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EFFECT OF BORON, ZINC, IRON AND THEIR TREATMENT COMBINATIONS ON GROWTH AND YIELD OF GYNOECIOUS CUCUMBER UNDER POLYHOUSE CONDITION

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ABSTRACT
A field experiment was conducted during *rabi* season of 2014–2015 to find out the dose of boron, zinc and iron to obtain high growth and yield in cucumber (*Cucumis sativus* L.). Twenty seven treatment combinations with three levels of boron (control, 20 and 40 ppm), three levels of zinc (control, 20 and 40 ppm) and three levels of iron (control, 40 and 80 ppm) were evaluated. Application of boron at 40 ppm, zinc at 40 ppm and iron at 80 ppm individually and their treatment combination was found to be significantly superior with respect to maximum number of branches per plant at 45 DAS, vine length at 60 DAS, chlorophyll (a) content in leaves (6.80, 6.84 and 6.63 mg/100) at 30, 60 and 90 DAS, chlorophyll (b) content in leaves (12.48, 12.62 and12.17 mg/100) at 30, 60 and 90 DAS, average fruit weight (130.33 g.), volume of fruit (135.43 cc), yield per plant (5.62 kg) of cucumber. It can be concluded that application of treatment $B_2Zn_2Fe_2$ (Boron at 40 ppm + Zinc at 40 ppm + Iron at 80 ppm) gave the highest growth and yield of cucumber under naturally ventilated polyhouse.

INTRODUCTION

Cucumber (*Cucumis sativus* L.), is one of the important vegetable grown in field as well as polyhouse condition in India. It is grown for its tender fruits for fresh consumption as *salad* or as pickling cucumber. The deficiency of micronutrient is the primary cause of crop losses worldwide. Deformed fruits and nutrional disorders are major shackles in cucumber cultivation especially under polyhouse condition.

Application of micronutrients at proper stage helps in correcting micronutrients deficiency and improves yield and quality of cucumber. Foliar spraying of microelements is very helpful when the roots cannot uptake necessary nutrients in required quantity from the soil. The application of boron is attributed to greater photosynthetic activity resulting the increased production and accumulation of carbohydrates and thus has favourable effect on retention of flowers and fruits, which increase number and weight of fruits (Brown 1979). Zinc activates the synthesis of tryptophan, the precursor of IAA, and it is responsible to increasing the photosynthesis and biomass production thus stimulates growth and yield of plant (Singh and Verma 1991).Iron is necessary for the biosynthesis of chlorophyll and cytochrome resulting significant increases the growth and yield (Agarwala *et al.*, 1985). There for the aim of present experiment was to study the individual as well as combination effect of boron, zinc and iron on growth and yield of gynoecious cucumber cv. kian under polyhouse condition.

MATERIALS AND METHODS

The experiment was conducted in factorial randomized block design with three replications under naturally ventilated polyhouse condition during 2014 – 2015 at College of Horticulture and Forestry, Jhalarapatan City, Jhalawar (Rajasthan). The crop was grown under the polyhouse on black cotton soil having characteristic to shrink during dry condition. The present experiment comprised of 27 treatment combinations including three levels of boron (control, 20 and 40 ppm) as source of boric acid, three levels of zinc (control, 20 and 40 ppm) as source of zinc sulphate and three levels of iron (control, 40 and 80 ppm) as source of ferrous sulphate. The crop was grown on raised beds at 60 x 30 cm spacing on drip system. Each treatment consisted of 10 plants for which 10-seeds were sown in a two rows of 1.5 meter length. The observations were recorded on number of branches per plant at 45 DAS, vine length at 60 DAS, chlorophyll (a) content in leaves at 30, 60 and 90 DAS, chlorophyll (b) content in leaves at 30, 60 and 90 DAS, average fruit weight, volume of fruit, yield per plant of cucumber.

RESULTS AND DISCUSSION

Individual effect of boron, zinc and iron on growth and yield of cucumber

The result of present study clearly indicate that (Table No.1) individual effect of boron (40 ppm), zinc (40 ppm), and iron (80 ppm), significantly affected in number of branches per

Table 1: Individual effect of foliar application of boron, zinc and iron on growth and yield of cucumber

Treatments	Number of branches per plant 45 DAS	Vine length per plant (cm) 60 DAS	Chlorophyll (a) content (mg /100g)			Chlorophyll (b) content (mg /100g)			Average fruit weight(g)	Volume of fruit (cc)	Yield per plant (kg)
			30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
B_0 (Control)	7.81	371.01	6.49	6.54	6.36	11.93	12.03	11.70	109.66	114.75	2.94
B_1 (20 ppm)	8.91	20.28	6.57	6.62	6.43	12.07	12.16	11.84	114.18	118.13	3.49
B_2 (40 ppm)	9.24	388.31	6.59	6.66	6.45	12.12	12.24	11.88	117.55	122.64	3.92
CD (5%)	0.31	NS	0.01	0.01	0.01	0.02	0.01	0.01	1.40	1.25	0.42
S. Em+	0.11	5.18	0.00	0.00	0.00	0.01	0.005	0.02	0.49	0.44	0.15
Zinc											
Zn_0 (Control)	7.48	358.27	6.46	6.51	6.33	11.89	11.98	11.66	108.81	113.85	2.87
Zn_1 (20 ppm)	9.06	390.99	6.58	6.64	6.44	12.08	12.18	11.85	115.32	119.29	3.53
Zn_2 (40 ppm)	9.41	391.57	6.61	6.67	6.47	12.15	12.27	11.90	117.27	122.38	3.94
CD (5%)	0.31	14.72	0.01	0.01	0.01	0.02	0.01	0.01	1.40	1.25	0.42
S. Em+	0.11	5.18	0.00	0.00	0.00	0.01	0.005	0.02	0.49	0.44	0.015
Iron											
Fe_0 (Control)	7.82	368.44	6.43	6.47	6.31	11.80	11.89	11.61	108.28	113.33	2.83
Fe_1 (40 ppm)	8.87	377.87	6.58	6.65	6.45	12.11	12.22	11.86	115.95	121.04	3.63
Fe_2 (80 ppm)	9.27	394.52	6.64	6.70	6.49	12.21	12.32	11.95	117.17	121.14	3.88
CD (5%)	0.31	14.72	0.01	0.01	0.01	0.02	0.01	0.01	1.40	1.25	0.042
S. Em+	0.11	5.18	0.00	0.00	0.00	0.01	0.005	0.02	0.49	0.44	0.015

plant at 45 DAS, chlorophyll (a & b) content in leaves at 30, 60 and 90 DAS, average fruit weight, volume of fruit and yield per plant as compared to control. While the application of boron had no significant effect on vine length at 60 DAS. The higher concentration of Boron (40 ppm) was found beneficial for influencing all the growth and yield attributes. The application of boron @ 40 ppm was found maximum number of branches per plant (9.24) at 45 DAS, chlorophyll (a) content in leaves at 30, 60 and 90 DAS (6.59, 6.66 and 6.45 mg/100g), chlorophyll (b) content in leaves at 30, 60 and 90 DAS (12.12, 12.24 and11.88 mg/100g), average fruit weight (117.55 g),volume of fruit (122.64 cc) and yield per plant (3.92 kg) as compared to control. Similarly, higher concentration of Zinc (40 ppm) influenced significantly all the characters. The maximum number of branches per plant at 45 DAS (9.41), vine length at 60 DAS, (391.57 cm), chlorophyll (a) content in leaves at 30, 60 and 90 DAS (6.61, 6.67 and 6.47 mg/100g), chlorophyll (b) content in leaves at 30, 60 and 90 DAS (12.15, 12.27 and 11.90 mg/100g), average fruit weight (117.27g), volume of fruit (122.38cc) and yield per plant (3.94 kg) were found in zinc @ 40 ppm (Zn2) while the lowest in control. Iron was gave all the growth and yield characters under study gave significant and best result at higher concentration (80 ppm) of Iron. The maximum number of branches per plant at 45 DAS (9.27), vine length at 60 DAS (394.52 cm), chlorophyll (a) content in leaves at 30, 60 and 90 DAS (6.64, 6.70 and 6.49 mg/100g), chlorophyll (b) content in leaves at 30, 60 and 90 DAS (12.21, 12.32 and 11.95 mg/100g), average fruit weight (117.17g), volume of fruit (121.14 cc) and yield per plant (3.88 kg) were found in iron @ 80 ppm (Fe2) over control. All the micronutrients had significant role in enhancing the yield in cucumber. Higher concentration of Boron (40 ppm), Zinc (40 ppm) and Iron (80 ppm) yielded 3.92 kg, 3.94 kg and 3.88 kg yield per plant and the increase in yield was 33.34, 37.28 and 37.10 per cent over their respective control, respectively. This can be explained on the basis that increasing boron enhances differentiation and hence, helps in root elongation and shoot growth of plant Patil *et al.,* 2008). Increase in yield of plant might be due to foliar application of boron which is involved in development of cell wall, cell differentiation and root and shoot elongation. It is also involved in ovary developments, seed development and maturity of crop plant. This may be attributed to greater photosynthetic activity, resulting the increased production and accumulation of carbohydrates and favorable effect on retention of flowers and fruits, which might have increased number and weight of fruits (Brown 1979). Zinc activates the synthesis of tryptophan, the precursor of IAA and it is responsible to increasing the photosynthesis and biomass production stimulates growth and yield of plant (Singh and Verma 1991). The iron plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochrome, which participate in different functions in the plant metabolism. Iron is necessary for the biosynthesis of chlorophyll and cytochrome, that it significant increases the yield Agarwala *et al.*, 1985).These results are also in close proximity with earlier researches the Sultana *et al.* (2001) in cucumber, Kazemi (2013) in cucumber,

Combined effect of boron, zinc and iron on growth and yield attributes

Table 2: Combined effect of foliar application of boron, zinc and iron on growth and yield of cucumber

Treatments		Number of branches per plant	Vine length per plant (cm)	Chlorophyll (a) content (mg/100g)			Chlorophyll (a) content (mg /100g)			Average fruit weight (g)	Volume of fruit (cm)	Yield per plant (kg)
B	Zn	45 DAS	60 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
	0	6.34	352.23	6.43	6.47	6.30	11.79	11.91	11.57	107.80	112.83	2.61
0	20	8.23	379.97	6.51	6.57	6.37	11.98	12.06	11.75	110.20	115.30	2.99
	40	8.84	380.82	6.52	6.59	6.40	12.02	12.11	11.78	110.99	116.11	3.21
	0	7.93	368.15	6.46	6.52	6.33	11.91	11.99	11.70	108.79	113.80	2.90
20	20	9.35	394.84	6.61	6.66	6.46	12.12	12.21	11.89	115.98	117.69	3.66
	40	9.44	381.55	6.63	6.69	6.49	12.17	12.29	11.93	117.77	122.89	3.91
	0	8.17	354.42	6.49	6.55	6.36	11.97	12.03	11.72	109.85	114.92	3.10
40	20	9.60	398.15	6.62	6.68	6.48	12.14	12.27	11.92	119.78	124.88	3.96
	40	9.94	412.34	6.67	6.74	6.53	12.27	12.41	12.01	123.03	128.13	4.71
CD (5%)	NS	NS	NS	0.01	0.01	0.03	0.03	0.012	2.43	2.16	0.072	
S.Em+	0.188	8.98	8.98	0.005	0.005	0.01	0.01	0.004	0.86	0.76	0.025	
B	Fe											
	0	6.46	347.52	6.39	6.43	6.27	11.72	11.81	11.52	107.83	112.89	2.52
0	40	8.21	376.17	6.50	6.57	6.39	11.99	12.08	11.74	110.23	115.32	3.06
	80	8.74	389.33	6.56	6.63	6.42	12.07	12.18	11.84	110.93	116.03	3.23
	0	8.48	372.08	6.43	6.48	6.31	11.82	11.90	11.65	108.20	113.22	2.91
20	40	9.02	378.66	6.62	6.67	6.46	12.14	12.25	11.89	116.42	121.52	3.66
	80	9.22	393.80	6.66	6.72	6.50	12.24	12.35	11.98	117.92	119.52	3.90
	0	8.51	385.71	6.45	6.51	6.34	11.87	11.98	11.67	108.81	113.90	3.07
40	40	9.37	378.77	6.63	6.70	6.49	12.19	12.32	11.96	121.20	126.28	4.18
	80	9.83	400.43	6.69	6.75	6.53	12.31	12.42	12.02	122.66	127.75	4.51
CD (5%)	0.53	NS	NS	0.01	0.01	0.03	0.03	0.012	2.43	2.16	0.072	
S.Em+	0.18	8.98	8.98	0.005	0.01	0.01	0.01	0.004	0.86	0.76	0.025	
Zn	Fe											
	0	6.62	321.25	6.37	6.40	6.23	11.69	11.76	11.51	107.13	112.00	2.48
0	40	7.73	367.97	6.48	6.55	6.37	11.96	12.05	11.71	109.34	114.46	2.99
	80	8.10	385.57	6.53	6.59	6.40	12.02	12.12	11.77	109.98	115.09	3.14
	0	8.37	392.80	6.44	6.50	6.33	11.85	11.92	11.65	108.55	113.69	2.94
	40	9.25	377.55	6.62	6.68	6.47	12.14	12.27	11.91	117.82	122.91	3.70
20	80	9.55	402.62	6.67	6.73	6.51	12.25	12.35	11.99	119.60	121.26	3.96
	0	8.46	391.26	6.46	6.52	6.35	11.87	11.99	11.67	109.17	114.31	3.08
	40	9.62	388.08	6.65	6.71	6.51	12.23	12.33	11.96	120.70	125.76	4.22
	80	10.14	395.36	6.72	6.78	6.56	12.35	12.48	12.08	121.93	127.07	4.53
CD (5%)	NS	25.49	25.49	0.01	0.01	0.03	0.03	0.01	2.43	2.16	0.072	
S.Em+	0.188	8.98	8.98	0.005	0.005	0.01	0.01	0.004	0.86	0.76	0.025	

The combined effect of micronutrients (B x Z, B x Fe and Z x Fe) performed better than alone application for influencing most of growth and yield attributes. These combinations influenced (Table No. 2) all the growth and yield characters. Combination of boron, zinc and iron at their higher concentration influenced most of the characters like vine length at 60 DAS, chlorophyll (a) content at 60 and 90 DAS, chlorophyll (b) content at 30, 60 and 90 DAS and yield per plant. The maximum value was obtained with boron @ 40 ppm + zinc @ 40 ppm (B_2Zn_2) *i.e.* chlorophyll (a) content of leaves (6.67, 6.74 and 6.53 mg/100g), chlorophyll (b) content of leaves(12.27, 12.41 and 12.01 mg/100g), average fruit weight (123.03g), volume of fruit (128.13cc) and yield per plant (4.71 kg), respectively and minimum under control (B_0Zn_0) respectively. While the number of branches at 45 DAS and vine length at 60 DAS was found non- significant. This means that the combination between foliar spray of boron and zinc might have enhanced utilization of nutrients and water by plants which ultimately get reflected in a good growth and biological yield. The other reason for the increase in growth and yield may be the synergistic relationship between boron and zinc. This perceived that optimized B and Zn combined application from beginning of the plant life could maintain the cell wall plasticity, cell elongation thus integrating plasma membrane and related metabolic activities which increased the growth and yield (Sainju *et al.,* 2003 and Arora *et al.,* 2012). Likewise B x Zn similarly combined application of boron and iron was found significantly affected growth and yield character. The maximum value was obtained with HBO_3 @ 40 ppm + $FeSO_4$ @ 80 ppm (B_2Fe_2) *i.e.* maximum number of branches at 45 DAS (9.83), chlorophyll (a) content of leaves at 30, 60 and 90 DAS (6.69, 6.75 and 6.53 mg/100g), chlorophyll (b) content of leaves at 30, 60 and 90 DAS (12.31, 12.41 and 12.02 mg/100g), average fruit weight (122.66 g), volume of fruit (127.75 cc) and yield per plant (4.51 kg) and minimum under control (B_0Fe_0), respectively. Whereas the vine length at 60 DAS was found non- significant. The interaction effect of boron and iron responded positively in increasing rate. The interaction effect of both micronutrient (boron and iron) significantly increased growth and yield of vegetable crops. It may be due to boron application causes higher uptake of iron. The combination plays an important role in the development and growth of new cells in plant meristem. It also acts as regulator of K/Ca ratio in plants and necessary for the translocation of sugar, starch, phosphorus and synthesis of amino acid and including chlorophyll synthesis, thylakoid synthesis, chloroplast, plant growth and development. Synergistic relationship between boron and iron has also been reported by Heidarian 2001 and Babaeian 2010)..

Same as these that combined application of zinc and iron had significantly effect. It increased the vine length at 60 DAS, chlorophyll (a and b) content of leaves, average fruit weight,

Table 3: Interaction effect of foliar application of boron, zinc and iron on growth and yield of cucumber

S. No.	Treatments	Number of branc hesper plant	Vine length per plant (cm)	Chlorophyll (a) content (mg /100g)			Chlorophyll (b) content (mg /100g)			Average fruit weight (g)	Volume of fruit (cc)	Yield per plant (kg)
		45 DAS	60 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
0	B0 Zn0 Fe0	4.93	277.90	6.33	6.34	6.16	11.53	11.66	11.31	106.88	111.47	2.22
1	B0 Zn0 Fe40ppm	6.67	388.73	6.47	6.52	6.36	11.92	12.01	11.68	108.08	113.37	2.71
2	B0 Zn0Fe80ppm	7.43	390.07	6.49	6.55	6.39	11.90	12.07	11.72	108.44	113.67	2.89
3	B0 Zn20ppmFe0	7.00	381.20	6.42	6.46	6.30	11.80	11.86	11.62	108.16	113.47	2.62
4	B0 Zn20ppm Fe40ppm	8.63	362.07	6.51	6.60	6.39	12.01	12.11	11.76	110.88	115.90	3.10
5	B0 Zn20ppm Fe80ppm	9.07	396.67	6.60	6.65	6.43	12.13	12.21	11.87	111.55	116.53	3.23
6	B0 Zn40ppm Fe0	7.47	383.47	6.44	6.49	6.34	11.83	11.91	11.64	108.45	113.73	2.73
7	B0 Zn40ppm Fe40ppm	9.33	377.73	6.53	6.60	6.42	12.05	12.13	11.77	111.73	116.70	3.37
8	B0 Zn40ppm Fe80ppm	9.73	381.27	6.60	6.69	6.46	12.17	12.28	11.92	112.78	117.90	3.55
9	B20ppm Zn0 Fe0	7.27	336.07	6.39	6.42	6.24	11.76	11.81	11.62	107.00	111.93	2.53
10	B20ppm Zn0 Fe40ppm	8.20	370.53	6.48	6.54	6.36	11.94	12.04	11.70	109.53	114.57	3.02
11	B20ppm Zn0 Fe80ppm	8.33	397.87	6.53	6.59	6.40	12.05	12.14	11.77	109.84	114.90	3.16
12	B20ppm Zn20ppm Fe0	8.93	392.93	6.45	6.50	6.35	11.86	11.92	11.66	108.16	113.22	3.02
13	B20ppmZn20ppmFe40ppm	9.40	386.93	6.68	6.72	6.50	12.22	12.34	11.98	118.53	123.70	3.84
14	B20ppmZn20ppmFe80ppm	9.73	404.67	6.72	6.75	6.52	12.27	12.38	12.03	121.26	116.15	4.11
15	B20ppmZn40ppmFe0	9.27	387.27	6.46	6.52	6.34	11.85	11.97	11.65	109.45	114.50	3.19
16	B20ppmZn40ppmFe40ppm	9.47	378.53	6.69	6.74	6.53	12.25	12.36	12.00	121.21	126.30	4.12
17	B20ppmZn40ppmFe80ppm	9.60	378.87	6.75	6.81	6.59	12.41	12.54	12.14	122.67	127.87	4.42
18	B40ppmZn0 Fe0	7.67	349.80	6.41	6.44	6.29	11.79	11.82	11.61	107.51	112.60	2.69
19	B40ppmZn0Fe40ppm	8.33	344.67	6.50	6.58	6.38	12.01	12.10	11.74	110.40	115.45	3.22
20	B40ppmZn0 Fe80ppm	8.53	368.80	6.56	6.63	6.40	12.12	12.17	11.82	111.65	116.72	3.38
21	B40ppmZn20ppmFe0	9.20	404.27	6.46	6.53	6.36	11.88	11.99	11.67	109.32	114.40	3.18
22	B40ppmZn20ppmFe40ppm	9.73	383.67	6.67	6.73	6.51	12.19	12.36	12.01	124.03	129.13	4.15
23	B40ppmZn20ppmFe80ppm	9.87	406.53	6.72	6.79	6.57	12.34	12.46	12.08	125.98	131.11	4.53
24	B40ppmZn40ppmFe0	8.67	403.07	6.49	6.57	6.37	11.94	12.12	11.72	109.60	114.70	3.33
25	B40ppmZn40ppmFe40ppm	10.07	408.00	6.73	6.80	6.58	12.38	12.51	11.72	129.17	134.27	5.17
26	B40ppmZn40ppmFe80ppm	11.10	425.97	6.80	6.84	6.63	12.48	12.62	12.17	130.33	135.43	5.62
	C.D. (5%)	NS	NS	0.03	0.02	0.02	0.05	0.05	0.02	4.21	3.74	0.125
	S. Em+	0.33	15.55	0.01	0.01	0.01	0.02	0.02	0.01	1.48	1.32	0.044

volume of fruit and yield per plant as compared to control. The maximum growth and yield character was obtained with zinc @ 40 ppm + iron @ 80 ppm (Zn_2Fe_2) *i.e.* maximum vine length at 60 DAS (402.62 cm), chlorophyll (a) content of leaves at 30, 60 and 90 DAS (6.72, 6.78 and 6.56 mg/100g), chlorophyll (b) content of leaves at 30, 60 and 90 DAS (12.35, 12.48 and12.08 mg/100g), average fruit weight (121.93g), volume of fruit (127.07cc) and yield per plant (4.53 kg) and minimum under control (Zn_2Fe_2), respectively. While the number of branches at 45 DAS was found non- significant. This could be explained in the way that interaction effect of zinc and iron activates the synthesis of tryptophan, the precursor of IAA and it is responsible to stimulate plant growth and plays an important role in promoting growth and yield characters, being a component of ferrodoxin an electron transport protein and is associated with chloroplast. It helps in photosynthesis might have helped in better vegetative growth and yield of plant (Mallick and Muthukrishnan 1991).Similar other researcher were recorded by Kazemi (2013) in tomato, Vala and Savaliya (2014) in bitter gourd, Keram, *et al*. (2014) in wheat and Ganie, *et al*. (2014) in french bean..

Interaction effect of boron, zinc and iron on growth and yield attributes

The interaction effect of boron, zinc and iron was found effective for influencing to all the growth and yield attributes in cucumber (Table No. 3). The foliar application of treatment combination $B_2Zn_2Fe_2$ (Boron at 40 ppm, Zinc at 40 ppm and Iron at 80 ppm) increased the chlorophyll (a) content of leaves at 30, 60 and 90 DAS (6.80, 6.84 and 6.63 mg/100), chlorophyll (b) content of leaves at 30, 60 and 90 DAS (12.48, 12.62 and12.17 mg/100), average fruit weight (130.33g), volume of fruit (135.43cc) and yield per plant (5.62 kg) and minimum under control ($B_0Zn_0Fe_0$), respectively. A glance presence of the table reavels that interaction was found non-significant of the number of branches at 45 DAS and vine length at 60 DAS. The interaction effect of boron, zinc and iron increased the growth and yield attributes. This is due to the fact that application of boron, zinc and iron might had rapidly provided nutrients in proper amount, required by plants for its growth and development. Essential micronutrients like boron, zinc and iron play an important role in physiology of crop and these are being a part of enzyme system or catalyst in enzymatic reactions. Amongst these role of micronutrients (boron, zinc and iron) seems to be one of the factors that may enhance fruit and seed yield. Though micronutrients are required in small quantities yet they play a significant role in modifying various physiological functions of the plant. They act as stimulant in chlorophyll formation, photosynthesis, energy system and catalysts in many metabolic processes of the plants. Some of them act as enzyme formers in these activities (Kumari, 2012). Similar result have been recorded by Ciuciuc *et al*. (1998) in watermelon, Singh *et al*. (2003) in tomato.

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