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Influence of Spacing and Weed Management Practices on the Growth Characters, Nutrient Removal of Weeds and Nutrient Uptake of Direct Seeded Rice

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ABSTRACT

Background: The field experiment was conducted at the Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu during *rabi,* 2022-2023 to study the influence of spacing and weed management practices on growth characters, nutrient removal by weeds and nutrient uptake of direct seeded rice (DSR).

Methods: The field experiment was laid out in split plot design with three replications. The main plots were spacing of 20 × 15 cm, 20 × 20 cm and 25 × 25 cm. Sub plots were assigned with weed management practices *viz*., pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE, Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Cono weeding on 20 DAS + hand weeding (HW) on 40 DAS, Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Cono weeding on 20 DAS and 40 DAS, Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Cono weeding on 40 DAS, Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Hand weeding on 40 DAS, Hand weeding at 20 and 40 DAS and unweeded control.

Result: The results indicated that the highest growth attributes, higher nutrient uptake of nitrogen, phosphorous and potassium under DSR and were significantly improved by spacing 20 × 20 cm along with pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Cono weeding on 40 DAS. This was on par with pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Hand weeding on 40 DAS and hand weeding on 20 and 40 DAS. Similarly lower nutrient removal by weeds were registered under 20 × 15 cm spacing along with pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS. The interaction of spacing 20 × 20 cm and pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Cono weeding on 40 DAS significantly increased the growth attributes such as plant height, dry matter production and total numbers of tillers and significantly lowered the nutrient removal by weeds.

Key words: Direct seeded rice, Nutrient removal, Nutrient uptake, Spacing, Weed management.

INTRODUCTION

Rice (*Oryza sativa* L.) is important cereal crop, which more than half of the people worldwide consume next to wheat. Rice is grown on 167 million ha worldwide, with Asia accounting for 146 m ha. Above 90 per cent of the globally produced rice is consumed in Asia (FAO, 2019). In India, rice is grown in an area of 45.7 m.ha with a production of 124.3 m.t and an average productivity of 2.7 t ha^{-1}. In Tamil Nadu, rice is cultivated in an area of 2.2 m.ha with a production of 7.9 m.t and a productivity of 3566 kg ha^{-1} (Indiastat, 2021). DSR is an alternative method of rice cultivation saves the water and reduces labour requirements upto 45% (Chakraborti *et al.,* 2017). Weeds are becoming major biotic problem to sustain the effective crop growth and weed control (Rathika and Ramesh, 2019). However, DSR cultivation depends on various factors, including proper crop geometry and effective weed management strategies (Jannu and Narender, 2023). Different spacing of DSR brings down the seed rate without lowering the productivity and

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growth and development. Plant density was influenced by crop geometry, which reduces weed pressure based on plant population under DSR condition (Kumar, 2015). Weeds are competing with rice plants for available resources and it's negatively affecting plant growth characters of DSR. Adoption of hand weeding alone increases the cost of weeding, In this concern effective weed control through use of pre and post emergence herbicides, mechanical and manual weeding are essential for reduces the weed interference and labour cost (Ramesh and Rathika, 2016). Appropriate weed control practices helps to mitigate the available resource competition, thereby promoting plant height, tiller production and overall biomass accumulation in DSR (Rathika *et al*., 2020). Therefore, plant geometry and integrated weed management were vital tools for increasing growth attributes and nutrient uptake and lowering nutrient removal by weeds (Kokilam *et al*., 2020). Hence, the present investigation was conducted to study the influence of spacing along with weed management practices on the growth and nutrient uptake of weeds in DSR.

MATERIALS AND METHODS

The field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India during *rabi* 2022-23. The experimental site was sandy clay loam in texture with pH of 9.0 and EC 0.2 dSm^{-1}. The initial soil fertility status showed that low organic carbon (0.47 per cent), low available N (223 kg ha^{-1}), medium available P_2O_5 (14.2 kg ha^{-1}) and high available K_2O (284 kg ha^{-1}).

The treatment consisted of three drum seeder spacing (20 × 15 cm (M_1), 20 × 20 cm (M_2) and 25 × 25 cm (M_3)) in main plots and seven weed management practices *viz*., pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE (S_1), Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + cono weeding on 20 DAS + hand weeding (HW) on 40 DAS (S_2), Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + cono weeding on 20 DAS and 40 DAS (S_3), Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS (S_4), Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + HW on 40 DAS (S_5), Hand weeding at 20 and 40 DAS (S_6) and unweeded control (S_7) were assigned in sub plots.

The experimental field was laid out in split plot design with three replications. The medium-duration variety TNAU Rice TRY 3 was used for this field experiment. Sprouted seeds were directly sown in puddled soil. Seed rates (25, 21 and 18 Kg ha^{-1}) were varied while using 20 × 15 cm, 20 × 20 cm and 25 × 25 cm spaced drum seeders. The biometric observation on growth characters, such as plant height, dry matter production and total numbers of tillers at harvest; similarly plant and weed samples collected for estimation of nutrient removal by weeds and nutrient uptake of DSR from respective treatments. The samples were dried in oven and finely ground in Wiley mill and used for estimating N, P and K content. The uptake of nutrients are calculated by multiplying the nutrient content and dry matter production and expressed in kg ha^{-1}. The data collected from the experimental field was statistically analyzed using the procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of spacing on growth parameters of DSR

Spacing exerted a significant influence on growth characteristics of direct seeded rice (Table 1). The highest plant height (112.7 cm), DMP (9674 kg ha^{-1}) and total number of tillers (478 no. m^{-2}) were recorded with a spacing 20 × 20 cm. It was followed by spacing 20 × 15 cm. The lowest growth characters such as plant height, DMP and total number of tillers were registered under 25 × 25 cm. The results showed that efficient weed management under 20 × 20 cm spacing significantly increases plant growth attributes. This might be due to the fact that optimum spacing positively resulted uniform and well distributed plant canopy that shade out weeds, reducing their growth and helps to capture solar radiation efficiently, promoting photosynthetic activity, less intra plant competition of DSR which was significantly increases the growth attributes of DSR. Similar findings were also reported by Sihag *et al.* (2015); Khan *et al.* (2017); Rex Immanuel *et al.* (2019); Ramesh and Rathika (2020) and Palani *et al.* (2020).

Effect of weed management practices on growth parameters of DSR

The plant height, DMP and total numbers of tillers were significantly improved by weed management practices. Among the weed management techniques application of Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS significantly registered the highest plant height (117.5 cm), DMP (10295 kg ha^{-1}) and total number of tillers (490 no. m^{-2}) and this was on par with application of pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + hand weeding on 40 DAS and hand weeding on 20 and 40 DAS. This might be due to integrated weed management strategies that lowered crop weed competition by create a barrier that inhibits weed emergence and provides targeted weed control which provides a weed-free situation. Simultaneously, mechanical weeding helps to incorporate the decomposed weeds near the root zone of the crops and provides available nutrients to the crop, which significantly improved the growth and development of direct seeded rice. This result was closely confirmative with Rathika and Ramesh (2018), Manisankar *et al.* (2019) and Sivakumar *et al.* (2021).

Significant interaction was found between 20 × 20 cm spacing and application pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC

at 25 g a.i. ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS for all the growth attributes *viz*., plant height, DMP and total number of tillers. The lowest growth characters were found under interaction between 25 × 25 cm spacing along with unweeded control. Similar findings were also reported by Nayak *et al.* (2014) and Sivakumar *et al.* (2021).

Nutrient removal by weeds

Effect of spacing on nutrient removal by weeds

Direct seeded rice sown using drum seeder with different spacing significantly influenced the nutrient removal by weeds at 45 DAS (Table 2). Higher amount of NPK removed by weeds (27.58, 17.53 and 12.84 kg ha^{-1}, respectively) in 25 × 25 cm spacing than 20 × 15 cm and 20 × 20 cm of drum seeders spacing. Under 20 × 15 cm spacing had the lowest amount of nitrogen (10.98 kg ha^{-1}), phosphorus (6.57 kg ha^{-1}) and potassium (5.90 kg ha^{-1}) removal, which was on par with 20 × 20 cm spacing. The results revealed that wider spacing 25 × 25 cm favoured the growth of weed seeds germination, which in turn created crop weed competition for available resource, such as nitrogen, phosphorous and potassium. Simultaneously narrow spacings of 20 × 15 and

Table 1: Influence of spacing and weed management practices on growth attributes of direct seeded rice at harvest.

	Plant height (cm)				Dry matter production (Kg ha^{-1})				Total number of tillers (No. m^{-2})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	92.7	100.8	85.4	93.0	7712	8624	6129	7488	399	432	360	397
S_2	106.8	112.8	101.1	106.9	8959	9007	8237	8734	451	481	422	451
S_3	108.1	114.8	103.5	108.8	9010	9225	8300	8845	457	488	427	457
S_4	117.3	123.1	112.2	117.5	10108	11420	9357	10295	489	522	459	490
S_5	116.5	122.3	111.1	116.6	10025	11223	9316	10188	485	517	454	485
S_6	115.1	121.7	110.0	115.6	9889	10998	9201	10029	478	511	448	479
S_7	84.6	93.3	70.9	82.9	5810	7220	5170	6067	357	395	293	348
Mean	105.9	112.7	99.1		8788	9674	7959		445	478	409	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	2.37	1.25	3.11	2.17	183.47	206.58	378.69	357.81	8.59	4.38	11.10	7.58
CD (P=0.05)	6.58	2.54	7.66	4.41	509.41	419.02	834.61	725.77	23.86	8.88	27.49	15.39

M_1: 20 × 15 cm, M_2: 20 × 20 cm and M_3: 25 × 25 cm, S_1: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE, S_2: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Cono weeding on 20 DAS + hand weeding (HW) on 40 DAS, S_3: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS PE + Cono weeding on 20 DAS and 40 DAS as PoE, S_4: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Cono weeding on 40 DAS, S_5: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + HW on 40 DAS, S_6: Hand weeding at 20 and 40 DAS and S_7: Unweeded control.

Table 2: Influence of spacing and weed management practices on nutrient removal by weeds at 45 DAS.

	N removal (Kg ha^{-1})				P removal (Kg ha^{-1})				K removal (Kg ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	13.89	14.62	34.29	20.93	6.95	7.35	19.77	11.36	7.21	7.36	15.20	9.92
S_2	11.56	12.25	29.19	17.67	4.87	5.13	16.50	8.83	5.00	5.16	11.34	7.17
S_3	10.37	11.78	28.56	16.90	4.16	4.88	16.11	8.38	4.89	5.02	11.18	7.03
S_4	4.84	5.56	15.05	8.48	1.99	2.28	12.45	5.57	2.15	2.63	7.52	4.10
S_5	5.32	6.12	15.94	9.13	2.21	2.43	12.76	5.80	2.37	2.74	7.69	4.27
S_6	6.14	6.97	16.59	9.90	2.36	2.51	12.97	5.95	2.51	2.88	7.78	4.39
S_7	24.76	25.49	53.47	34.57	23.45	24.21	32.15	26.60	17.20	17.75	29.15	21.37
Mean	10.98	11.83	27.58		6.57	6.97	17.53		5.90	6.22	12.84	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	0.67	0.85	1.52	1.47	0.5	0.29	0.69	0.51	0.41	0.55	0.97	0.95
CD (P=0.05)	1.86	1.73	3.31	2.99	1.41	0.6	1.69	1.04	1.14	1.11	2.1	1.93

M_1: 20 × 15 cm, M_2: 20 × 20 cm and M_3: 25 × 25 cm, S_1: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE, S_2: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Cono weeding on 20 DAS + Hand weeding (HW) on 40 DAS, S_3: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS PE + Cono weeding on 20 DAS and 40 DAS as PoE, S_4: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Cono weeding on 40 DAS, S_5: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + HW on 40 DAS, S_6: Hand weeding at 20 and 40 DAS and S_7: Unweeded control.

20 × 20 reduced the total weed density and weed dry weight; it helps to boost the uptake of nitrogen, phosphorous and potassium by direct seeded rice. These results were confirmative with Payman and Singh (2008) and Tilahun (2019).

Effect of weed management practices on nutrient removal of weeds

Among the weed management strategies followed in direct seeded rice, application of pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS significantly lowered the N,P and K removal (8.48, 5.57 and 4.10 kg ha^{-1}) by weeds, which was on par with application of pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + hand weeding on 40 DAS and hand weeding on 20 and 40 DAS. This might be due to application of pre, post emergence herbicides and mechanical weeding were effectively manage the weed population, lower weed dry weight which led to reduce nutrient removal by weeds. The unweeded control exhibited higher weed density, weed dry weight and nutrient content in the weeds, leading to a greater removal of nutrients. These findings align with the research of Rathika and Ramesh (2018), Shanmugapriya *et al.* (2021) and Manisankar *et al.* (2021).

Nutrient uptake of DSR

Effect of spacing on nutrient uptake of DSR

Direct seeded rice sown using drum seeder with different spacing significantly influenced the uptake of nitrogen, phosphorous and potassium (Table 3). Drum seeder spacing 20 × 20 cm significantly increases the N, P and K uptake (115.8, 28.4 and 78.0 kg ha^{-1}, respectively) of DSR and it was followed by 20 × 15 cm. The lowest uptake of N, P and K (100.2, 22.6 and 66.7 kg ha^{-1}, respectively) was registered with 25 × 25 cm of spacing. This might be due to the fact that optimum spacing between plants minimises the competition for resources such as essential nutrients, moisture and solar radiation, reduces nutrient stress and promotes healthy root development, which enables plants to efficiently uptake essential elements from the soil. This is in agreement with the findings of Ram *et al.* (2014) and Rex Immanuel *et al.* (2019).

Effect of weed management practices on nutrient uptake of DSR

Application of pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS significantly registered higher nutrient uptake of nitrogen (127.3 kg ha^{-1}), phosphorus (31.3 kg ha^{-1}) and potassium (83.3 kg ha^{-1}) of rice under direct seeded condition, which was comparable with application of pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + hand weeding on 40 DAS and hand weeding on 20 and 40 DAS over rest of weed management practices. Unweeded control registered significantly lower nutrient uptake of nitrogen (68.6 kg ha^{-1}), phosphorous (16.1 kg ha^{-1}) and potassium (49.1 kg ha^{-1}), respectively. This was mainly due to lower weed competition, total weed density and total weed dry weight improved the soil aeration led to higher WCE and lower depletion of N, P and K by weeds, which were assisted the increases the uptake of nitrogen, phosphorous and potassium to the crop for growth

Table 3: Influence of spacing and weed management practices on nutrient uptake of direct seeded rice at harvest.

	N uptake (Kg ha^{-1})				P uptake (Kg ha^{-1})				K uptake (Kg ha^{-1})			
	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	90.4	93.4	84.7	89.5	19.4	23.8	16.8	20.0	60.2	64.4	53.1	59.2
S_2	109.7	118.9	103.2	110.6	25.9	28.7	21.3	25.3	73.9	79.9	68.9	74.2
S_3	112.4	121.4	105.8	113.2	26.8	29.1	22.2	26.0	75.8	82.5	70.6	76.3
S_4	127.2	135.2	119.7	127.3	31.8	33.2	28.9	31.3	83.3	89.4	77.4	83.3
S_5	124.5	132.9	116.2	124.5	31.3	32.1	28.1	30.5	82.2	88.7	76.4	82.4
S_6	121.8	129.3	113.8	121.6	30.1	32.8	27.7	30.2	80.7	87.8	75.0	81.2
S_7	68.2	79.6	58.1	68.6	16.1	18.8	13.3	16.1	48.3	53.2	45.8	49.1
Mean	107.7	115.8	100.2		25.9	28.4	22.6		72.0	78.0	66.7	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	2.29	3.21	5.64	5.57	0.58	0.98	1.68	0.58	1.47	2.07	3.63	3.58
CD (P=0.05)	6.36	6.52	12.15	11.3	1.61	1.99	3.55	1.61	4.09	4.2	7.81	7.27

M_1: 20 × 15 cm, M_2: 20 × 20 cm and M_3: 25 × 25 cm, S_1: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE, S_2: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Cono weeding on 20 DAS + Hand weeding (HW) on 40 DAS, S_3: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS PE + Cono weeding on 20 DAS and 40 DAS as PoE, S_4: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + Cono weeding on 40 DAS, S_5: Pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + Bispyribac sodium 10% SC at 25 g a.i ha^{-1} on 20 DAS as PoE + HW on 40 DAS, S_6: Hand weeding at 20 and 40 DAS and S_7: Unweeded control.

and development of direct seeded rice. This corroborated with the findings of Parameswari and Srinivas (2014), Chakraborti *et al.* (2017) and Sanodiya *et al.* (2017).

CONCLUSION

The direct seeded rice by adopting spacing 20 × 20 cm along with application of pyrazosulfuron ethyl 10% WP at 20 g a.i ha^{-1} on 3 DAS as PE + bispyribac sodium 10% SC at 25 g a.i. ha^{-1} on 20 DAS as PoE + cono weeding on 40 DAS resulted in maximum growth characters and N, P and K uptake. This treatment combinations paves way for maximizing the growth and development and nutrient uptake of direct seeded rice.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this article.

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