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Effect of foliar and soil application of different agrochemicals on phenology, physiological parameters and productivity of rice (*Oryza sativa* L.)

Yasmeen Begum, RP Patil, MK Meena, A Amaregouda and Mahantashivayogayya

Abstract

The experiment was carried out to study the influence of different agrochemicals on yield and yield components of rice variety GNV10-89 at Agricultural Research Station, Gangavati, UAS, Raichur, Karnataka. The experiment was laid out in a randomized complete block design with three replications during *kharif* 2017. The experiment consisting of 10 treatment along with control *i.e.*, 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 revealed that the yield and yield attributes of rice was differed significantly by foliar as well as soil application of different agrochemicals at 65 (10 days before panicle initiation) and 85 days after transplanting (10 days after panicle initiation). Foliar spray ofT_2 (NPK- 19:19:19 @ 1.0 %) recorded the significantly higher Phenology and physiological parameters, number of filled spikelets per panicle (232.9), percent increase of filled spikelet's over control (33.6), least number of unfilled spikelets per panicle (61.3), less per cent of chaffyness (20.9 %), 1000 grain weight (23.6 g), the highest grain yield (8709.8 kg ha^{-1}) and percent increase of grain yield over T_{10} (control) (22.9 %) as compared to rest of the treatments. Soil application of T_1 (N- 25 % extra) was the third highest among 10 different treatments.

Keywords: agrochemicals, foliar and soil application, phenology, physiological parameters and productivity

Introduction

Rice is an important food crop of the world. It is the staple food of the people of South East-Asia. Presently more than half of the world population subsists on this crop. It is second most important cereal crop of the world as well as India after wheat ranks first in area and production in India. It is one of the most important crop of the world and forms the staple diet of about 2.7 billion people and it needs to be produced 50 per cent more than what produced now by 2050 to cope with the growing demand.

The crop plant requires a sufficient supply of essential mineral elements and growth regulators for optimal crop growth and final crop yield. An insufficient availability of essential nutrients (macro and micro) and hormones may cause stunted growth and limits the crop productivity. The growth and development of a plant is a complex process and is influenced by genetic, environmental and hormonal factors. In this experiment agrochemicals used which include plant growth regulators and nutrients (macro and micro) play an important role in modifying the growth parameters for producing potential yield of the crop. Foliar application of different agrochemicals gives immediate nutrition to the plant during peak growth period which in-turn improves the grain yield. In most of the circumstances foliar spray of nutrient is preferred because it gives quicker and better results than the soil application (Jamal *et al*. 2006) [8] but according to Alam *et al.* (2010) [1] soil application of N is better than foliar application because soil application gives higher grain yield and worthy economic performance. Method of nutrients or plant growth regulators application is a nonmonetary input which influences growth and consequently the crop yields. Foliar application of nutrients along with recommended dose of fertilizers increased the yield components due to foliar spray as it facilitates the higher photosynthates translocation to sink by increasing the photosynthesizing area and its capacity of particular crop (Thakur *et al*., 2017) [19].

The variety GNV10-89 was selected for this experiment. It is a dual season (*kharif* and *summer*), high yielding, short duration and medium slender variety.

The specialty of GNV-10-89 is maximum number of spikelets up to 300-350 per panicle but generally 200-250 spikelets per panicle in other varieties *viz.*, Sona Masoori and Kaveri Sona which are also popular varieties in this region. But the problem found in GNV-10-89 is 35 per cent of spikelets are unfilled *i.e.*, chaffy grains it might be due to inefficient translocation of reserve photosynthates to the reproductive parts of the plant. Therefore, the response of yield and yield attributes to foliar and soil application of different agrochemicals was observed during *kharif* season related aspects are presented in this paper.

Material and Methods

A field experiment was carried out at Agricultural Research Station (ARS), Gangavati, University of Agricultural Sciences, Raichur, during *kharif* season 2017 to study the effect of different agrochemicals on yield and yield attributes 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 laid out in randomized complete block design with 10 treatments replicated 3 times. 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 where 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 Phenology and physiological parameters, yield and yield attributing parameters *viz.*,filled spikelets and unfilled spikelets, per panicle, per cent chaffyness, grain yield and per cent increase of grain yield over T_{10} (control).Comparisons were made using one-way analysis of variance (ANOVA)as specified by Panse and Sukhatme (1985) [16].

Results and Discussion

Phenology

In this study significantly higher number of days to initiation of flowering was noticed in T_{10} (control) and the significantly lower number of days to initiation of flowering recorded in T_2 (NPK- 19:19:19 @ 1.0 %) followed by T_7 (6-BAP- 20 ppm) and T_1 (25 % extra N soil application as top dressing). The treatments such as T_3 (triacontanol- 2.0 ml/l) T_4 (GA_3- 50 ppm) T_6 (salicylic acid- 500 ppm) showed nonsignificant differences. The foliar application of T_2 (NPK- 19:19:19 @ 1.0 %) and T_7 (6-BAP- 20 ppm) were also nonsignificant. The data on phonological parameters (Table, 1) particularly days to 50 per cent flowering and days to physiological maturity indicated numerical variations due to foliar spray of growth regulators and nutrients. The plant growth regulators certainly help to prevent the abscission of flowers and fruits, when applied at the time of flowering (Ramesh and Thirumuguran, 2001) [18]. Agrochemicals treatment significantly advanced 50 per cent flowering by 10-16 days and physiological maturity stage by 7-17 days over untreated plants. The treatments T_2 (NPK- 19:19:19 @ 1.0 %) and T_7 (6-BAP- 20 ppm) significantly reduced the time for 50 % flowering and physiological maturity. The number of days to 50 per cent flowering recorded highest in T_{10} (control) and lowest in T_2 (NPK- 19:19:19 @ 1.0 %) foliar spray. But it was onpar with T_7 (6-BAP- 20 ppm) foliar spray. The nonsignificant differences were observed in T_3 (triacontanol- 2.0 ml/l) and T_4 (GA_3- 50 ppm); T_5 (nitrobenzene- 20 ppm) and T_6 (salicylic acid- 500 ppm); T_2 (NPK- 19:19:19 @ 1.0 %) and T_7 (6-BAP- 20 ppm). Exogenous applied GA_3 showed early flowering and this early flowering was accompanied by more number of flower buds by increasing the floral stem length (Naeem *et al.*, 2004) [13]. Similarly, the more number of days to physiological maturity was recorded in T_{10} (control). The less number of days to physiological maturity was noticed in T_2 (NPK- 19:19:19 @ 1.0 %). But it was onpar with T_5 (nitrobenzene- 20 ppm). The non-significant differences was observed in T_1 (25 % extra N soil application as top dressing), T_3 (triacontanol- 2.0 ml/l), T_7 (6-BAP-20 ppm) and T_9 (triacontanol-2.0 ml/l + borax-0.2 %).

Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1})

The plant performance is attributed to the genetic factors differences in the basic physiological and biochemical process are of great importance, as the plant metabolism depends on various biochemical constituents (Kashid, 2008) [9]. It is known that thousands of reactions are undergoing in the plants simultaneously which ultimately decide the growth and development and the final yield. In the present investigation the effect of different agrochemicals on photosynthetic rate is depicted in the Fig. 1. In this study the photosynthetic rate differed significantly among the treatments at 75 DAT. The photosynthetic rate was (Table 2 and Figure 1) significantly higher in plants sprayed with T_2 (NPK- 19:19:19 @ 1.0 %) over T_{10} (control. The significant increase in photosynthesis may be due to agrochemicals treatment which in turn may cause prolonged chlorophyll synthesis and strengthening the physiological activity. The results of present investigation are in line with the findings of Khan *et al.* (2003) [11] and Anjum *et al.* (2013) [2] in soybean. At later *i.e.*, at 95 DAT the photosynthetic rate increased significantly in 1.0 % foliar spray of 19:19:19 followed by foliar spray of T_7 (6-BAP- 20 ppm). But at harvest the photosynthetic rate decreased significantly it might be due to ageing of leaves. Some of the treatments showed onpar results such as T_5 (nitrobenzene- 20 ppm) and T_1 (25 % extra N soil application as top dressing). T_3 (triacontanol- 2.0 ml/l) and T_9 (Triacontanol- 2.0 ml/l + borax- 0.2 %) were also onpar with each other.

Transpiration rate (m mol H_2O m^{-2} s^{-1})

The transpiration rate increased due to agrochemicals treatments. It increased from 75 DAT to 95 DAT but the significant decrease in transpiration rate was observed at harvest. Among the different agrochemicals treatments T_2 (NPK- 19:19:19 @ 1.0 %) recorded higher transpiration rate as compared to other treatments at all growth stages. The lower transpiration rate was noticed in T_{10} (control) at all the growth stages (Table, 2). At 75 DAT the rate of transpiration was differed significantly in all the treatments. T_2 (NPK- 19:19:19 @ 1.0 %) recorded the higher (7.4 m mol H_2O m^{-2} s^{-1}) transpiration rate over rest of the treatments and the significantly lower (2.8 m mol H_2O m^{-2} s^{-1}) transpiration rate was recorded in T_{10} (control). The non-significant difference were observed in some of the treatments *i.e.,* T_7 (6-BAP- 20 ppm) (6.3 m mol H_2O m^{-2} s^{-1}) and T_1 (25 % extra N soil application as top dressing) (6.3 m mol H_2O m^{-2} s^{-1}). The treatments T_9 (triacontanol-2.0 ml/l + borax- 0.2 %) and T_3 (triacontanol-2.0 ml/l) were also non-significant (4.4 and 4.5 m mol H_2O m^{-2} s^{-1}). A similar trend was followed at harvest where the rate of transpiration was very less and the treatment T_2 (NPK-19:19:19 @ 1.0 %) showed the highest (1.6 m mol H_2O m^{-2} s^{-1}) among all the treatments and T_{10} (control) recorded the significantly lower (0.2 m mol H_2O m^{-2} s^{-1}) transpiration rate. The results of present investigation are in line with the findings of Khan *et al.* (2003) [11] and Anjum *et al.* (2013) [2] in soybean.

Yield and yield components

The data on test weight (Table. 3) was significantly higher (23.6 g) in T_2 (NPK- 19:19:19 @ 1.0 %). But in T_1 (N- 25 % extra) soil application was higher (18.1) than T_{10} (control). The significantly lower (15.5 g) test weight was noticed in T_{10} (control).Foliar spray of GA_3 at higher concentrations alone or at lower concentration in combination with urea or boric acid increased the test weight significantly over rest of the treatments (Biradarpatil and Shekhargouda, 2006) [3]. These chemicals might have facilitated better translocation and mobilization of metabolites from source to sink, resulting in better seed filling and higher test weight (Garg *et al.*, 1980 and Kaur and Singh, 1986) [6].

The total number of spiklets are divided into filled spiklets and unfilled spikelets per panicle where the treatment T_2 (NPK- 19:19:19 @ 1.0 %) recorded higher number of filled spikelets and lower number of unfilled spikelets as compared to other treatments presented in the Fig. 1. But the treatment T_7 (6-BAP- 20 ppm) and T_1 (25 % extra N soil application as top dressing) showed onpar result. The significantly maximum total number of spikelets was recorded in T_{10} (control) but the filled spikelets were less and unfilled spikelets were more (Table 3 and Figure 2). The similar results were obtained by Pan *et al.* (2013) [15] studied that the significant difference was found in the number of spikelets per panicle and grain filling percentage between GA_3 (20 mg l^{-1}) and 6-BA (30 mg l^{-1}) treatment in rice (cv. Peizataifeng and Huayou86). The treatment T_4 (GA_3- 50 ppm) and T_3 (triacontanol- 2.0 ml/l) showed nonsignificant difference, these results are in conformity with the findings of Naik *et al.* (2015) [14] in hybrid rice (var. KRH-2) and Mu and Yamagishi (2001) indicated that GA_3 increased the number of spikelets. But in accordance with Gavino *et al.* (2008) [7] indicated that the total number of spikelets were less as compared to other treatments with GA_3 foliar application. The less per cent of chaffyness (20.9 %) was recorded in the treatment foliar spray of T_2 (NPK- 19:19:19 @ 1.0 %) and other treatments *viz.,* T_7 (6-BAP- 20 ppm) and T_1 (25 % extra N soil application as top dressing) registered onpar results. The untreated plants showed the higher percentage of chaffyness (41.8 %). The per cent increase in filled spikelets per panicle in different agrochemicals treatments (Table 3). The treatment T_2 (NPK-19:19:19 @ 1.0 %) recorded 34.2 per cent increase in filled spikelets per panicle as compared to other treatments. Foliar spray of T_7 (6-BAP- 20 ppm) increased the filled spikelets upto 33.5 per cent followed by 25 per cent extra N soil application as top dressing 32.4 per cent over T_{10} (control).

The data on grain yield depicted in the Table 3 and Figure 3 indicated that foliar spray of T_2 (NPK- 19:19:19 @ 1.0 %) recorded the significantly higher (8709.8 kg ha^{-1}) grain yield as compared to soil application of T_1 (N-25 % extra) (8419.9 kg ha^{-1}). However, the significantly lower (7080.3 kg ha^{-1}) grain yield was recorded in T_{10} (control). The treatments such as T_7 (6-BAP-20 ppm) (8509.9 kg ha^{-1}) and T_1 (25 % extra N) soil application as top dressing (8419.9 kg ha^{-1}) showed nonsignificant difference. The per cent increase of grain yield in each treatment presented in the Table 1. Foliar spray of T_2 (NPK- 19:19:19 @ 1.0 %) increased the grain yield upto 22.9 % over control. The foliar spray of T_7 (6-BAP- 20 ppm) recorded the second highest increase in grain yield (20.6 %) over T_{10} (control). The percent increase of grain yield in soil application of T_1 (N-25 % extra) presented third highest (18.8 %) among the treatments. These results are in conformity with the findings of Dakshina *et al.* (2014) [4]. Who revealed 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) [17] and Das and Jana (2015) [5] who also reported the effect of water soluble fertilizer (NPK) spray on growth and yield of pulses showed the significantly higher seed yield.

Conclusions

The present investigation revealed that among foliar and soil application of different agrochemicals in addition to recommended dose of fertilizers foliar application having positive effects on Phenology and physiological parameters viz., photosynthetic rate and transpiration rate and all are having direct co relation with the final yield of the crop plants due to which all the yield components such as the number of filled spikelets per panicle and reduced number of unfilled spikelets per panicle has increased as compared to soil application. Foliar spray of agrochemicals showed reduced chaffyness percentage, higher test weight, grain yield and percent increase of grain yield over T_{10} (control). It might be due to foliar application provides immediate nutrition to the crop during peak growth period promotes vegetative growth, helpful in giving the vigor to the crop and also acts as yield booster and foliar spray of NPK (19:19:19) provides nutrients necessary for higher yield.

Table 1: Effect of agrochemicals on days to initiation of flowering, days to 50 % flowering and days to physiological maturity of rice

Treatments	Days to initiation of flowering (days)	Days to 50 % flowering (days)	Days to physiological maturity (days)
T_1 - 25 % extra N soil application as top dressing	65.5	90.2	117.2
T_2 - Foliar application of NPK (19:19:19) @ 1.0 %	64.7	86.5	110.5
T_3 - Foliar application of triacontanol (2.0 ml/l)	70.2	96.3	116.3
T_4 - Foliar application of GA_3 (50 ppm)	70.1	97.4	114.1
T_5 - Foliar application of nitrobenzene (20 ppm)	67.9	93.1	111.7
T_6 - Foliar application of salicylic acid (500 ppm)	70.6	92.2	120.1
T_7 - Foliar application of 6-BAP (20 ppm)	64.2	87.7	116.4
T_8 - Foliar application of borax (0.2 %)	71.4	99.2	123.5
T_9 - Foliar application of T_3 + T_8	69.3	94.3	116.2

T_{10} - Control	73.2	102	127.3
Mean	68.7	93.9	117.3
S.Em (±)	0.33	0.81	0.62
C.D. at 5 %	0.98	2.43	1.85

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

Table 2: Effect of agrochemicals on photosynthetic rate (µ mol CO_2 m^{-2} s^{-1}) and transpiration rate (m mol H_2O m^{-2} s^{-1}) at different growth stages of rice

Treatments	Photosynthetic rate (µ mol CO_2 m^{-2} s^{-1})			Transpiration rate (m mol H_2O m^{-2} s^{-1})		
	75 DAT	95 DAT	At harvest	75 DAT	95 DAT	At harvest
T1 - 25 % extra N soil application as top dressing	7.6	13.6	3.9	6.3	15.7	1.2
T2 - Foliar application of NPK (19:19:19) @ 1.0 %	8.4	15.4	4.8	7.4	16.2	1.6
T3 - Foliar application of triacontanol (2.0 ml/l)	7.1	11.3	2.7	4.5	13.3	0.5
T4 - Foliar application of GA3 (50 ppm)	6.7	10.7	2.4	3.7	13.1	0.6
T5 - Foliar application of nitrobenzene (20 ppm)	7.4	12.5	3.5	4.9	14.6	0.9
T6 - Foliar application of salicylic acid (500 ppm)	5.5	8.9	1.7	3.1	12.4	0.3
T7 - Foliar application of 6-BAP (20 ppm)	8.1	14.2	4.2	6.3	16.2	1.4
T8 - Foliar application of borax (0.2 %)	6.3	9.6	1.9	3.6	12.7	0.4
T9 - Foliar application of T3 + T8	6.9.	11.7	2.8	4.4	14.3	0.7
T10 - Control	5.2	7.4	0.8	2.8	8.5	0.2
Mean	6.90	11.5	2.90	4.70	13.7	0.80
S.Em (±)	0.079	0.24	0.10	0.07	0.074	0.044
C.D. at 5 %	0.23	0.70	0.30	0.21	0.22	0.12

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

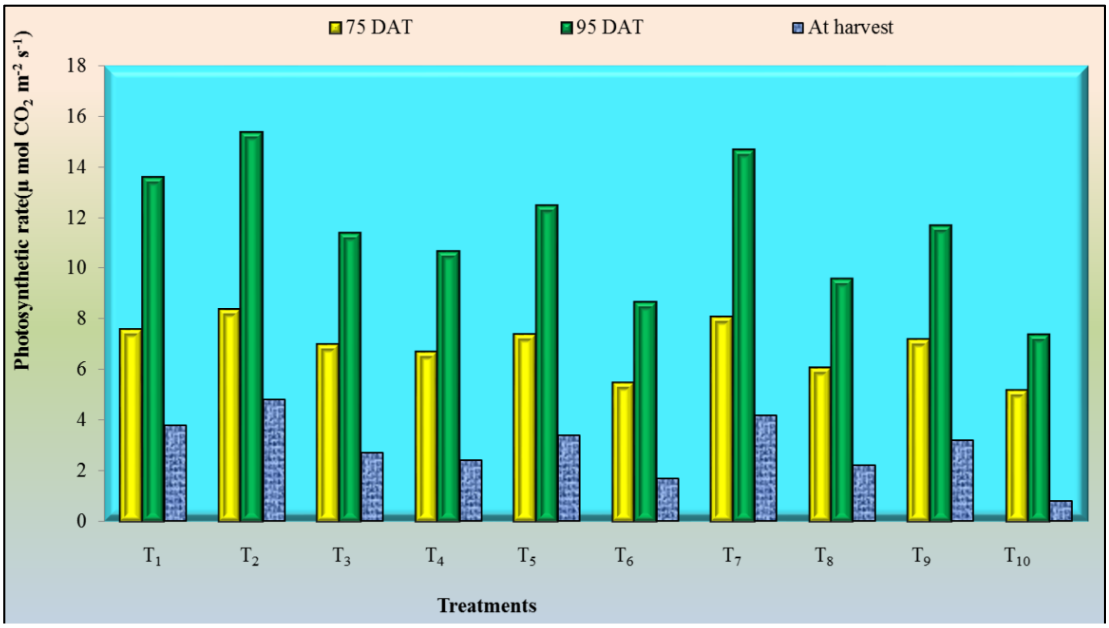

Fig 1: Effect of agrochemicals on photosynthetic rate (µ mol CO_2 m^{-2} s^{-1}) at different growth stages of rice

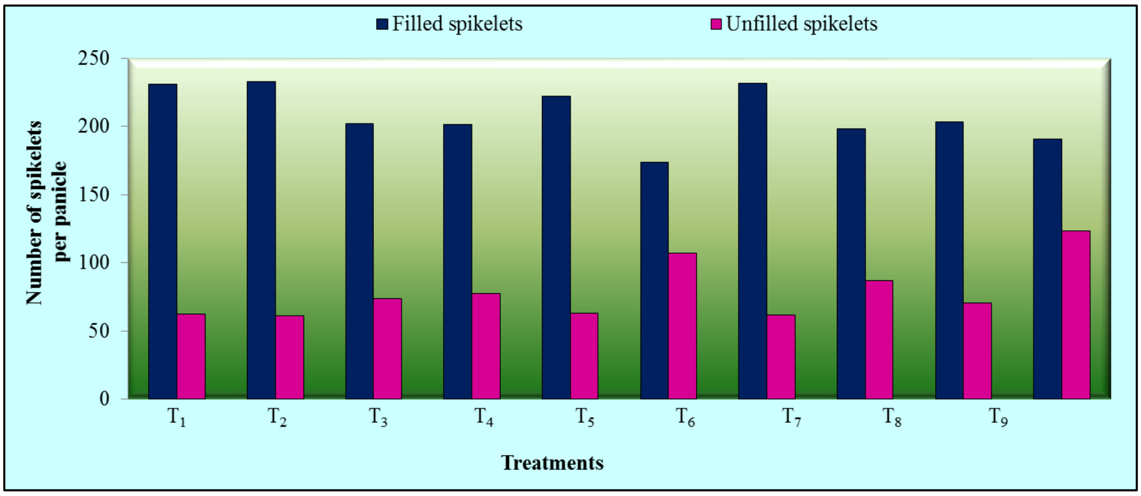

Fig 2: Effect of agrochemicals on number of filled spikelets and number of unfilled spikelets per panicle after harvest of rice

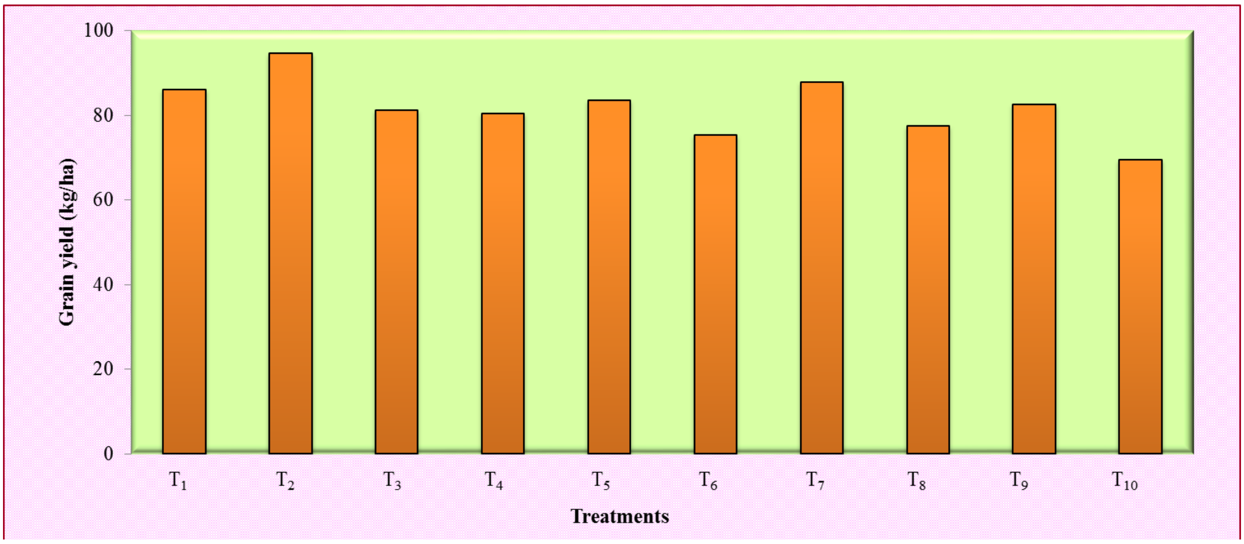

Fig 3: Effect of agrochemicals on grain yield of rice (kg ha^{-1})

Table 3: Effect of different agrochemicals on yield and yield attributes of rice

Treatment	Filled spikelets $panicle^{-1}$	Unfilled spikelets $panicle^{-1}$	Per cent chaffyness (%)	Test weight (g)	Yield (kg ha^{-1})	Per cent increase of yield over control (%)
T_1 - 25 % extra N soil application as top dressing	231.2	62.2	21.3	18.1	8419.9	18.8
T_2 - Foliar application of NPK (19:19:19) @ 1.0 %	232.9	61.3	20.9	23.6	8709.8	22.9
T_3 - Foliar application of triacontanol (2.0 ml/l)	202.1	74.0	26.8	17.4	8080.0	14.1
T_4 - Foliar application of GA_3 (50 ppm)	201.7	77.3	27.7	17.3	7890.2	11.3
T_5 - Foliar application of nitrobenzene (20 ppm)	222.4	63.1	22.1	18.1	8350.1	17.9
T_6 - Foliar application of salicylic acid (500 ppm)	190.5	106.9	33.8	16.9	7540.4	6.5
T_7 - Foliar application of 6-BAP (20 ppm)	231.8	61.5	21.0	19.5	8509.9	20.6
T_8 - Foliar application of borax (0.2 %)	198.0	86.9	30.5	17.2	7730.0	8.8
T_9 - Foliar application of T_3 + T_8	203.1	70.6	25.6	17.8	8219.7	16.2
T_{10} - Control	172.7	123.7	41.8	15.5	7080.3	-
Mean	208.6	78.75	27.15	18.14	8053.0	-
S.E.m (±)	0.80	1.50	0.20	0.20	0.80	-
C.D. at 5 %	2.40	4.50	0.60	0.60	2.40	-

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

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