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Studies on Growth, Yield Attributes, Yield and Economics of Lathyrus in Rice Fallow under Various Tillage Systems and Foliar Spray of Nutrients in Red and Lateritic Soils

Sumana Biswas, K. Akhil, Siddharth Shankar Patre and Arun Kumar Barik

Dept. of Agronomy, Palli Siksha Bhavana, Institute of Agriculture, Visva-Bharati, Sriniketan, Birbhum, West Bengal (731 236), India

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Corresponding arunkumar.barik@visva-bharati.ac.in

0000-0001-6638-2310

ABSTRACT

A field experiment was conducted during *rabi* seasons (November to March) of 2022–23 and 2023–24 at Agricultural farm of Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, West Bengal, India to find out the effect of various tillage systems and foliar spray of nutrients on growth, yield attributes, yield and economics of lathyrus in rice fallow. The experiment was laid out in split plot design replicated thrice having two tillage practices (zero tillage and conventional tillage) in main plots and six levels of foliar spray of nutrients in sub-plots. Various tillage practices had on significant response on growth and yield attributes of lathyrus. Among different tillage practices, significant response with highest seed yield (1311.5 kg ha^{-1}), stover yield (1584.4 kg ha^{-1}) and gross return (74101 ₹ ha^{-1}) was received under conventional tillage but return per rupee investment was recorded highest on Zero tillage (2.73 ₹ ha^{-1}). Foliar spray of nutrients had significant response on various growth parameters, yield attributes, yield (seed, stover and biological) and economic returns except harvest index of lathyrus. Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS registered significantly highest seed yield (1432.1 kg ha^{-1}), stover yield (1691.8 kg ha^{-1}) and gross return, net return and return rupee^{-1} investment (80915 ₹ ha^{-1}, 53125 ₹ ha^{-1}, 2.91 ₹ ha^{-1}, respectively) among different foliar spray of nutrients.

KEYWORDS: Tillage, foliar spary, lathyrus, $ZnSO_4$, boron, conventional tillage

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1. INTRODUCTION

About 88% of India's rice crop, spanning 12 mha, is concentrated in eastern states like Assam, West Bengal, Bihar, Jharkhand, Chhattisgarh, Odisha, Madhya Pradesh, and the North East Hill. (Chowdhury et al., 2020, Deka et al., 2020). Addition of pulses to a monocropping system can address nutrient mining issues, allowing for double cropping, increased legume output, and improved productivity. (Samajdar et al., 2019, Ghosh et al., 2022). However, in rainfed monocropped area, farmers receive less yield from second crops due to water scarcity (Sorokhaibam et al., 2016, Jana et al., 2018, Deka et al., 2021). Pulses, often referred to as "poor man's meat" and "rich man's vegetable," provide 25% dietary protein, energy, minerals, vitamins, minimal fat, and low glycemic index, making them an ideal dietary choice for Type 2 diabetes management (Banerjee et al., 2019, Barik, 2021). Though the adaptation of conservation tillage is at its initial stage in Indian agricultural scenario, conservation agricultural techniques to minimize loss of soil moisture and progresses seeding though developed for large scale mechanized agriculture need to be adopted for rabi pulses also (Sharma et al., 2016, Ramesh et al., 2019, Kumar et al., 2019). The sub soiling is an urgent need to break the hard pan and also improve the soil porosity and percolation. Therefore, some of the research findings have already indicated that the sub soiling may be beneficial to improve the productivity and profitability of the system, compared to adopting conventional tillage system. (Singh et al., 2019 and Ogieriakhi and Woodward, 2022). Farmers are occasionally overlooked fertilizing lathyrus after rice and grow lathyrus with residual fertilizer or apply only basal dose of fertilizer. This is also one of the reasons for low productivity of lathyrus. The imbalanced and inadequate use of fertilizers, along with low efficiency of chemical fertilizers, has significantly decreased the yield and quality of different crops (Birla et al., 2023 and Ghosh et al., 2021). Indra et al. (2024) observed that soil application of nutrients applied at the time of sowing or 35 days after sowing often results in lower fertilizer use efficiency of all concerned nutrients which ultimately affect the growth and yield of the crop. So foliar nutrition was better way to lock loss of nutrients. With this technique, nutrients can reach to the site of food synthesis directly, leaving no wastage (Akhil at al., 2024). Though there is no wastages and requirement is also low so cost is also reduced. Foliar application of nutrients has been proved to be an important asset in fertilizer application with a specific aim of increasing nutrient availability at the time of need especially in the later stage of plant growth (Kobir et al., 2020). Foliar spray has been shown to be more successful in improving yields by delaying senescence and converting late flushes of flower into pods thereby balancing source to sink relationship ultimately enhancing grain production (Banerjee et al., 2019, Sarkar et al., 2024). After rice harvest the most crucial limiting macronutrient is phosphorus and lathyrus is extremely vulnerable to shortages in micronutrients, especially zinc and boron (Baskey et al., 2025; Gupta et al., 2021; Prasad and Shivay, 2019). Indian agriculture is entering into a new era of post green revolution and conservation agriculture is gaining importance due to widespread resource degradation, economic benefit, and sustainability in food production (Saha et al., 2020, Yadav et al., 2020). Keeping in view of the above mentioned scope of research, the present study was attempted to find out response of various tillage practices and foliar spray of nutrients on growth, productivity and economic returns of lathyrus in rice-fallow.

2. MATERIALS AND METHODS

2.1. *Experimental period and location*

A field experiment was conducted during *rabi* seasons from November to March of 2022–23 and 2023–24 at agricultural farm of Palli Shiksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, India situated at 23°39´ N latitude, 87°42´ E longitude with an altitude of 58.9 m from mean sea level. The experimental soil was low in available nitrogen (147.1 kg ha^{-1}) and available phosphorus (13.6 kg ha^{-1}) and medium in available potassium (146.5 kg ha^{-1}).

2.2. *Experimental design and treatment details*

The field experiment, consists of two main plots and six subplot treatments having twelve treatment combinations, was carried out in split plot design with three replications of each treatment (Main plot treatment :-tillage method: ZT: Zero tillage CT: Conventional tillage; Sub-plot treatment:- foliar nutrient management: FS1: 100% RDF N-P-K soil application; FS2: Foliar spray with DAP @ 2% at 30 DAS and 45 DAS;FS3: Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS; FS4: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @0.5% at 40 DAS; FS5: Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS+Boron (20%) @0.1% at 50 DAS; FS6: Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS)

2.3. *Package and practices*

A recommended dose of fertilizers (20:40:20 of N: P2O5:K2O in kg ha^{-1}) was applied in the form of Urea, Muriate of Potash (MOP). Foliar application of N-P-K @ 19:19:19 was done. Application of $ZnSO_4$ and Borax was done as a source of Zn and Boron. Lathyrus (variety-Ratan) was sowing with a spacing of 30×10 cm^2. The lathyrus crops were raised following proper package of practices. Lathyrus was sown during first week of November, in 2022 and 2023 and harvested during second week of March, 2023 and 2024, respectively.

2.4. Observations and procedure of data recorded

The biometric observations for different growth attributes, yield attributes and yield of lathyrus were recorded at regular interval. Plant height, number of plant^{-1}, Number of branches plant^{-1} at harvest leaf area index, dry matter accumulation, crop growth rate was measured and calculated. Whereas, at harvest, yield components like number of pods plant^{-1}, number of seed pod^{-1}, Test weight, seed yield, straw yield, biological yield, harvest index were measured and recorded for estimation of yield of lathyrus. The cost of cultivation, gross return, net return and return rupee^{-1} invested (gross return/cost of cultivation) were calculated on the basis of prevailing market price of different inputs and selling price of crop produce.

2.5. Methods of statistical analysis

The data were analysed by following Analysis of Variance (ANOVA) technique and mean difference were adjusted by the multiple comparison test (Gomez and Gomez, 1984). The significance of different source of variance was tested by error mean square of Fisher's 'F' test at Probability level 0.05. Fisher and Yate's tables were consulted for the determination of critical difference at 5% level of significance. The value of standard error of mean (SEm±) and the critical difference (CD) to compare the difference between the treatment means and co-efficient of variance (CV%) have been provided in the tables.

3. RESULTS AND DISCUSSION

3.1. Growth attributes

3.1.1. Effect of tillage practices

The main plot treatments with different tillage practices (viz. ZT: Zero tillage and CT: Conventional tillage) did not influence significantly various growth attributes such as plant height, number of branches plant^{-1}, leaf area index, dry matter accumulation and crop growth rate of lathyrus (Table 1). However, among various tillage practices, zero tillage method registered highest plant height (56.1 cm), number of branches plant^{-1} (6.0) and dry matter accumulation (228.5 g m^{-2}) at harvest as well as highest LAI (1.74) at 70 DAS which was higher than conventional tillage. Crop growth rate registered highest in conventional tillage (1.98 g m^{-2} day^{-1}). Improved soil health and a microclimate with sufficient residual moisture might be the cause of lathyrus with superior growth characteristics in zero tillage regime. Similar findings were reported by Banjara et al. (2017).

3.1.2. Effect of foliar spray of nutrients

Foliar spray of nutrients (zinc and boron) alone or in combination significantly responded to various growth parameters such as plant height, number of branches plant^{-1}, LAI, dry matter accumulation and crop growth rate (Table 1). FS6: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS produced significantly highest plant height (59.6 cm), number of branches plant^{-1} (6.5), dry matter accumulation (234.5 g m^{-2}) at harvest and highest LAI at 70 DAS (2.0). But FS5: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS was at par with highest value in case of plant height (57.7 cm) and dry matter accumulation at harvest (233.7 g m^{-2}) where as FS4: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS also showed at par value of dry matter accumulation at harvest (230.6 g m^{-2}). With respect to crop growth rate, FS4: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS showed higher value (2.04 g m^{-2} day^{-1}) which was at par with FS3: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS (2.02 g m^{-2} day^{-1}), FS5: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+Boron (20%) @0.1% at 50 DAS (2.01 g m^{-2} day^{-1}) and FS6: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS (1.97 g m^{-2} day^{-1}). Upadhyay and Singh (2016) opined that foliar application of Zn promoted enhanced branching due to promotion of bud and branch development by auxins and accelerated the translocation of photo assimilates.

No significant interaction between tillage practices and foliar spray of nutrients on growth parameter of lathyrus was found (Table 1).

3.2. Yield attributes and yield

3.2.1. Effect of tillage practices

Yield attributes (no. of pods plant^{-1}, no. of seeds pod^{-1}, Test weight and harvest index) of lathyrus did not vary significantly due to different tillage practices (Table 2). Amongst various tillage practices, zero tillage recorded higher number of seeds pod^{-1} (4.0), Test weight (68.5 g), harvest index (46.4%) and highest number of pods plant^{-1} (23.4) recorded at conventional tillage.

Seed yield, straw yield and biological yield varied significantly due to different tillage practices (Table 2). Significantly highest seed yield (1311.5 kg ha^{-1}), straw yield (1584.4 kg ha^{-1}) and biological yield (2895.8 kg ha^{-1}) were recorded in conventional tillage over zero tillage. Das et al. (2022) also was in conformity with these findings where better establishment and better use of available soil

Table 1: Effect of tillage and foliar nutrient management on growth attribute of lathyrus at different growth stages. (Pooled data)

Treatment	Plant height at harvest (cm)	Number of branches plant^{-1} at harvest	Leaf area index (LAI) at 70 DAS	Dry matter accumulation at harvest (g m^{-2})	Crop growth rate at 40–70 DAS (g m^{-2} day^{-1})
Tillage (T)					
ZT	56.1	6.0	1.74	228.5	1.91
CT	55.1	5.7	1.66	218.3	1.98
SEm±	0.36	0.10	0.02	3.01	0.01
CD (*p*=0.05)	NS	NS	NS	NS	NS
Foliar nutrient management (FS)					
FS1	54.2	5.9	1.7	220.4	1.85
FS2	52.2	5.3	1.4	197.0	1.77
FS3	53.6	5.6	1.6	224.2	2.02
FS4	56.4	5.8	1.8	230.6	2.04
FS5	57.7	6.1	1.8	233.7	2.01
FS6	59.6	6.5	2.0	234.5	1.97
SEm±	0.68	0.13	0.03	2.89	0.12
CD (*p*=0.05)	2.00	0.39	0.08	8.53	0.37
Interaction (T×FS)					
SEm±	1.02	0.22	0.043	5.08	0.18
CD (*p*=0.05)	NS	NS	NS	NS	NS
Interaction (FS×T)					
SEm±	0.96	0.19	0.037	4.09	0.18
CD (*p*=0.05)	NS	NS	NS	NS	NS

ZT: Zero tillage; CT: Conventional tillage; FS1: 100% RDF N-P-K soil application; FS2: Foliar spray with DAP @ 2% at 30 DAS and 45 DAS; FS3: Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS; FS4: Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS+$ZnSO_4$ @0.5% at 40 DAS; FS5: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+Boron (20%) @0.1% at 50 DAS; FS6: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS); NS: Non-significant; DAS: Days after sowing

moisture might be the reasons for enhanced crop growth comparatively greater performance under zero tillage and conventional tillage.

3.2.2. *Effect of foliar spray of nutrients*

In lathyrus, yield attributes, seed yield, straw yield and biological yield were influenced significantly by foliar spray of nutrients except harvest index based on pooled values (Table 2). Higher number of pods plant^{-1} (26.8), number of seeds pod^{-1} (4.3) and test weight (69.9 g) were recorded in FS6: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS which was at par with FS5:Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS and FS4: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS which ultimately increased seed yield as well as straw yield.

The results indicated that significantly highest seed yield (1432.1 kg ha^{-1}), straw yield (1691.8 kg ha^{-1}) biological yield (3123.8 kg ha^{-1}) and harvest index of lathyrus were recorded with the application of foliar spray of nutrients with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS which was superior to all other foliar applications. However, straw yield of lathyrus was at par with FS5:Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS (1607.9 kg ha^{-1}). The increased yield-attributing characteristics might be resulted from foliar application of micronutrients through activation of photosynthetic capacity, which in turn encouraged buildup of dry matter and effective partitioning of photosynthates towards sinks (Dhayal et al., 2023).

Better photosynthetic efficiency with urea application might have helped in easy translocation of carbohydrates

Table 2: Effect of tillage and foliar nutrient management on yield attribute and yield of lathyrus. (Pooled data)

Treatment	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Tillage (T)							
ZT	23.3	4.0	68.5	1229.6	1422.7	2652.2	46.4
CT	23.4	4.0	68.1	1311.5	1584.4	2895.8	45.3
SEm±	0.376	0.05	0.30	6.52	20.68	18.93	0.37
CD (p=0.05)	NS	NS	NS	39.66	125.80	115.16	NS
Foliar nutrient management (FS)							
FS1	22.5	3.9	67.7	1223.3	1397.5	2620.7	46.7
FS2	17.3	3.4	66.7	1102.0	1354.2	2456.2	44.9
FS3	23.6	4.1	67.7	1240.0	1448.5	2688.5	46.2
FS4	25.1	4.2	68.7	1292.7	1521.2	2813.9	46.0
FS5	24.9	4.2	69.1	1333.2	1607.9	2941.1	45.4
FS6	26.8	4.3	69.9	1432.1	1691.8	3123.8	45.8
SEm±	0.69	0.05	0.73	20.33	30.73	44.81	0.64
CD (p=0.05)	2.03	0.16	2.15	59.97	90.65	132.18	NS
Interaction (T×FS)							
SEm±	1.04	0.09	1.07	29.49	48.13	66.14	0.97
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS
Interaction (FS×T)							
SEm±	0.97	0.07	1.03	28.76	43.46	63.37	0.90
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS

ZT: Zero tillage; CT: Conventional tillage; FS1: 100% RDF N-P-K soil application; FS2: Foliar spray with DAP @ 2% at 30 DAS and 45 DAS; FS3: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS; FS4: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS; FS5: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS; FS6: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS); NS: Non-significant; DAS: Days after sowing

to grain, which could also have ultimately resulted in higher grain yield. Pal et al. (2019) also reported similar results in chickpea and these results confirmed the findings of Meena et al. (2020).

No significant interaction between tillage practices and foliar spray of nutrients on yield component and yield of lathyrus was found (Table 2).

3.3. Economics

3.3.1. Effect of tillage practices

Different tillage practices (viz. ZT: Zero tillage and CT: Conventional tillage) significantly influenced gross return and return rupee^{-1} investment except net return on the basis of pooled values (Table 3). However, among various tillage practices, CT: Conventional tillage method registered highest average cost of cultivation (28920 ₹ ha^{-1}) and significantly highest gross return (74101 ₹ ha^{-1}) but return rupee^{-1} investment was recorded highest in Zero tillage (2.73 ₹ ha^{-1}). Net return was not influenced significantly by different tillage practices and highest net return was recorded on conventional tillage (45182 ₹ ha^{-1}).

3.3.2. Effect of foliar spray of nutrients

Foliar application of nutrients significantly influenced gross return, net return and return rupee-1 investment in lathyrus on pooled data basis (Table 3). Highest cost of cultivation (27790 ₹ ha^{-1}), gross return (80915 ₹ ha^{-1}), net return (53125 ₹ ha^{-1}) and return rupee^{-1} investment (2.91 ₹ ha^{-1}) was recorded in FS6: Foliar spray with N: P: K (19:19:19) @2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS which was superior to all other foliar application of nutrients.

Higher seed yield was responsible for corresponding highest gross return, net return and return rupee^{-1} investment of these treatments as compared to others. Earlier it was reported by Saha et al. (2023) in Utera Rapeseed-Mustard

Table 3: Effect of tillage and foliar nutrient management on economics of lathyrus

Treatment	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Return $rupee^{-1}$ (₹ ha^{-1})
	Mean	Pooled	Pooled	Pooled
Tillage (T)				
ZT	25420	69473	44053	2.73
CT	28920	74101	45182	2.56
SEm±	-	340.18	340.18	0.02
CD (*p*=0.05)	-	2069.67	NS	0.10
Foliar nutrient management (FS)				
FS1	27987	69120	41133	2.47
FS2	25153	62260	37108	2.49
FS3	27148	70061	42913	2.59
FS4	27444	73041	45597	2.67
FS5	27498	75327	47829	2.74
FS6	27790	80915	53125	2.91
SEm±	-	1156.04	1156.04	0.04
CD (*p*=0.05)	-	3409.81	3409.81	0.12
Interaction (T×FS)				
SEm±	-	1669.91	1669.91	0.06
CD (*p*=0.05)	-	NS	NS	NS
Interaction (FS×T)				
SEm±	-	1634.89	1634.89	0.06
CD (*p*=0.05)	-	NS	NS	NS

ZT: Zero tillage; CT: Conventional tillage; FS1: 100% RDF N-P-K soil application; FS2: Foliar spray with DAP @ 2% at 30 DAS and 45 DAS; FS3: Foliar spray with N: P: K (19:19:19) @ 2% at 30 DAS and 45 DAS; FS4: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS; FS5: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+Boron (20%) @ 0.1% at 50 DAS; FS6: Foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS); NS: Non-significant; DAS: Days after sowing

in Rice-Fallow of Alluvial Soils. Similar findings of higher economic returns were also mentioned by Dhaliwal et al. (2021) and Pal et al. (2019) in chickpea due to application of zinc and urea.

No significant interaction between tillage practices and foliar spray of nutrients on economics of lathyrus was found (Table 3).

4. CONCLUSION

Among different tillage practices, conventional tillage was most efficient for increasing growth parameters, yield attributing characters, yield and economic returns of lathyrus. Combined use of foliar spray with N:P:K (19:19:19) @ 2% at 30 DAS and 45 DAS+$ZnSO_4$ @ 0.5% at 40 DAS+Boron (20%) @ 0.1% at 50 DAS registered significantly higher growth attributes, yield attributes, yield and economic returns of lathyrus in rice fallow of red and lateritic soil of West Bengal.

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