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Effect of Balance Potassium Management on Performance of Basmati Rice (*Oryza sativa* L.) in Rice – Potato –Maize Cropping System of Western Uttar Pradesh, India

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Keywords

Balance potassium fertilization, basmati rice performance SSNM

A B S T R A C T

To investigate potassium management in intensive cropping system a field experiment was conducted during *Kharif* season 2015 at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.).Twelve treatments comprising 100% NP, 100% NPK, 100% NP+125% K, 100% NP+150% K, 125% NPK, 150% NPK, 100% NP + Crop residue, 100% NP+FYM, 100% NP+SPM, SSNM, SSNM-K and SSNM+K were replicated thrice in a randomized block design. The soil of experimental field was sandy loam in texture, having bulk density 1.41 Mgm^{-3}, pH and electrical conductivity of 1:2 solution 8.03 and 0.29 dSm-1, respectively. Soil was low in organic carbon (4.00 g kg-1), and available N (202.0kg ha-1) medium in available P (14.0kg ha-1) and available K (195 kg ha-1) The experimental results revealed that significant difference was found in growth and, yield and its attributing traits, although also difference was found in content of nitrogen, phosphorus, potassium, sulphur, zinc, boron and iron in rice. Among the different treatments nitrogen, phosphorus and potassium content at various stages were maximum with the application of 150% NPK. However S, Zn, B and Fe content was highest in SSNM (Site Specific Nutrient Management) + K (Potassium). Therefore application of 150% RDF (100:60:60 kg NPK) proved to be better for achieving higher yield and maintaining the nutrient status of soil. Although the yield was high in 150% NPK but it did not differ from SSNM therefore. The practice of SSNM is found better for sustainability of crop yield and quality.

Introduction

Rice (*Oryza sativa* L.) is the most important food crops in the world forms the staple diet of 2.7 billion people the area, production and productivity of India is 43.42 m ha, 105.24 mt and 24.23 qha^{-1}, respectively. (Anonymous, 2015). Uttar Pradesh is the 2^{nd} largest rice growing state only after West Bengal in the country, in which rice is grown over an area of 58.6 lakh ha with the production of 144.1 lakh t and the productivity is 2460 kg ha^{-1}. Total rice cultivated area in Meerut is 14514 ha, production 39362 t and productivity 2710 kg ha^{-1} (Anonymous, 2015). Pusa Basmati-1509 was developed in 2013 and has been ranked the best among the Basmati varieties.

The rice-potato-maize is a dominant cropping sequence being followed in western Uttar Pradesh. Potassium is the third essential plant nutrient along with N and P. Its availability to plants depends upon the concentration of K in soil solution and on exchange sites. Potassium is essential for enzyme activation, charge balance and osmotic regulation in plants. It is present in cation form in plant cell to maintain ionic balance and up to 10% of plant dry matter is made up of K (Marschner, 1995). Its ease of access to plants depends upon its status in soil solution, exchangeable K and rate of exchange of K from exchangeable form to soil solution form (Wakeel, 2011).

Specific functions that occur in cytoplasm require small amount of potassium while a major portion (90%) of K is present in vacuole where it acts as an osmotic contributing to extension growth of plants (Wakeel *et al.,* 2011). High K contents in plant tissue increase its resistant to sudden environmental variations like temperature stress, rain in late season, cold and frost (Cakmak, 2005). Potassium accumulation in the plant tissue also decreases damage to plant in response to osmotic stress and physiological burdens (Rajkumara, 2008). Deficiency system appears on younger leaves and finally plant can die (Tiwari, 2000). Thus poor nutrient management due to lack of proper and balanced use of chemical fertilizers including micronutrients is one of the factor responsible for low yields and poor grain quality of basmati rice. Balance site specific nutrient management in combination with micronutrients which break the yield barrier which is similarly reported by Kumar *et al.,* (2015). The rice quality such as crude protein, zinc and iron is calculated on the basis of plant nutrients content in grain. Supply of plant nutrients in balanced and sufficient quantity is essential to sustain its productivity on long-term basis. Plants require potassium (K) in large quantity. Decline in crop productivity due to lack of K supply was reported even in K rich soils Srinivasarao *et al.,* 2011, Singh and Wanjari, 2012).Therefore, the present study was carried out to investigate the Effect of balance potassium fertilization management on performance of basmati rice in rice – potato –maize cropping system

Materials and Methods

Site description

This research was conducted at Crop Research Centre (CRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during the *kharif* season of 2015, which is located at a latitude of 29^0 40′ N and longitude of 77^0 42′ E and at an altitude of 237 m amsl. Meerut lies in the heart of Western Uttar Pradesh and has semi-arid to sub-tropical climate. The experiment was laid in randomized block design (RBD) with twelve treatments comprising 100% NP, 100% NPK, 100% NP+125% K, 100% NP+150% K, 125% NPK, 150% NPK, 100% NP + Crop residue, 100% NP+FYM, 100% NP + SPM, SSNM, SSNM-K and SSNM + K and three replication. The size of each plot was 5X3 m^2. All recommended package of practices were followed during the experiment. The weather data for the experimental period recorded at the meteorological observatory of SVPUA&T, Meerut during the crop growing season. Soil samples from a depth of 0-15 cm were collected from each plot of the experiment prior to transplanting and a composite sample was drawn for determining its physical and chemical properties of soils are BD (Mgm^{-3}) 1.41, textural classsandy loam soil, O.C (4.00 g kg^{-1}), pH (8.03), EC (dS m^{-1}) 0.29, Available N (kg ha^{-1}) 202.0, Available P (kg ha^{-1}) 14.25, Available K (kg ha^{-1}) 195.0. Observed related to growth parameter viz. plant height, number of tillers.

Data collection

Growth parameters at harvest stage were recorded by selecting five hills randomly from observation row of each plot. Test weight (g) one thousand filled grains from each plot samples were counted and weighed on electronic balance and their weight was expressed in grams. Quality of rice determined by amount of content changed over RDF (recommended dose of fertilizer) in the form of protein, zinc and iron.

Plant sampling and analysis

The plants measured for growth and yield were used for analyzing the N, P and K content in plant (at 30 and 60 DAT, grains and straw). The samples were dried at 70 °C in a hot air oven. The dried samples were ground in a stainless steel Thomas Model 4 Wiley ® Mill. The N content in plant was determined by digesting the samples in sulfuric acid (H2SO4), followed by analysis of total N by the Kjeldahl method (Page, 1982) using a Kjeltec™ 8000 auto analyzer (FOSS Company, Denmark) and then multiply with 5.73 for protein content in maize (AOAC, 1960). The uptake of the nutrients was calculated by multiplying the nutrient content (%) by respective yield (kg ha^{1}) and was divided by 100 to get the uptake values in kg ha^{1}. The P content in plant was determined by the vanadomolybdo-phosphoric yellow colour method and the K content was analyzed in di-acid (HNO3 and HClO4) digests by the flame photometeric method (Page, 1982).

Zinc and Fe (mg kg^{-1}) was determined DTPA extra ctant and estimated on atomic absorption spectrophotometer (GBC Avanta PM Modal) and Boron (mg kg^{-1}) was determined by Azomethine-H Colour Method (Lindsay and Norvell, 1978).

Statistical analysis

The data on growth, yield, total nutrient uptake, soil nutrients status and economic analysis was recorded as per the standard procedure. The data obtained were subjected to statistical analysis as outlined by Gomez and Gomez (1984). The treatment differences were tested by using “F” test and critical differences (at 5% probability).

Results and Discussion

Growth and yield attributes

It was found that maximum plant height was recorded with the application 150% NPK (T_6) that was significantly higher than the other treatments except T_5, T_{10} and T_{12}. Neither the deletion of potassium from RDF NPK nor the addition of super optimal level of potassium resulted any significant effect over 100% NPK. Plamt height differ significantly due to additional application of 25 and 50 % NPK over 100% NPK. Number of tillers differ from 51.15 to 62.87. Maximum number of tillers 62.87 recorded in T_6 was significantly higher than the treatments except T_5, T_{10}, T_{11} and T_{12}. It was because experimental soil was deficient in nitrogen, therefore when additional application of nitrogen was applied, it responded in term of taller plant, more number of effective tillers. Nitrogen is an integral part of chlorophyll, it stimulates chlorophyll synthesis hence it accelerate rate of assimilation (photosynthesis) which finally results improvement in grain quality in term of protein content, similar results have been reported by Singh *et al.,* (1999). Organic sources did not result any significant effect on growth parameter. Nutrient application on SSNM based in various treatments produce significantly higher number of tillers in T_{10}than T_2. Since the soil was deficit in nitrogen, recommended dose of nitrogen was not enough to fulfill the requirement of nitrogen for growth therefore the response of plant height and number of tillers to additional application of nitrogen over recommended dose is well accepted. Balance application of nutrients to the plants. SSNM practice showed positive and favorable effect on improving almost all the growth attributes of rice varieties (Shanker *et al.*, 2014).

Yield and harvest index

The Grain yield differs from 24.0 to 42.76 q ha^{-1}.Maximum grain yield 42.76 qha^{-1} produced with the application of 150% NPK (T_6) that was significantly higher than the treatments except T_5, T_{10}, T_{11} and T_{12} (Table1). A significant effect reduction of 25% in grain yield was noticed due to skipping of potassium from RDF. Significant increase in grain yield was noticed due to super optimal application of potassium or NPK over RDF.

At harvest rice straw yield differ from 36.11 to 64.14 q ha^{-1}. The highest straw yield 64.14 q ha^{-1} recorded with the application 150% NPK (T_6) was significantly higher than the treatment except T_5, T_{10} and T_{12}. Straw yield decline significantly due to deletion of K from RDF NPK while, a significant increase was noticed due to super optimal application of potassium. Straw yield also differ significantly due to additional application of 25 and 50% NPK. Straw yield reduced due to addition of crop residue while no effect was noticed of FYM and SPM. Nutrient application on SSNM base produce significantly higher straw yield than T_2 where RDF NPK was applied. Harvest index which is a ratio of grain yield to biological yield was highest in the T_5 treatment with the application of 125% NPK while minimum 38.75 in case T_2 where 100% NPK was applied. Organic sources did not result any significant effect on grain and straw yield. Grain yield differ significantly among T_2 to T_{10}. Nutrient application on SSNM based produce significantly higher grain yield than RDF. The extra yield rice through SSNM over farmer Practice (Singh *et al.*, 2008). Balance site specific nutrient management in combination with micronutrients which break the yield barrier which is similarly reported by Kumar *et al.*, (2015). SSNM strategies significantly improved the grain yields of rice and wheat reported by Regmia *et al.*, (2006).

Grain quality

It is clear from figure 1 that the application of balanced fertilization through SSNM practice, protein, zinc and iron content of rice grain increased. Much more variation in zinc and iron content over RDF was found in T_{10} where SSNM was applied. Percentage change over RDF in crude protein due to application of different nutrient combinations ranged from 2.34 to 12.28%. Variation due to application of different nutrient combinations in Zn & Fe content was 0.82 to 36.57 and 7.16 to 51.09% respectively, rice quality in respect of crude protein decline due to deletion of potassium from RDF. Grain quality improved due to additional application of potassium over RDF and additional application of NPK over RDF. Grain quality decline in respect of crude protein with the application of organic sources however, an improvement was noticed by adoption of SSNM.

Nutrient content

Application of additional 50% NPK fertilizer over RDF brought a significant difference in NPK content in plant at all phenological stages (Table 2). Moreover, it also showed its superiority at tillering stage and statistically similarity in respect of phosphorus at panicle initiation stage. The increase N content in150% NPK (T_6) might be due to delayed maturity of rice which could tap up more nitrogen for longer period as consequence higher content at different phonological stages. Similar result were also reported by Kondapa Naidu *et al.,* (2009) and Dwivedi *et al.,* (2015). Moreover, Maximum P content in tillering, panicle initiation and at harvest was recorded with the the application of 150% NPK.

Fig.1 Effect of different fertility levels on rice grain quality over RDF

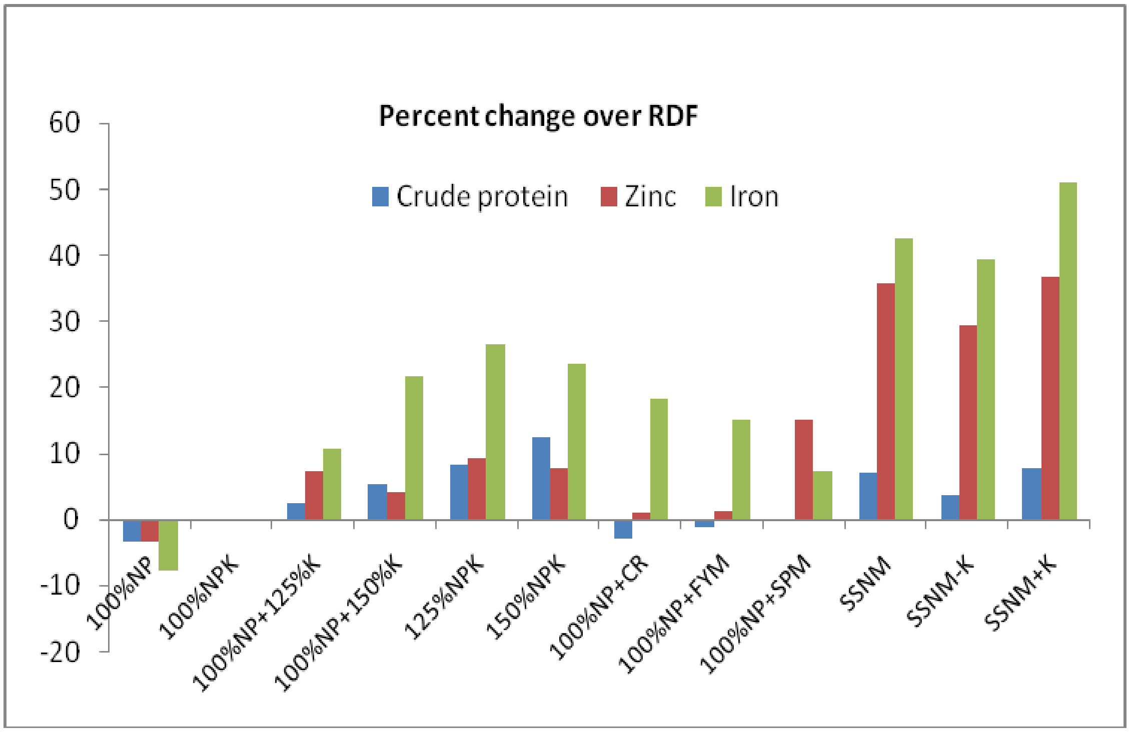

Table.1 Effect of different fertility levels on growth, yield and yield attributing character at harvest stage

Treatments	Plant height (cm)	No. of tillers per meter row length.	No. of grains per panicle	Test weight (g)	Grain yield (qha^{-1})	Straw Yield (qha^{-1})	H.I (%)
100%NP	81.76	51.15	70.23	28.45	24.00	36.11	39.93
100%NPK	82.88	53.25	71.45	29.45	32.00	49.67	38.75
100%NP+125%K	83.67	55.58	73.42	30.15	38.71	58.15	40.01
100%NP+150%K	84.25	56.22	75.25	30.56	39.51	59.25	40.01
125%NPK	85.35	59.57	76.61	30.24	40.76	61.54	40.08
150%NPK	86.83	62.87	77.12	31.42	42.76	64.14	40.00
100%NP+CR	82.68	55.12	72.24	30.12	29.21	43.80	39.95
100%NP+FYM	83.68	55.14	73.35	30.16	32.77	49.15	40.020
100%NP+SPM	82.38	56.21	73.19	30.00	32.33	48.49	40.00
SSNM	85.87	60.12	76.62	31.86	42.40	63.81	39.92
SSNM-K	82.43	59.23	74.12	30.23	40.10	60.15	40.00
SSNM+K	84.76	60.58	76.89	32.85	42.16	63.99	39.99
SEm ±	0.71	1.26	0.28	1.19	0.99	1.11	-
CD = 0.05	2.10	3.71	0.83	N.S.	2.94	3.29	-

RDF NPK (100:60:60), SSNM (100:60:60:25:30:5) CR (Crop residue), SPM 10 t ha^{-1} (sulfonated pressmud), FYM 10 t ha^{-1}(Farm yard manure), H.I (Harvest index).

Table.2 Effect of different fertility levels on N, P and K content (%) at various stages

Treatment	Ncontent (%)				Pcontent (%)				Kcontent (%)			
	Tillering	Panicle initiation	Harvest		Tillering	Panicle initiation	Harvest		Tillering	Panicle initiation	Harvest	
			Grain	Straw			Grain	Straw			Grain	Straw
100%NP	1.98	1.48	1.65	0.40	0.191	0.162	0.254	0.080	2.77	2.65	0.161	1.33
100%NPK	2.05	1.55	1.71	0.42	0.193	0.164	0.256	0.088	2.82	2.75	0.182	1.42
100%NP+125%K	2.08	1.57	1.75	0.43	0.195	0.169	0.265	0.089	2.91	2.82	0.191	1.52
100%NP+150%K	2.12	1.59	1.80	0.48	0.196	0.171	0.277	0.091	3.05	2.87	0.196	1.55
125%NPK	2.16	1.82	1.85	0.72	0.198	0.172	0.256	0.099	2.97	2.85	0.195	1.74
150%NPK	2.24	1.92	1.92	0.76	0.200	0.176	0.283	0.120	3.06	2.89	0.201	1.91
100%NP+CR	2.02	1.50	1.66	0.41	0.192	0.169	0.259	0.110	2.83	2.66	0.182	1.54
100%NP+FYM	2.04	1.52	1.69	0.43	0.193	0.170	0.268	0.090	2.81	2.78	0.179	1.46
100%NP+SPM	2.07	1.54	1.71	0.51	0.194	0.168	0.274	0.091	2.80	2.74	0.181	1.48
SSNM	2.23	1.86	1.83	0.68	0.197	0.174	0.281	0.092	2.96	2.77	0.189	1.86
SSNM-K	2.11	1.58	1.77	0.44	0.196	0.173	0.278	0.097	2.8	2.68	0.180	1.57
SSNM+K	2.20	1.81	1.84	0.69	0.198	0.175	0.280	0.098	3.04	2.88	0.199	1.87
SEm ±	0.97	0.07	0.05	0.03	0.004	0.001	0.002	0.014	0.03	0.05	0.003	0.02
CD = 0.05	N.S	0.22	0.14	0.08	N.S	0.004	0.006	N.S.	0.10	0.14	0.010	0.07

Table.3 Effect of different fertility levels on S content (%), Zn content (mg kg^{-1}) and B content (mg kg^{-1}) at various stages

Treatment	Scontent (%)				Zn content (mg kg^{-1})				B content (mg kg^{-1})			
	Tillering	Panicle initiation	Harvest		Tillering	Panicle initiation	Harvest		Tillering	Panicle initiation	Harvest	
			Grain	Straw							Grain	Straw
100%NP	0.44	0.36	0.22	0.21	36.14	21.02	27.11	5.78	16.80	8.30	5.60	6.62
100%NPK	0.44	0.36	0.25	0.21	39.16	22.39	28.11	6.12	17.24	8.74	6.70	6.68
100%NP+125%K	0.46	0.38	0.26	0.23	38.24	24.04	30.12	7.27	17.59	9.25	6.89	7.50
100%NP+150%K	0.46	0.38	0.27	0.23	35.84	26.34	29.24	6.98	19.37	11.26	7.12	7.98
125%NPK	0.47	0.37	0.28	0.20	39.23	23.25	30.68	7.24	16.45	16.64	7.88	8.95
150%NPK	0.48	0.37	0.28	0.21	36.15	28.04	30.25	7.54	22.70	14.41	8.39	9.40
100%NP+CR	0.45	0.35	0.27	0.19	38.12	24.23	28.34	7.11	16.80	8.51	6.50	6.68
100%NP+FYM	0.45	0.35	0.27	0.17	38.45	31.45	28.45	6.98	17.20	8.88	6.88	7.30
100%NP+SPM	0.52	0.43	0.34	0.23	42.38	30.98	32.32	7.24	18.54	10.23	7.23	7.80
SSNM	0.54	0.46	0.35	0.24	52.17	35.06	38.12	9.45	23.53	16.86	8.24	9.60
SSNM-K	0.53	0.45	0.34	0.25	51.25	33.23	36.38	9.44	21.45	13.13	7.98	9.20
SSNM+K	0.46	0.46	0.35	0.25	53.45	35.25	38.39	9.46	25.18	16.93	8.50	9.80
SEm ±	0.01	0.01	0.01	0.01	1.09	1.21	1.38	0.005	0.56	0.85	0.12	0.18
CD = 0.05	0.02	0.04	0.03	0.03	3.22	3.57	4.07	0.015	1.65	2.52	0.36	0.52

Table.4 Effect of different treatments on Iron content (mg kg^{-1}) of rice at different stages

Treatment	Tillering	Panicle initiation	Harvest	
			Grain	Straw
100%NP	312.65	170.21	56.58	148.89
100%NPK	326.85	174.43	61.45	162.86
100%NP+125%K	329.26	179.73	67.97	169.44
100%NP+150%K	349.76	199.08	74.67	193.95
125%NPK	350.45	195.71	77.65	186.87
150%NPK	353.37	191.83	75.88	183.55
100%NP+CR	340.74	183.58	72.64	167.86
100%NP+FYM	335.84	184.41	70.63	168.87
100%NP+SPM	357.70	182.13	65.85	165.66
SSNM	359.56	203.96	87.76	206.75
SSNM-K	364.85	208.18	85.59	206.96
SSNM+K	366.93	212.22	92.85	212.59
SEm ±	4.79	3.49	4.24	2.17
CD = 0.05	14.14	10.32	12.53	6.39

Although minimum P content was recorded with the application of 100% NP (T_1). It was mainly due to comparative lower dry matter accumulation in absence of such nutrients. Moreover, increase in P content under T_6 was may be due to high dose of balance fertilization. P uptake at tillering, panicle initiation and in harvesting stage (grain+straw and total biomass) followed similar trend was found in case of nitrogen. Furthermore, treatment which received 50% more nutrients over RDF resulted significantly higher K content in tillering, panicle initiation and harvest stage comparatively better root development with super optimal level of NPK will exploit more reserve K from soil as well as applied through fertilizer. Secondly due to fact that K which play a vital role in activating several enzymatic activities of plant therefore higher application of K resulted higher K content in plant (Dwivedi *et al*., 2015). Similar opinions were also put forward by Dwivedi *et al.,* (2015) and Kumar *et al.*, (2015).

Sulphur content at tillering, panicle and harvest stage varied significantly due to various treatments (Table 3). Maximum Sulfur content at all the stages was recorded with the application of SSNM and SSNM+K package respectively was significantly higher than the treatments except T_9 and T_{11}. Additional application of 25 and 50% K, resulted non-significant effect while 25 and 50% NPK significant effect on content of sulphur. Among organic source with the exception of 100% NP+SPM exhibited non-significant effect over RDF. Nutrient application on SSNM base produced significantly higher sulfur content than T_2 where RDF NPK practiced. These finding are in consonance with the finding of Kondapa Naidu *et al.*, (2009) and Kumar *et al.,* (2015).

Data presented in Table 3 & 4 revealed that treatment which receive SSNM+K (T_{12}) better content of micronutrients (Zn, B & Fe). Nutrient application on SSNM based resulted significantly higher content and uptake of micronutrient over RDF due to balance application and possibility poor availability from native source. Additional application of 25 and 50% K over RDF showed significant effect. Micronutrients content (Zn, B & Fe) at various stages differ significantly due to additional application of 25 and 50% NPK over 100% RDF. Organic sources with exception of SPM were unable to show any significant effect. Micronutrients content (Zn, B & Fe) at various stages differs significantly between T_2 and T_{10}. Nutrient application on SSNM based resulted in significant higher Micronutrients content (Zn, B & Fe) at various stages than T_2 where RDF was applied. These finding are in consonance with the finding of Kondapa Naidu *et al.*, (2009) and Kumar *et al.*, (2015).

On the basis of experiment it can be concluded that balanced nutrient management for rice through site specific nutrient management can be best option in terms of crop productivity, soil fertility and economic feasibility. Although the experimental soil was medium in available potassium but application of potassium in balanced manner improves the quality of produce and maintains the potassium level in soil. The soil reserve K should not be allowed to be depleted to a great extent which may lead to fixation of the K applied in nominal doses without benefiting the crop (Sahoo etal (1998). Therefore, it is suggested that K should be applied to each crop as a soil maintenance dose.

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