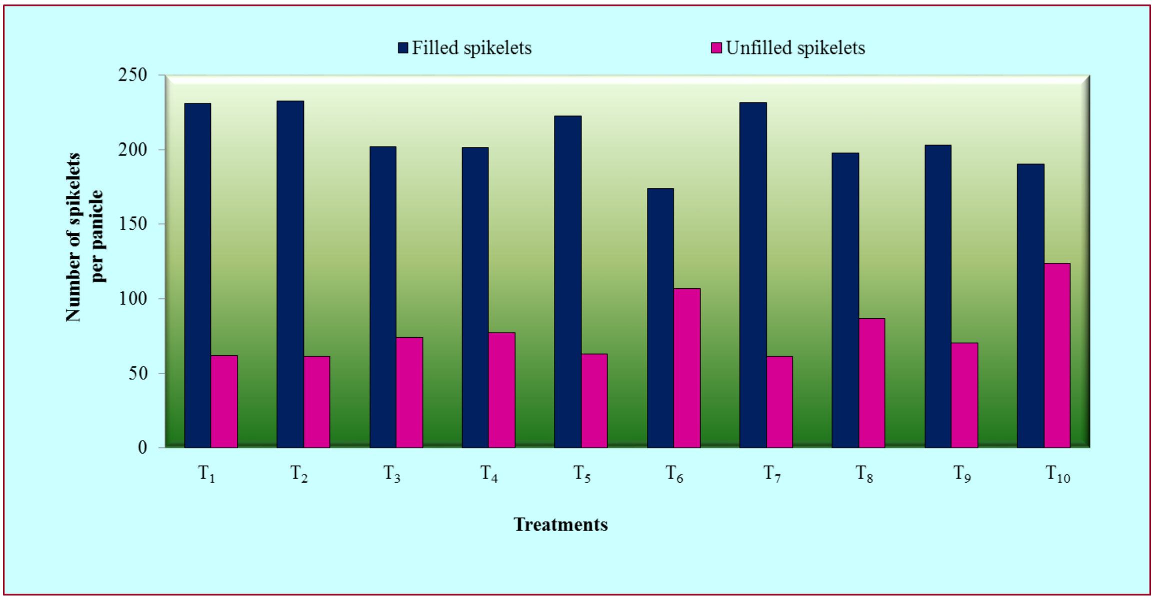

Fig 3: Effect of agrochemicals on number of filled spikelets and number of unfilled spikelets per panicle after harvest of rice

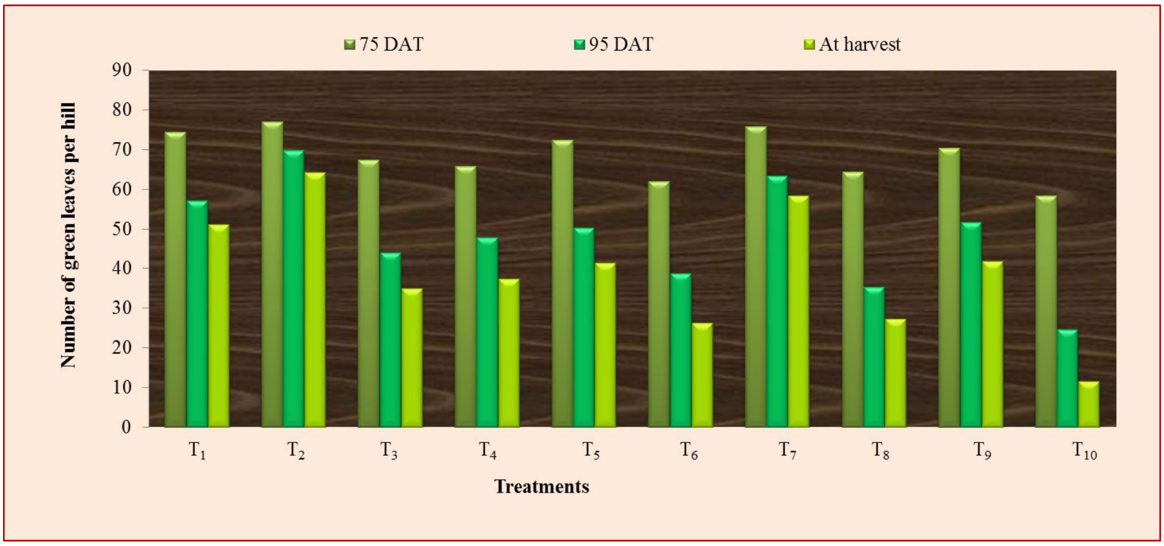

Fig 4: Effect of agrochemicals on number of green leaves per hill at different growth stages of rice

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