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Influence of Planting Geometry and Nitrogen Levels on Nutrient Content, Uptake and Soil Fertility Status in Scented Rice (*Oryza sativa* L.)

B.R. Praveen, O.P. Lathwal[1], A.K. Dhaka[2], R.S. Garhwal[1], Magan Singh V. Rundan and Rakesh Kumar

Agronomy Section, ICAR-National Dairy Research Institute, Karnal-132 001, India
[1]College of Agriculture, Kaul, Kaithal-136 021, India
[2]Department of Agronomy, CCS HAU, Hisar-125 004, India
E-mail: praveengowdabr07@gmail.com

Abstract: An experiment was carried out during *kharif* 2018 at Research Farm, College of Agriculture, Kaul (Kaithal) to study the influence of planting geometry and nitrogen levels on nutrient (N, P and K) content, uptake and soil fertility status under scented rice (Pusa 1121). The experiment was conducted using split plot design with four replications having three planting geometry in main plots and five nitrogen levels in sub plots. Grain and straw yield were significantly higher at 20 cm x 15 cm and 120 kg N/ha. N, P and K concentrations in grain and straw were non-significant with planting geometry. However, these concentration increases significantly with increase in nitrogen level and maximum at 120 kg N/ha. N, P and K uptake by both grain and straw were significant at planting geometry 20 cm x 15 cm and nitrogen rate of 120 kg/ha. The available N, P_2O_5 and K_2O of experimental field before cultivation were 163, 27 and 379 kg/ha, respectively. N, P_2O_5 and K_2O content in soil after cultivation was higher under 30 cm x 20 cm. However, N content in soil after cultivation was maximum at 120 kg N/ha, but P_2O_5 and K_2O content was in control.

Keywords: Scented rice, Planting geometry, Nitrogen levels, Soil fertility

Rice (*Oryza sativa* L.) is the most important cereal food crop of the developing world and staple food for more than three billion people. Mainly two types of rice *i.e.*, non scented and scented are grown in the country. Scented rice gives a distinctive scent due to the presence of natural chemical compounds and having unique quality features, excellent cooking and eating quality characters. Apart from special natural fragrance, scented rice also has high nutritional value and contains many kinds of amino acids, proteins, alkaloids, vitamin B_1 and B_2 and other essential nutrients for human beings (Shen et al 2016). The increased rice production might be due to the adoption of high yielding varieties, use of chemical fertilizers and increase in irrigated area from last few decades. For yield and quality increment and also for maintaining soil quality, sustainable technologies are highly essential which may include cost minimization by saving resources and adoption of low cost or non-monetary inputs (Haque et al 2016). Hence crop management practices like judicious application of nitrogen fertilizer and maintenance of planting geometry are of prime importance in rice crop production. Nitrogen is an imperative limiting nutrient in almost all Indian soils and also for rice crop growth in all environments. Since, 75 % of leaf nitrogen is associated with chloroplast, it is very essential in rice which physiologically helps in dry matter production through photosynthesis. Apart from enhancing growth, it also benefits the quality of crop by improving the concentration of nutrients in the vegetative mass and boosting the uptake of nutrients. It also involved in synergistic mechanism with few essential nutrients and improving their efficiency to the benefit of crop and maintaining soil quality (Kabat and Satapathy 2011). Planting geometry and spatial configuration exploit the initial vigour of the genotypes with enhanced soil aeration creating favourable condition for better crop establishment (Shukla et al 2014). Optimum planting geometry measures the optimum plant density that ensures the plant to grow properly with their aerial and underground parts by utilizing more solar radiation and optimum soil nutrients and also helps in maintaining the nutrient status of crop and soil after the cultivation. Hence, planting geometry is directly or indirectly responsible for the nutrients uptake especially nitrogen, phosphorous and potassium in the rice crop apart from maintaining soil nutrient balance. Hence by knowing the importance of nitrogen and planting geometry, an experiment was conducted to study the effect of nitrogen levels and planting geometry on nutrient (N, P and K) content, uptake and soil fertility status under scented rice (Pusa 1121).

MATERIAL AND METHODS

Experimental site: A field experiment was conducted at Research Farm, College of Agriculture, Kaul (Haryana) during *kharif* season of 2018 which is situated at 29° 51' N latitude and 76° 41' E longitude, with an altitude of 241 m above mean sea level. The region is characterized by sub-humid climate with desiccating hot winds of average velocity during summer and severe cold winds during winter. The mean weekly meteorological data of crop season *kharif* 2018 was recorded at meteorological observatory, College of Agriculture, Kaul (Fig. 1). The experimental field soil was sandy clay loam in texture. The soil was medium in organic C (5.4 g/kg), low in available N (163 kg/ha), medium in available P_2O_5 (27 kg/ha) and high in available K_2O (379 kg/ha) with pH of 7.7 and EC 0.29 dS/m.

Treatment details and crop management: The experiment was carried out in split-plot design having fifteen treatment combinations including three planting geometry *viz.*, 20 cm x 15 cm, 30 cm x 15 cm and 30 cm x 20 cm in main plots and five nitrogen levels *viz*., control (0 kg/ha), 30 kg/ha, 60 kg/ha, 90 kg/ha and 120 kg/ha in subplots with four replications. An extra-ordinary scented rice variety Pusa 1121 was used as experimental material and urea as a nitrogen source in the experiment. The nursery was raised in the field itself using seed rate of 40-50 g/m^2 area and the field was puddled thoroughly at the time of transplanting. The 30 days old seedlings were transplanted manually in the experimental field keeping main plot treatments of different planting geometry with 2 seedlings per hill. At the time of transplanting, half dose of each level of nitrogen along with 60 kg P_2O_5/ha and 25 kg zinc sulphate ($ZnSO_4$) per ha were applied in their respective sub plots. Remaining doses of each level of nitrogen for their respective sub plots were applied in two splits, first at 20 days after transplanting (DAT) and second at 40 DAT as top dressing. Other agronomic practices were followed as per the standard package of practices in rice cultivation.

Plant sample analysis: The samples of grain and straw were collected through destructive plant sampling and dried properly and then ground to digest them with di-acid mixture of H_2SO_4 and $HClO_4$ for the estimation of total nitrogen through Nessler's Reagent Method (Linder 1944). Phosphorus and potassium were estimated by digesting the grain and straw sample in di-acid mixture of HNO_3 and $HClO_4$ through vanadomolybdophosphoric by Yellow Color Method (Koening and Johnson, 1942) and Flame Photometer Method (Piper 1966), respectively. The harvested crop from each treatment plot were threshed and then weighed separately to record grain and straw yield per plotafter drying and expressed per hectare. N, P and K uptake by grain and straw were determined in kg/ha by using grain and straw yield, respectively as per the following formulas:

$$\text{Nutrient uptake by grain (kg/ha)} = \frac{\text{Nutrient content in gram (\%)} \times \text{Grain yield (kg/ha)}}{100}$$

$$\text{Nutrient uptake by straw (kg/ha)} = \frac{\text{Nutrient content in straw (\%)} \times \text{Straw yield (kg/ha)}}{100}$$

Soil sample analysis: The soil samples were collected from the experimental field of 0-15 cm depth soil from 10 different

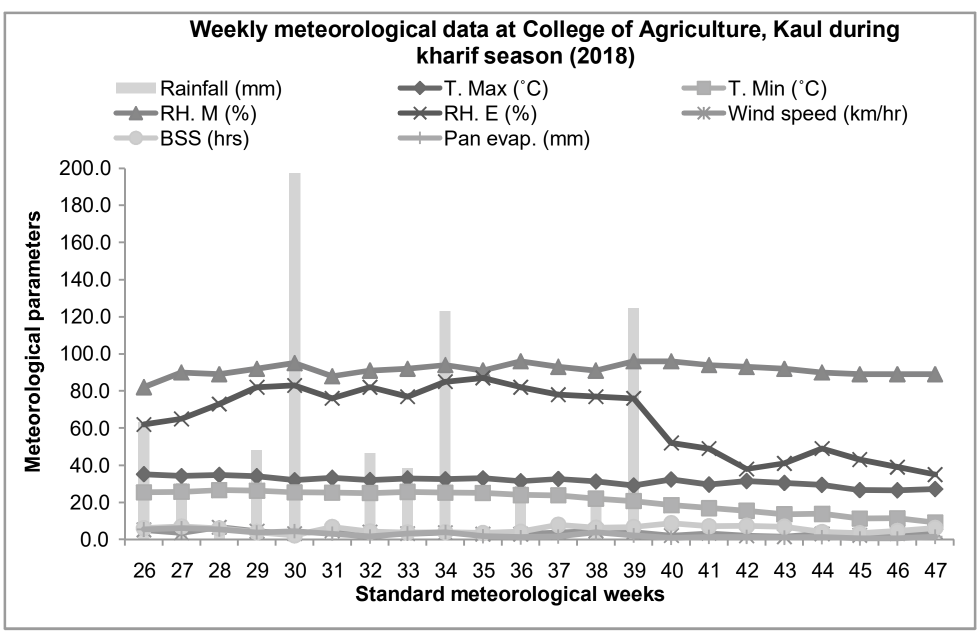

Fig. 1. Weekly meteorological data at College of Agriculture, Kaul during *kharif* season (2018)

spots in zig-zag pattern before cultivation and also collected from all experimental plots of different treatments after harvesting the rice crop and these samples were dried under shade, grounded gently with the help of mortar to pass through 2 mm sieve. Finally, soil samples were subjected to chemical analysis as per the standard analytical procedures. The available nitrogen was determined by alkaline permanganate Method (Subbaiah and Asija 1956), available phosphorus was determined by Olsen's Method (Olsen et al 1954) and available potassium was determined by Flame Photometer Method (Jackson 1973).

Statistical analysis: The experimental data obtained were statistically analyzed by using standard procedure to determine the significance of difference between treatment means.

RESULTS AND DISCUSSION

Grain and straw yield: Significant response was observed for grain and straw yield under varying planting geometry and nitrogen rates as depicted in Figure 2. Among planting geometry, 20 cm x 15 cm recorded significantly higher grain (4394 kg/ha) and straw yield (5939 kg/ha) as compared to 30 cm x 15 cm and 30 cm x 20 cm. This was due to higher number of effective tillers, dry matter accumulation and higher plant population under narrow geometry. Similar findings were published by Das et al (2013). The rate of increase in grain and straw yield was more up to 30 kg N/ha and reached to maximum at 120 kg N/ha (4458 and 5829 kg/ha, respectively) which was significantly higher over remaining nitrogen levels except the fact that grain yield at 120 kg N/ha was statistically at par with 90 kg N/ha. This trend of increasing grain and straw yield with increase in nitrogen rates was due to better overall growth of plants under higher nitrogen levels. Similar pattern of results were reported by Dubey et al (2016) and Narayan et al (2017).

N, P and K content in grain and straw: The effect of planting geometry was non-significant on nitrogen (N), phosphorus (P) and potassium (K) content in grain and straw but N, P and K concentration in grain and straw increased significantly with successive increment in nitrogen level (Table 1). However, higher concentration of N, P and K in grain (0.93, 0.18 and 0.43 %, respectively) and straw (0.52, 0.14 and 1.25 %, respectively) were at planting geometry of 20 cm x 15 cm. The similar results were reported by the findings of Singh et al (2013). Among nitrogen levels, higher concentration of N and K in grain (1.10 and 0.52 %, respectively) and straw (0.64 and 1.41 %, respectively) were at 120 kg N/ha which were significantly higher than lower concentration and control. The higher P concentration in grain (0.22 %) and straw (0.18 %) was also at 120 kg N/ha which was statistically at par with nitrogen level of 90 kg/ha but significantly higher than the concentration at 60 and 30 kg N/ha and control. The higher N, P and K concentration at higher nitrogen level was due to more nitrogen input and synergistic interaction between N, P and K. The results were similar to the findings of (Kabat and Satapathy 2011).

N, P and K uptake by grain and straw: N, P and K uptake by grain and straw influenced significantly with planting geometry and nitrogen levels (Table 2). N, P and K uptake by grain and straw decreased with increase in planting geometry. Maximum N and K uptake by grain (42.0 and 19.2 kg/ha, respectively) were with planting geometry of 20 cm x 15 cm which was significantly higher than 30 cm x 15 cm and 30 cm x 20 cm. P uptake by grain was also higher (8.3 kg/ha)

Table 1. Nutrient (N, P and K) content of scented rice as affected by planting geometry and nitrogen levels

Treatments	N, P and K content in grain (%)			N, P and K content in straw (%)		
	N	P	K	N	P	K
Planting geometry						
20 cm x 15 cm	0.93	0.18	0.43	0.52	0.14	1.25
30 cm x 15 cm	0.91	0.17	0.42	0.51	0.13	1.23
30 cm x 20 cm	0.90	0.16	0.41	0.50	0.13	1.21
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen levels (kg/ha)						
Control	0.71	0.11	0.31	0.35	0.08	0.98
30	0.81	0.16	0.37	0.44	0.11	1.17
60	0.93	0.18	0.42	0.53	0.14	1.26
90	1.02	0.20	0.48	0.59	0.17	1.35
120	1.10	0.22	0.52	0.64	0.18	1.41
CD (p=0.05)	0.04	0.02	0.03	0.03	0.02	0.04

than planting geometry of 20 cm x 15 cm, but it was statistically at par with 30 cm x 15 cm and significantly higher than the 30 cm x 20 cm. Maximum N and P uptake by straw (31.1 and 8.7 kg/ha, respectively) were with planting geometry of 20 cm x 15 cm which were statistically at par with 30 cm x 15 cm and significantly higher as compared to 30 cm x 20 cm. K uptake by straw was also higher (75.0 kg/ha) with planting geometry of 20 cm x 15 cm which was significantly more than the K uptake by straw with planting geometry of 30 cm x 15 cm and 30 cm x 20 cm. N, P and K uptake by grain and straw was higher at closer planting geometry of 20 cm x 15 cm because of higher grain and straw yield. These results were also supported by Bommayasamy et al (2010). N, P and K uptake by grain and straw at different nitrogen levels showed that it increased significantly with each increment in nitrogen level. Maximum N, P and K uptake by grain (49.2, 9.8 and 23.0 kg/ha, respectively) were at 120 kg N/ha which were significantly higher when compared with the N, P and K uptake by grain at 90, 60, 30 kg N/ha and control. Maximum N and K uptake by straw were at 120 kg N/ha which were significantly higher than N and K uptake at 90, 60, 30 kg N/ha and control. P uptake by straw was also higher (10.6 kg/ha) at 120 kg N/ha, but it was statistically at par with P uptake by straw at 90 kg N/ha and significantly higher than the P uptake at 60, 30 kg N/ha and control. Higher N, P and K uptake was with higher nitrogen level at 120 kg/ha due to improved growth of above and below ground plant parts and higher grain and straw yield. This finding was similar to the earlier findings (Majumdar et al 2005, Oq et al 2007, and Singh et al 2015).

Available N, P_2O_5 and K_2O status of soil before and after cultivation: The available N, P_2O_5 and K_2O of experimental

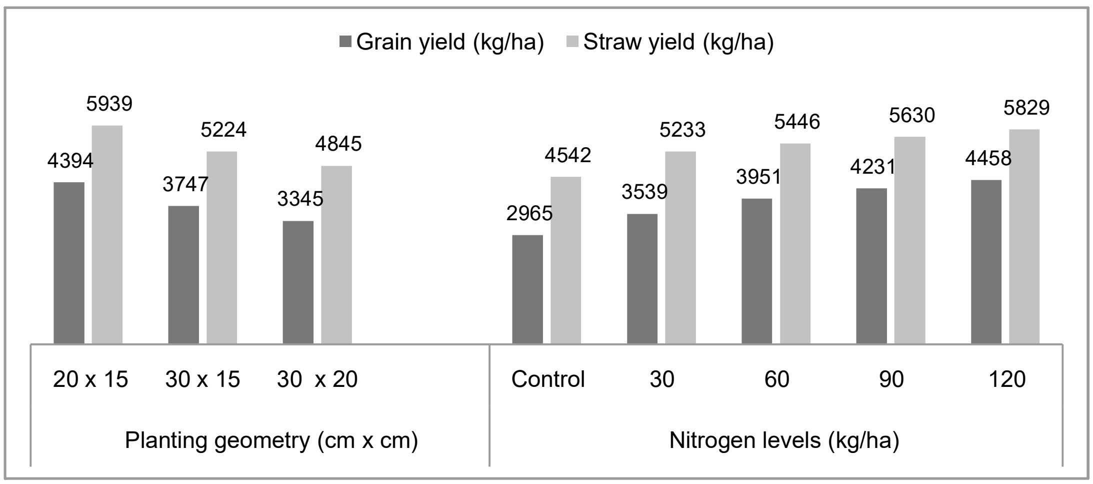

Fig. 2. Grain and straw yield as influenced by planting geometry and nitrogen levels

Table 2. Nutrient (N, P and K) uptake by scented rice as affected by planting geometry and nitrogen levels

Treatments	N, P and K uptake by grain (kg/ha)			N, P and K uptake by straw (kg/ha)		
	N	P	K	N	P	K
Planting geometry						
20 cm x 15 cm	42.0	8.3	19.2	31.1	8.7	75.0
30 cm x 15 cm	35.0	6.6	16.0	27.0	7.1	65.0
30 cm x 20 cm	30.4	5.6	13.9	24.6	6.6	59.5
CD (p=0.05)	5.7	1.7	3.0	4.3	1.7	9.6
Nitrogen levels (kg/ha)						
Control	21.0	3.2	9.0	15.7	3.6	44.8
30	28.8	5.5	13.0	23.2	6.0	61.0
60	36.7	7.1	16.5	28.6	7.7	68.7
90	43.1	8.5	20.1	33.2	9.4	75.9
120	49.2	9.8	23.0	37.1	10.6	82.1
CD (p=0.05)	3.2	1.1	1.7	2.8	1.3	5.2

Table 3. Nutrient (N, P_2O_5 and K_2O) status of soil after cultivation of scented rice as affected by planting geometry and nitrogen levels

Treatments	N, P_2O_5 and K_2O status of soil after cultivation (kg/ha)		
	N	P_2O_5	K_2O
Planting geometry			
20 cm x 15 cm	106.7	8.9	142.3
30 cm x 15 cm	119.9	9.1	145.1
30 cm x 20 cm	132.8	9.3	148.1
CD (p=0.05)	2.3	0.1	2.2
Nitrogen levels (kg/ha)			
Control	102.0	10.4	152.1
30	110.1	9.8	150.2
60	121.2	9.1	144.9
90	129.3	8.3	141.3
120	136.4	7.9	137.2
CD (p=0.05)	1.6	0.2	1.8

field before cultivation were 163, 27 and 379 kg/ha, respectively. The effect of planting geometry and nitrogen levels were significant on available N, P_2O_5 and K_2O of soil after cultivation of scented rice (Table 3). Among planting geometry, higher available N, P_2O_5 and K_2O in soil after cultivation (132.8, 9.3 and 148.1 kg/ha, respectively) were at wider planting geometry of 30 cm x 20 cm which were significantly higher than 30 cm x 15 cm and 20 cm x 15 cm. Available N, $P_2O_5$and K_2O content in soil after cultivation were higher under wider planting geometry of 30 cm x 20 cm might be due to lesser uptake of nutrients by the crop under wider planting geometry because of less number of populations per unit area. The higher available N in soil after cultivation (136.4 kg/ha) was at 120 kg N/hawhich was significantly higher than 90, 60, 30 kg N/haand control. Available P_2O_5 and K_2O of soil were higher (10.4 and 152.1 kg/ha, respectively) at control which were significantly higher than 30, 60, 90 and 120 kg N/ha. The condition in which available N content in soil after cultivation was also higher at 120 kg N/ha, but P and K content was higher at control might be due to increasing nutrients uptake with increase in nitrogen level. Similar results were also reported by Sikdar et al (2008) and Singh et al 2010).

CONCLUSIONS

The maximum amount of N, P and K content in grain and straw were with 120 kg N/ha but revealed non-significant response with planting geometry. N, P and K uptake by grain and straw were maximum with closer planting geometry of 20 cm x 15 cm at 120 kg N/ha. In case of available nutrient content after cultivation of scented rice, maximum available N, P_2O_5 and K_2O with wider planting geometry of 30 cm x 20 cm. However, maximum available N was recorded at 120 kg N/ha but available P_2O_5 and K_2O content was higher at control.

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REFERENCES

Bommayasamy N, Ravisankar N and Subramani T 2010. Influence of non-monetary inputs on growth and yield of rice (*Oryza sativa* L.) under system of rice intensification (SRI). *Indian Journal of Agronomy* **55**(2): 95-99.

Das S, Chaki AK, Sarker AR, Mondal S, Sarker MMR and Moniruzzaman M 2013. Effect of spacing of transplanting, rate and depth of placement of urea super granules (USG) on the yield of *boro* rice. *Bulletin of the Institute of Tropical Agriculture* **36**: 85-94.

Dubey SK, Tiwari DD, Pandey SB, Singh UN and Katiyar NK 2016. Effect of nitrogen, sulphur and zinc application on yield, nutrient uptake and quality of rice. *Research on Crops* **17**(1): 13-15.

Haque MA and Haque MM 2016. Growth, yield and nitrogen use efficiency of new rice variety under variable nitrogen rates. *American Journal of Plant Sciences* **7**: 612-622.

Jackson ML 1973. *Soil chemical analysis*. Preintice Hall of India Pvt. Ltd., New Delhi.

Jiankai Shen, Zhenyu Xie, Zhizhou He, Qiyun Lin and Ming Yin 2016. Composition and development prospects of scented rice. *Asian Agricultural Research* **8**(2): 73-77.

Kabat B and Satapathy MR 2011. Effect of planting date and nitrogen level on grain yield of hybrid rice. *Oryza* **48**(2): 186-187.

Koening RA and Johnson CR 1942. Colorimetric determination of phosphorus in biological materials. *Industrial and Engineering Chemistry,* Analytical edition **14**: 155-156.

Linder RC 1944. Rapid analytical methods for some of the most common inorganic constituents of plant tissues. *Plant Physiology* **19**: 76-78.

Majumdar B, Venkatesh MS, Kumar K and Patiram 2005. Nitrogen requirement for low land rice (*Oryza sativa* L.) in valley lands of Meghalaya. *Indian Journal of Agricultural Science* **75**: 504-506.

Narayan H, Ramachandra C, Murthy KKN, Mallareddy and Prabhudev DS 2017. Effect of nitrogen level and time of application on yield and water use efficiency of aerobic rice. *International Journal of Agricultural Sciences* **9**(3): 3690-3693.

Olsen SR, Cok CV, Watanable PS and Dean LA 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate. *U.S.D.A. Circular* **34**: 939.

Oq NML, Shivay YS and Kumar D 2007. Effect of nitrogen and sulphur fertilization on yield attributes, productivity and nutrient uptake of aromatic rice (*Oryza sativa* L.). *Indian Journal of Agricultural Sciences* **77**(11): 772-775.

Piper CS 1966. *Soil and water analysis*. Published by University Adelaid (Australia).

Shukla UN, Srivastava VK, Singh S, Sen A and Kumar V 2014. Growth, yield and economic potential of rice (*Oryza sativa* L.) as influenced by different age of seedlings, cultivars and weed management under system of rice intensification. *Indian Journal of Agricultural Sciences* **84**(5): 628-636.

Sikdar MSI, Rahman MM, Islam MS, Yeasmin MS and Akhtar MM

2008. Effect of nitrogen levels on aromatic rice varieties and soil fertility status. *International Journal of Sustainable Crop Production* **3**(3): 49-54.

Singh F, Kang JS, Singh A and Singh T 2015. Nutrient uptake, nutrient availability and quality parameters of mechanically transplanted rice (*Oryza sativa* L.) under split doses of nitrogen. *Agricultural Science Digest* **35**(2): 95-100.

Singh N, Thenua OVS, Kumar D and Tyagi VK 2013. Root growth, yield and N P K uptake of rice (*Oryza sativa* L.) varieties grown by system of rice intensification with varying planting geometry and weed management practices. *Annals of Agricultural Research* **34**(1): 26-35.

Singh T, Singh TP and Sikka R 2010. Effect of dates of transplanting, plant population and nitrogen levels on nitrogen uptake and nutrient status of soil in basmati rice. *Crop Research* **40**(1, 2 and 3): 12-15.

Subbiah BV and Asija GL 1956. A rapid procedure for determination of available nitrogen in soils. *Current Science* **25**: 259-260.

Yoshida S 1981. *Fundamentals of Rice Crop Science*. International Rice Research Institute, Philippines: 269.

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