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Effect of liquid fertilizers and growth stages of application on growth and yield of transplanted paddy

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Abstract

A field investigation entitled “Effect of liquid fertilizers and growth stages of application on growth and yield of transplanted paddy” was carried out at Agronomy Farm, College of Agriculture, Nagpur, during *khari* season of 2023- 2024. The experimental field was laid out in a factorial randomized block design (FRBD) with two factors. The first factor was comprised of four liquid fertilizers treatments viz., L₁ (Foliar application of 1% 19:19:19), L₂ (Foliar application of 1% 19:19:19 + PDKV Grade-2), L₃ (Foliar application of 1% 13:0:45) and L₄ (Foliar application of 1% 13:0:45 + PDKV Grade-2) and the second factor comprised of three growth stages of application viz., G₁ (Maximum tillering), G₂ (Grain filling) and G₃ (Maximum tillering and grain filling) forming 12 treatment combinations replicated three times. Results revealed that, significantly higher values of plant height, dry matter accumulation hill⁻¹, effective tillers hill⁻¹, number of grains panicle⁻¹, weight of grains hill⁻¹, test weight, grain yield ha⁻¹, straw yield ha⁻¹, GMR, NMR and B:C ratio were recorded with the foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) over rest of the liquid fertilizers. However, it was found at par with foliar application of liquid fertilizer 1% 13:0:45 (L₃) for all the parameters except test weight. On the other hand, all the above mentioned parameters were found to be significantly superior with liquid fertilizer application at maximum tillering and grain filling stages (G₃), which was found at par with the liquid fertilizer application at maximum tillering stage (G₁) for all the parameters.

Keywords: Foliar application, liquid fertilizers, growth stages of application, paddy, growth and yield

Introduction

The productivity level of rice in India is low as compared to the productivity levels of many countries in the world. Also, about 90% of the cultivated land belong to marginal, small and medium farmers which is another constraint in increasing the productivity of rice in the country. Fertilizers have a crucial role in enhancing food production and quality particularly with the introduction of high yielding and fertilizer responsive varieties (Ma, 2004) [12]. Application of needed nutrients by foliar means is one of the options in supplying nutrients to the plant. Most fertilizers like 19:19:19, 13:0:45 and other micronutrient fertilizers are 100% water soluble, hence they do not contain impurities that could damage plants and lead to accumulation of toxic residues in the production cycle (Kannan *et al.*, 2010) [9]. These liquid fertilizers when applied foliarly, can enter the leaf either by penetration of the cuticle or via stomatal pathway thus enhancing the nutrient uptake and translocation to the edible parts of the crop. Thus, foliar fertilizer application is one of the most effective and safest approaches to enrich those nutrients in crop grain (Fang *et al.*, 2008; Jin *et al.*, 2008) [6, 8]. Keeping these things in mind, instead of mere soil application of nutrients at one or two stages of the crop it would be better to go for foliar application of completely water soluble fertilizer (WSF) at its definite concentration at proper time, to meet the need of paddy crop during its different growth stages. Foliar application of liquid fertilizers and micro nutrients at critical growth stages of paddy can improve the use efficiency of applied nutrients and support tillering, panicle initiation, grain filling and overall crop development, leading to improved yields and quality with least investment (Bernal *et al.*, 2007) [3]. Thus, keeping the above facts in view, the present investigation was undertaken.

Methods and Materials

The present investigation entitled “Effect of liquid fertilizers and growth stages of application on growth and yield of transplanted paddy” was conducted during *kharif* season of 2023-2024 on the field of Agronomy Section, College of Agriculture, Nagpur. The experimental site was fairly uniform with levelled topography. The soil was vertisol and clayey in texture. It was low in available nitrogen (225.10 kg ha⁻¹), medium in available phosphorus (24.16 kg ha⁻¹), high in available potassium (339.30 kg ha⁻¹), medium in organic carbon (0.58%) and slightly alkaline in reaction (7.70).

The experimental was laid out in a factorial randomized block design (FRBD) with two factors. The first factor was comprised of four liquid fertilizers viz., L₁ (Foliar application of 1% 19:19:19), L₂ (Foliar application of 1% 19:19:19 + PDKV Grade-2), L₃ (Foliar application of 1% 13:0:45) and L₄ (Foliar application of 1% 13:0:45 + PDKV Grade-2) and the second factor was comprised of three growth stages of application viz., G₁ (Maximum tillering), G₂ (Grain filling) and G₃ (Maximum tillering and grain filling) forming 12 treatment combinations replicated three times. Spacing of 20 cm × 15 cm was adopted for the rice variety PDKV- Tilak. The recommended dose of fertilizer was (100:50:50 N P K kg ha⁻¹) and other package of practices for rice were imposed uniformly for all the treatments. During the study, observations on growth and yield attributing characters as well as grain yield and straw yield were recorded at harvest to evaluate treatment effects and statistical analysis was done. Cost of cultivation was calculated and studies on economics were carried out with the help of prevailing market price of paddy.

Results and Discussion

Results obtained during the period of investigation pertaining to the topic are presented in appropriate tables under the following heads. The inferences are discussed and have been supported by logical reasoning and proper evidences.

Effect of liquid fertilizers on growth and yield attributes; yield and economics of paddy

Data on plant height, dry matter accumulation hill⁻¹, effective tillers hill⁻¹, number of grains panicle⁻¹, weight of grains hill⁻¹ and test weight, as influenced by different liquid fertilizer treatments is presented in Table-1 and data on grain yield ha⁻¹, straw yield ha⁻¹, GMR, NMR and B:C ratio as influenced by different liquid fertilizer treatments is presented in Table-2.

Effect of liquid fertilizers on growth attributes of paddy

Data presented in Table-1 showed that growth attributes i.e., plant height and dry matter accumulation hill⁻¹ of paddy at harvest was significantly influenced due to different liquid fertilizers treatments. Foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) recorded significantly higher plant height (110.83 cm) and dry matter accumulation hill⁻¹ (38.16 g) than other liquid fertilizers at harvest. However, it was found at par with foliar application of liquid fertilizer 1% 13:0:45 (L₃) in respect of plant height (109.04 cm) and dry matter accumulation hill⁻¹ (37.02 g). This might be due to high K in 13:0:45 playing a significant role in cell elongation as well as due to micro-nutrients in PDKV Grade-2 which are involved in chlorophyll production, enzyme activation and hormone regulation leading to enhanced plant height and dry matter accumulation hill⁻¹. Similar results were obtained by Bharaani *et al.*, (2020)^[4] and Ghodake *et al.*, (2022)^[7].

al., (2020)^[4] and Ghodake *et al.*, (2022)^[7].

Effect of liquid fertilizers on yield attributes of paddy

Data presented in Table-1 revealed that yield attributes viz., effective tillers hill⁻¹, number of grains panicle⁻¹ and weight of grains hill⁻¹ differed significantly due to different liquid fertilizers treatments. Foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) recorded significantly higher number of effective tillers hill⁻¹ (11.32), number of grains panicle⁻¹ (156.98) and grain weight hill⁻¹ (23.51 g), which was found at par with foliar application of liquid fertilizer 1% 13:0:45 (L₃) in respect of number of effective tillers hill⁻¹ (10.82), number of grains panicle⁻¹ (153.36) and grain weight hill⁻¹ (21.95 g). This might be due to adequate supply of potassium, along with micronutrients, which support efficient grain filling, enzymatic and physiological functions, thus optimizing photosynthesis which improves overall plant health and root development, leading to higher number of effective tillers hill⁻¹, grains panicle⁻¹ and grain weight hill⁻¹. Similar results were obtained by Kunjammal *et al.*, (2016)^[11] and Singh *et al.*, (2021)^[16].

Whereas, test weight of paddy due to different liquid fertilizers treatments was found to be non-significant at harvest. Test weight being a genetic character was not affected due to different liquid fertilizers. However, numerically maximum test weight (13.55 g) was observed with foliar application of 1% 13:0:45 + PDKV Grade-2 (L₄) followed by 1% 19:19:19 + PDKV Grade-2 (L₂) (13.36 g) and 1% 13:0:45 (L₃) (13.32 g), while lowest test weight (13.28 g) by application of 1% 19:19:19 (L₁).

Effect of liquid fertilizers on yield of paddy

Data presented in Table-2 revealed that grain yield ha⁻¹ and straw yield ha⁻¹ were significantly influenced due to different liquid fertilizers treatments. Foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) recorded significantly higher grain yield ha⁻¹ (3830 kg) and straw yield ha⁻¹ (5002 kg) of paddy over rest of the liquid fertilizers. However, it was found at par with foliar application of liquid fertilizer 1% 13:0:45 (L₃) with respect to grain yield ha⁻¹ (3601 kg) and straw yield ha⁻¹ (4610 kg) of paddy. This might be due to higher availability of potassium which enhances photosynthesis, cell expansion, water regulation and promotes robust vegetative growth, while micronutrients such as zinc and boron contribute to various enzymatic reactions and chlorophyll synthesis and also are critical for reproductive growth, further leading to better accumulation of photosynthates in the grain and straw thereby increasing grain and straw yield of paddy ha⁻¹. Similar results were reported by Sivakamipriya *et al.*, (2022)^[18] and Amoah *et al.*, (2023)^[1].

Effect of liquid fertilizers on economics

Data presented in Table-2 showed that GMR and NMR were significantly influenced due to different liquid fertilizers treatments. Foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) recorded significantly higher gross monetary returns (Rs. 88604 ha⁻¹) and net monetary returns (Rs. 48928 ha⁻¹), but it was found at par with foliar application of liquid fertilizer 1% 13:0:45 (L₃) with GMR (Rs. 83222 ha⁻¹) and NMR (Rs. 45307 ha⁻¹). Similarly, highest B:C ratio of (2.23) was recorded with the foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) followed by foliar application of

1% 13:0:45 (L₃) (2.19). Higher GMR, NMR and B:C ratio might be due to higher grain yield and straw yield obtained in (L₄). Similar results were reported by Ghodake *et al.*, (2022)^[7].

Effect of growth stages of application on growth and yield attributes; yield and economics of paddy

Data regarding plant height, dry matter accumulation hill⁻¹, effective tillers hill⁻¹, number of grains panicle⁻¹, weight of grains hill⁻¹ and test weight, as influenced by different growth stages of application is presented in Table-1 and data regarding grain yield ha⁻¹, straw yield ha⁻¹, GMR, NMR and B:C ratio as influenced by different growth stages of application is presented in Table-2.

Effect of growth stages of application on growth attributes of paddy

Data presented in Table-1 showed that growth attributes *i.e.*, plant height and dry matter accumulation hill⁻¹ of paddy at harvest was significantly influenced due to different growth stages of application. Liquid fertilizer application at maximum tillering and grain filling stages (G₃) recorded significantly superior plant height (109.44 cm) and dry matter accumulation hill⁻¹ (37.93 g) than other growth stages at harvest, but it was found at par with liquid fertilizer application at maximum tillering stage (G₁) with respect to plant height (107.91 cm) and dry matter accumulation hill⁻¹ (36.87 g). This might be due to application of liquid fertilizers at two growth stages of paddy which leads to enhanced nutrient availability, chlorophyll content and leaf area, resulting in improved photosynthetic efficiency promoting stem elongation and thus more plant height and higher dry matter accumulation hill⁻¹. The results obtained were in correlation with those obtained by Singh and Singh (2018)^[15] and Singh *et al.*, (2020)^[17].

Effect of growth stages of application on yield attributes of paddy

Data presented in Table-1 revealed that yield attributes such as effective tillers hill⁻¹, number of grains panicle⁻¹ and weight of grains hill⁻¹ of paddy at harvest was significantly influenced due to different growth stages of application. Application of liquid fertilizers at maximum tillering and grain filling stages (G₃) was found significantly superior in respect of number of effective tillers hill⁻¹ (11.18), number of grains panicle⁻¹ (155.08) and weight of grains hill⁻¹ (22.82 g) over other treatments. However, it was found at par with liquid fertilizer application at maximum tillering stage (G₁) with respect to number of effective tillers hill⁻¹ (10.77), number of grains panicle⁻¹ (151.57) and weight of grains hill⁻¹ (21.53 g). This might be due to dual application of liquid fertilizers, which ensures that plants have sufficient nutrients during critical growth phases, enhancing tiller survival and grain formation, thus resulting in higher number of effective tillers hill⁻¹, grains panicle⁻¹ and weight of grains hill⁻¹. The results obtained were in correlation with those obtained by Kundu and Sarkar (2009)^[10], Radhika *et al.*, (2013)^[13] and Anand *et al.*, (2020)^[12].

Whereas, different growth stages of application did not show significant effect on the test weight of paddy at harvest. Test

weight being a genetic character was not affected due to different growth stages of application, but liquid fertilizer application at maximum tillering and grain filling (G₃) recorded the highest test weight of paddy (13.49 g) numerically, followed by application at maximum tillering (G₁) (13.39 g), while the lowest test weight (13.26 g) with application at grain filling (G₂).

Effect of growth stages of application on yield of paddy

Data presented in Table-2 revealed that grain yield ha⁻¹ and straw yield ha⁻¹ of paddy was significantly influenced due to different growth stages of application. Liquid fertilizer application at maximum tillering and grain filling (G₃) recorded significantly higher grain yield ha⁻¹ (3779 kg) and straw yield ha⁻¹ (4867 kg) of paddy than that of other growth stages. However, it was found at par with liquid fertilizer application at maximum tillering stage (G₁) with respect to grain yield ha⁻¹ (3580 kg) and straw yield ha⁻¹ (4554 kg) of paddy. This might be due to the fact that fertilizers applied at maximum tillering promote the development of more productive tillers and increase the number of potential grains panicle⁻¹. Additionally, supplying nutrients during the grain filling supports cell expansion and overall plant vigour and is also critical for filling grains effectively, resulting in higher grain yield ha⁻¹ and straw yield ha⁻¹. The results were found similar with those of Elankavi *et al.*, (2020)^[5] and Shah *et al.*, (2022)^[14].

Effect of growth stages of application on economics

Data presented in Table-2 showed that GMR and NMR of paddy was significantly influenced due to different growth stages of application. Liquid fertilizer application at maximum tillering and grain filling stages (G₃) recorded significantly superior gross monetary return (Rs. 87362 ha⁻¹) and net monetary return (Rs. 47578 ha⁻¹), but it was found at par with liquid fertilizer application at maximum tillering stage (G₁) with GMR (Rs. 82709 ha⁻¹) and NMR (Rs. 44402 ha⁻¹). Similarly, liquid fertilizer application at maximum tillering and grain filling (G₃) recorded maximum value of B:C ratio (2.20) numerically, followed by application at maximum tillering (G₁) (2.16). Higher GMR, NMR and B:C ratio might be due to higher grain yield and straw yield obtained in (G₃). The results obtained are in correlation with those obtained by Kundu and Sarkar (2009)^[10].

Effect of interaction of liquid fertilizers and growth stages of application on growth and yield attributes; yield and economics of paddy

Data regarding plant height, dry matter accumulation hill⁻¹, effective tillers hill⁻¹, number of grains panicle⁻¹, weight of grains hill⁻¹ and test weight as influenced by interaction of different liquid fertilizers and growth stages of application is presented in Table-1 and data regarding grain yield ha⁻¹, straw yield ha⁻¹, GMR, NMR and B:C ratio as influenced by interaction of different liquid fertilizers and growth stages of application is presented in Table-2 which were found non-significant.

Table 1: Effect of liquid fertilizers and growth stages of application on growth and yield attributes of paddy at harvest

Treatments	Plant height (cm)	Dry matter accumulation hill ⁻¹ (g)	Number of effective tillers hill ⁻¹	Number of grains panicle ⁻¹	Weight of grains hill ⁻¹ (g)	Test weight (g)
A. Liquid fertilizers (L)						
L ₁ - Foliar application of 1% 19:19:19	104.97	35.16	9.86	145.67	18.72	13.28
L ₂ - Foliar application of 1% 19:19:19 + PDKV Grade-2	105.77	36.04	10.34	148.89	20.49	13.36
L ₃ - Foliar application of 1% 13:0:45	109.04	37.02	10.82	153.36	21.95	13.32
L ₄ - Foliar application of 1% 13:0:45 + PDKV Grade-2	110.83	38.16	11.32	156.98	23.51	13.55
S.E(m) ±	0.64	0.51	0.20	1.80	1.03	0.11
CD at 5%	1.88	1.50	0.58	5.27	3.01	NS
B. Growth stages of application (G)						
G ₁ - Maximum tillering	107.91	36.87	10.77	151.57	21.53	13.39
G ₂ - Grain filling	105.61	34.98	9.82	147.03	19.15	13.26
G ₃ - Maximum tillering and grain filling	109.44	37.93	11.18	155.08	22.82	13.49
S.E(m) ±	0.56	0.44	0.17	1.55	0.89	0.09
CD at 5%	1.63	1.30	0.50	4.56	2.60	NS
C. Interaction (A × B)						
S.E(m) ±	1.11	0.88	0.34	3.11	1.78	0.19
CD at 5%	NS	NS	NS	NS	NS	NS
General mean	107.65	36.59	10.59	151.23	21.17	13.38

Table 2: Effect of liquid fertilizers and growth stages of application on yield and economics of paddy at harvest

Treatments	Yield (kg ha ⁻¹)		Economics (Rs. ha ⁻¹)		
	Grain	Straw	GMR	NMR	B:C ratio
A. Liquid fertilizers (L)					
L ₁ - Foliar application of 1% 19:19:19	3216	4237	74438	36841	1.98
L ₂ - Foliar application of 1% 19:19:19 + PDKV Grade-2	3426	4310	79090	39976	2.02
L ₃ - Foliar application of 1% 13:0:45	3601	4610	83222	45307	2.19
L ₄ - Foliar application of 1% 13:0:45 + PDKV Grade-2	3830	5002	88604	48928	2.23
S.E(m) ±	137	150	3014	3014	-
C.D. at 5%	403	441	8840	8840	-
B. Growth stages of application (G)					
G ₁ - Maximum tillering	3580	4554	82709	44402	2.16
G ₂ - Grain filling	3195	4198	73943	36309	1.96
G ₃ - Maximum tillering and grain filling	3779	4867	87362	47578	2.20
S.E(m) ±	119	130	2610	2610	-
C.D. at 5%	349	382	7656	7656	-
C. Interaction (A × B)					
S.E. (m) ±	238	260	5221	5221	-
C.D. at 5%	NS	NS	NS	NS	-
General mean	3518	4540	81338	42763	2.11

Conclusion

On the basis of the results obtained from the present investigation, it can be concluded that, the foliar application of liquid fertilizer 1% 13:0:45 + PDKV Grade-2 (L₄) recorded significantly higher growth characters, yield attributes, yield as well as GMR, NMR and B:C ratio of paddy as compared to other liquid fertilizers. Application of liquid fertilizers at both maximum tillering and grain filling stages (G₃) recorded significantly better growth characters, yield attributes, yield as well as GMR, NMR and B:C ratio of paddy as compared to application at individual growth stages.

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