Effects of different treatments combination under Hydroponics and Pot cultivation condition in climatic zones of Prayagraj for better growth and yield of strawberry (*Fragaria ananassa) cv. Chandler*

Abstract

An experiment was conducted during the year 2019-2020 and 2020-2021 at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (India), to study the effects of different treatments combination under hydroponics and pot cultivation condition in climatic zones of Prayagraj for better growth and yield of strawberry**.** The experiment was laid out in Factorial randomized block design with three replications each consisting of two cultivation system i.e., hydroponics system and pot culture, each having 12 treatments with T0 (control). The two type (Pot Experiment + Hydroponic Experiment) of planting system, and their interaction have a significant effect on the growth and yield of the plants. According to the findings, plants cultivated in hydroponic system along T_7 (with Grow, Micro & Bloom) at 24 hours interval of 42 days maximize yield while also performing best in growth, quality, and yield contributing attributes. The hydroponic system yielded 20.92 per cent and 16.91 per cent higher than soilless media and soil, respectively. The nutrient uptake was also recorded highest under this treatment leading to conclusion that nutrients are more readily available to the plants under hydroponic system as compared to soilless media or soil and gave the maximum net returns and maximum benefit: cost ratio.

***Key words*:** Strawberry, Hydroponics, Nutrients, Vermicompost, Perlite, Cocopeat, Growth and yield

Introduction

Strawberry (*Fragaria* × *ananassa Duch*esne ex Rozier) is a short-day plants for which temperatures ranging between 22°C - 25°C during the daytime and between 7°C - 13°C during night time are considered optimal (**De and Bhattacharjee, 2012).** Although, it is cultivated

commercially in temperate climate, yet it can be grown under tropical and subtropical climatic conditions.

Nowadays, greenhouse cultivation has changed radically. Goals of earliness, productivity increase and product quality improvement resulted in farmers adopting new skills for enhancement of crop productivity and more-effective management of resources. The greatest change has been the move away from soil cultivation to isolated growing systems. However, farmers produce off-season agricultural products and sell them in a very competitive world market, hence the lower the production cost, the larger the profit margins are. So, the choice of the production system in order to obtain out-of-season production, constitutes a significant part to achieve higher levels of profitability. These aspects are quite relevant for horticultural commodities in general, and especially in the case of strawberry production **(Salem, 1993).**

The traditional cropping system using soil as a growing media for the production of strawberry plants poses many problems like soil borne diseases caused by Verticillium spp. and Phytophthora spp., nematodes and soil limiting factors resulting in loss of plants **(Durner, 2002).** Soilless (hydroponic) cultivation is an artificial means of providing plants with support and a reservoir for nutrients and water **(Raja *et al.*, 2018).** The characteristics of growing media which make it suitable for cultivation are good water and nutrient holding capacity, free from morbific organisms and virulent compounds, providing better aerify to the root system **(Johnson *et al.*, 2010**). The peculiarity of organic and inorganic growing media allows better nutrient translocation which results in better growth, and development of the plants thereby ameliorating water and oxygen retention capacity **(Albaho *et al.*, 2008).** The physiochemical properties of the growing media used plays a vital role in the growth of plants grown in container **(Riaz *et al.*, 2008).** In addition to improving the yield potential of strawberry, the proportion of growing media used also augments the quality of fruit by accurate control over the distribution of water, nutrients, pH, and root zonal temperature**.**

Materials and methods

Hydroponic and soil plants were grown and maintained at the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, India. The greenhouse temperature was maintained at 70°F (21.14°C) during the day (5:30 AM to 6:30 PM)

and 60°F (15.55°C) (6:31 PM to 5:29 AM) at night with relative humidity averaging at 30%. Sixty bare-root, ever-bearing strawberry plants (‘Chandler,’ *Fragaria x ananassa*) were purchased from the nursery. Thirty strawberries were planted in hydroponic conditions and thirty strawberries were planted in soil-substrate media conditions. The media plants and the hydroponics plants were randomized and placed in eleven rows on two tables. Both the hydroponic and the media plants were numbered for recording and monitoring plants health. In both growing conditions, first-buds and runners were manually removed to increase fruit production.

Media system: The Chandler strawberries were planted according to manufacturing instructions, in 3-gallon black plastic nursery pots with drainage holes in the bottom of the pots. Two strawberries were planted in each pot, approximately 10” apart. The soilless Media was a mixture of M0 – Soil, M1 – Vermicompost + Perlite + Cocopeat (15:40:45) and M2 – Vermicompost + Perlite + Cocopeat (25:35:40). The pH of the soil was monitored using a portable pH meter before planting and during the season.

Hydroponic system: The nutrient film technique system is employed consisting of vanilla round shaped pots that each having 2.8 litter capacity were placed on above of each other with help of a metal pole to form a cylinder shaped column. The 20 cm PVC cut-pipe sleeves placed between every two pots to keep pots vertically apart of each other and the first pot from the bottom placed at 45 cm elevation from surface of the ground which gave a column with height of 162 cm. The distance between row and columns was 100 cm and 70 cm, respectively. Each column consist in four pots and each pot accommodated four plants with sixteen plants per column. Each pot supplied with nutrient solution through micro tubes with 8 liters per hour discharging capacity from above lateral lines. Treatments include different concentrations of GROW, MICRO and BLOOM at different hours viz. (12 hours, 18 hours and 24 hours), also plants growth stages stated as seedling stage, vegetative growth, transition, bloom and bloom ripening. There were 11 treatments each replicated thrice followed by a change of nutrients and water after every 20 days. The experiment was laid out in Factorial Randomized Block Design.

Results and Discussion

Growth characters

The result of the present study indicated that growth parameters of such as Plants height, Plants spread, No. of leaves, Leaf area, and Root length of strawberry *(Fragaria ananassa)* cv. Chandler were significantly influenced by different treatments and two different system. In Table 1 and 2 may be seen results comparing among the concentrations (Grow, micro and bloom) in treatments. In T_7 of 24 h giving the highest growth (18.72, 157.71, 25.71, 27.02 and 49.42 cm), respectively as compared to other treatment and hour in hydroponic system followed by T_8(18.70, 156.21, 25.34, 16.26 and 56.12cm) and minimum (0.00, 0.00, 0.00, 0.00 and 0.00 cm) was T_0(the control, Plain water) at harvest. However, similar trend was also obtained in pot experiment of different growth media in (Table 1-2).

Hydroponic system might have led to increased plants height than cocopeat and soil due to continuous supply of nutrients and massive root growth, while cocopeat had more plants height than soil due to porous nature of the media.

These results are in conformity with the findings of **Mishra *et al.* (2016)** who reported that average plants height of strawberry *(Fragaria ananassa)* cv. Chandler transplanted from Ayurvet progreen hydroponic machine performed better under field conditions in comparison to the conventional system. **Rai *et al.* (2016)** also reported significant differences between two systems for plants height. According to, **Kulkarni *et al.* (2017**), the plants grown in hydroponically conditions (Spinach-28.33cm and Coriander-47.21cm) were found to have slightly more height when compared to soil grown plants (Spinach - 25.22 cm and Coriander - 42.60 cm).

Similarly, **Spehia *et al.* (2018)** also reported maximum leaf area per plants from concentration with (Grow, micro and bloom) in hydroponic system. Similar results were found with the study of **Karne *et al.* (2018**), where the maximum leaf area was observed under green hydroponic structure followed by the treatment cocopeat under green hydroponic structure.

Yield attributes

Yield attributes, which determine yield, is the resultant of the vegetative development of the plants. All the attributes of yield viz. No. of flower/plants, Days taken to first flowering, Days taken to first fruit, No. fruits per plants, Average fruit weight (g) and Yield per setup (kg) of strawberry *(Fragaria ananassa)* cv. Chandler were significantly influenced by different treatments and two different system. Among the concentration (Grow, micro and bloom) in treatments T_7 of 24 hr giving the highest growth (44.46, 55.90, 82.09, 23.00, 18.20 and 47.86), respectively as compared to other treatment and hour in hydroponic system followed by T_8(44.03, 57.87, 86.76, 22.39, 17.69 and 47.08) and minimum in the control(0.00, 0.00, 0.00, 0.00 and 0.00 cm) was T_0(Plain water) at harvest. However, similar trend was also obtained in pot experiment of different growth media (Table 3-4). The highest (1:3.09) benefit cost ratio was worked out in treatment T7 which was rated as the most profitable and cost effective and was statistically significant than all other treatments whereas, lowest (0.00) benefit cost ratio was recorded under control treatment T_0.

Higher yield of hydroponics results from the easy availability of nutrients and water to the plants which allow for continuous production year round. The present results get support from the findings of **Treftz & Omaye (2015)** who reported 17per cent increase in the yield of hydroponics grown strawberries as compared to soil-grown strawberries. **Rai *et al.* (2016)** also reported higher yield/acre between hydroponics and conventional cultivation in strawberry.

Table 1 : Effects of different treatments under two different system on plants height (cm), plants spread and number of leaves per plants of strawberry *(Fragaria ananassa)* cv. Chandler.

Treatments	Plants height (cm)						Plants spread						No. of leaves					
	NFT hydroponics system			Pot system			NFT hydroponics system			Pot system			NFT hydroponics system			Pot system		
	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2
T_0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	11.50	14.38	15.05	10.34	13.22	13.89	124.20	146.31	146.98	126.04	144.15	143.82	19.27	20.31	20.98	18.28	19.15	19.64
T_2	12.19	14.85	15.52	11.05	13.71	14.38	76.48	88.51	89.18	75.34	87.37	88.04	14.39	17.37	18.04	13.25	16.23	16.90
T_3	13.36	16.13	16.80	12.20	14.97	15.64	135.27	153.58	154.25	134.67	153.92	154.59	20.04	23.71	24.38	18.88	22.55	23.22
T_4	12.32	14.96	15.63	11.19	13.84	14.51	88.18	101.61	102.28	87.05	100.49	101.16	16.23	19.43	20.10	15.11	18.30	18.97
T_5	12.52	15.15	15.82	11.40	14.03	14.70	103.44	118.77	119.44	102.32	117.65	118.32	18.08	21.49	22.16	16.97	20.38	21.05
T_6	12.73	15.45	16.12	11.60	14.32	14.99	121.84	139.79	140.46	120.71	138.66	139.33	18.83	22.40	23.07	17.70	21.27	21.94
T_7	15.25	18.05	18.72	14.07	16.87	17.54	137.79	157.04	157.71	136.63	155.88	156.55	21.46	25.04	25.71	20.26	23.85	24.52
T_8	15.23	18.03	18.70	14.06	16.85	17.52	137.23	155.54	156.21	136.03	154.35	155.02	21.00	24.67	25.34	19.84	23.51	24.18
T_9	14.32	17.09	17.76	13.16	15.93	16.60	135.34	151.29	152.96	134.17	150.12	151.79	20.55	24.03	24.70	19.39	22.86	23.53
T_{10}	15.09	17.65	18.12	14.00	16.56	17.03	129.69	147.06	147.73	129.60	145.97	145.64	19.97	23.06	23.61	18.88	21.97	22.52
T_{11}	15.49	17.33	16.79	14.63	16.23	15.45	108.75	123.47	124.14	107.65	122.37	123.04	17.84	21.00	21.67	16.88	19.90	20.39
	SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%	
Hour and soil	0.242	0.500	*	0.258	0.533	*	1.443	2.978	*	1.337	2.759	*	0.315	0.651	*	0.324	0.668	*
Treatments	0.464	0.958	*	0.495	1.021	*	2.763	5.703	*	2.56	5.283	*	0.604	1.247	*	0.62	1.279	*

Table 2: Effects of different treatments under two different system on Leaf Area and Root length (cm) of strawberry *(Fragaria ananassa)* cv. Chandler.

Treatments	Leaf Area						Root length (cm)					
	NFT hydroponics system			Pot system			NFT hydroponics system			Pot system		
	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2
T_0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	10.83	13.60	14.27	9.67	12.44	13.11	40.36	47.16	47.94	39.54	45.50	46.42
T_2	12.99	15.50	16.17	33.55	37.81	38.43	33.39	39.14	39.81	32.50	38.00	38.55
T_3	11.66	14.21	14.88	10.50	13.05	13.72	46.20	53.49	54.16	45.04	52.33	53.00
T_4	11.59	14.13	14.80	21.74	25.67	26.22	35.07	40.95	41.62	17.50	39.83	40.50
T_5	11.95	14.50	15.17	10.83	13.38	14.05	37.75	43.91	44.58	36.64	42.79	43.46
T_6	11.73	14.31	14.98	10.60	13.18	13.85	42.00	48.80	49.47	40.87	47.67	48.34
T_7	22.92	26.48	27.02	11.88	14.39	15.06	49.42	56.56	57.23	48.22	55.36	56.03
T_8	13.07	15.59	16.26	11.82	14.34	15.01	48.16	55.45	56.12	47.00	54.29	54.96
T_9	12.62	15.17	15.84	11.46	14.01	14.68	46.02	52.73	53.40	44.85	51.57	52.24
T_{10}	12.66	15.13	15.80	11.57	14.04	14.71	42.85	49.17	49.84	41.76	48.08	48.75
T_{11}	12.17	14.61	15.28	11.07	13.51	14.18	39.00	44.85	45.52	37.90	43.75	44.42
	SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%	
Hour and soil	0.543	1.121	*	0.553	1.141	*	0.524	1.082	*	1.336	2.757	*
Treatments	1.04	2.146	*	1.059	2.185	*	1.004	2.072	*	2.558	5.279	*

Table 3: Effects of different treatments under two different system on No. of flower/plants, Days taken to first flowering and Days taken to first fruit of strawberry *(Fragaria ananassa)* cv. Chandler.

Treatments	No. of flower/plants						Days taken to first flowering						Days taken to first fruit					
	NFT hydroponics system			Pot system			NFT hydroponics system			Pot system			NFT hydroponics system			Pot system		
	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2
T_0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	31.27	37.52	38.19	30.11	36.36	37.03	76.32	74.95	73.98	76.89	75.52	74.55	100.16	99.83	99.36	100.57	100.24	99.77
T_2	26.72	31.51	32.18	25.83	30.37	31.04	74.61	73.24	72.27	75.18	73.81	72.84	94.50	94.17	93.90	94.91	94.58	94.31
T_3	33.56	38.94	39.61	32.39	37.77	38.44	59.77	58.40	57.43	60.34	58.97	58.00	117.03	116.70	116.33	117.44	117.11	116.74
T_4	27.45	32.19	32.86	26.47	31.07	31.74	68.91	67.54	66.57	69.48	68.11	67.14	89.94	89.61	89.24	90.35	90.02	89.65
T_5	29.08	34.03	34.70	27.97	32.91	33.58	64.08	62.71	61.74	64.65	63.28	62.31	115.12	114.79	114.42	115.53	115.20	114.83
T_6	32.66	38.17	38.84	31.53	37.04	37.71	71.59	70.22	69.25	72.16	70.79	69.82	111.21	110.88	110.56	111.62	111.29	110.97
T_7	38.09	43.79	44.46	36.89	42.59	43.26	58.24	56.87	55.90	58.81	57.44	56.47	82.79	82.46	82.09	83.20	82.87	82.50
T_8	37.50	43.36	44.03	34.35	39.73	40.40	60.21	58.84	57.87	62.33	60.96	59.99	87.46	87.13	86.76	119.43	119.10	118.73
T_9	35.52	40.90	41.57	36.34	42.20	42.87	61.76	60.39	59.42	60.78	59.41	58.44	119.02	118.69	118.32	87.87	87.54	87.17
T_{10}	32.69	37.71	38.38	31.60	36.62	37.29	67.34	65.97	65.00	67.91	66.54	65.57	100.98	100.65	100.30	101.39	101.06	100.71
T_{11}	29.50	34.15	34.82	28.40	33.05	33.72	67.05	65.68	64.71	67.62	66.25	65.28	104.00	103.67	103.36	104.41	104.08	103.77
	SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%	
Hour and soil	0.438	0.904	*	0.439	0.905	*	0.705	1.456	*	0.717	1.479	*	1.023	2.112	*	1.026	2.117	*
Treatments	0.839	1.732	*	0.84	1.734	*	1.351	2.788	*	1.373	2.833	*	1.959	4.044	*	1.964	4.054	*

Table 4: Effects of different treatments under two different system on No. fruits per plants, Average fruit weight (g) and Yield per setup (kg) of strawberry *(Fragaria ananassa)* cv. Chandler.

Treatments	No. fruits per plants						Average fruit weight (g)						Yield per setup (kg)					
	NFT hydroponics system			Pot system			NFT hydroponics system			Pot system			NFT hydroponics system			Pot system		
	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2	12 hrs	18 hrs	24hrs	M_0	M_1	M_2
T_0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_1	11.93	14.88	15.55	10.87	13.72	14.39	7.40	9.58	10.25	6.24	8.42	9.09	14.99	18.46	19.13	13.83	17.30	17.97
T_2	17.28	20.33	21.00	16.09	19.14	19.81	9.67	11.79	12.46	8.70	10.66	11.33	29.51	34.70	35.37	28.37	33.56	34.23
T_3	16.34	19.52	20.19	15.18	18.36	19.03	12.58	15.17	15.84	11.41	14.00	14.67	36.50	42.14	42.81	35.34	40.97	41.64
T_4	17.58	20.92	21.59	16.47	19.81	20.48	9.81	12.10	12.77	8.76	10.98	11.65	29.55	34.66	35.33	28.43	33.54	34.21
T_5	16.99	20.31	20.98	15.86	19.18	19.85	11.33	13.80	14.47	10.22	12.68	13.35	32.75	38.21	38.88	31.64	37.10	37.77
T_6	17.05	20.08	20.75	15.88	18.91	19.58	12.60	15.30	15.97	11.47	14.17	14.84	36.82	42.91	43.58	35.69	41.78	42.45
T_7	18.82	22.33	23.00	17.88	21.19	21.86	14.79	17.53	18.20	13.60	16.33	17.00	41.10	47.19	47.86	39.91	45.99	46.66
T_8	18.23	21.72	22.39	17.11	20.60	21.27	14.25	17.02	17.69	13.09	15.86	16.53	40.18	46.41	47.08	39.02	45.25	45.92
T_9	17.33	20.51	21.18	16.17	19.35	20.02	13.57	16.16	16.83	12.40	14.99	15.66	37.49	43.13	43.80	36.33	41.96	42.63
T_{10}	16.68	19.67	20.34	15.59	18.58	19.25	12.58	15.05	15.72	11.49	13.96	14.63	34.13	39.34	40.01	33.04	38.25	38.92
T_{11}	17.16	20.24	20.91	16.06	19.14	19.81	11.50	13.86	14.53	10.40	12.76	13.43	32.68	37.73	38.40	31.58	36.63	37.30
	SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%		SE(m)	C.D. at 5%	
Hour and soil	0.27	0.557	*	0.267	0.552	*	0.219	0.453	*	0.22	0.454	*	0.463	0.956	*	0.463	0.956	*
Treatments	0.517	1.067	*	0.512	1.057	*	0.42	0.867	*	0.421	0.869	*	0.887	1.83	*	0.887	1.83	*

Table 5 : Overall Cost: benefit ratio of nutrient in vertical hydroponics system for 12_{hr}, 18_{hr} and 24_{hr}.

Treatments	Hydroponic					
	12_{hr}		18_{hr}		24_{hr}	
	Net return Rs./)	Benefit cost ratio	Net return Rs./)	Benefit cost ratio	Net return Rs./)	Benefit cost ratio
T0	0	1:0.00	0	0.00	0	1:0.00
T1	62	1:0.98	564	1.20	684	1:1.25
T2	2,532	1:1.91	3,467	2.25	3,587	1:2.29
T3	2,537	1:1.91	3,457	2.24	3,577	1:2.29
T4	3,110	1:2.12	4,092	2.47	4,213	1:2.51
T5	3,850	1:2.39	4,945	2.78	5,066	1:2.82
T6	4,452	1:2.60	5,573	3.00	5,693	1:3.05
T7	4,615	1:2.66	5,710	3.05	5,831	1:3.09
T8	3,971	1:2.43	4,985	2.79	5,106	1:2.84
T9	3,363	1:2.21	4,301	2.55	4,421	1:2.59
T10	3,110	1:2.12	4,092	2.47	4,213	1:2.51
T11	3,099	1:2.11	4,008	2.44	4,128	1:2.48

Table 6: Overall Cost benefit ratio of nutrient in pot system for different substrate media.

Treatments	Pot					
	Soil		Vermicompost + Perlite + Cocopeat (15:40:45)		Vermicompost + Perlite + Cocopeat (25:35:40)	
	Net return Rs./)	Benefit cost ratio	Net return Rs./)	Benefit cost ratio	Net return Rs./)	Benefit cost ratio
T0	0	1:0.00	0	1:0.00	0	1:0.00
T1	271	1:0.90	266	1:1.09	298	1:1.10
T2	2,327	1:1.84	3,173	1:2.11	3,205	1:2.08
T3	2,335	1:1.84	3,166	1:2.10	3,198	1:2.08
T4	2,909	1:2.04	3,803	1:2.32	3,835	1:2.29
T5	3,646	1:2.31	4,653	1:2.62	4,685	1:2.59
T6	4,243	1:2.53	5,275	1:2.84	5,307	1:2.79
T7	4,399	1:2.58	5,406	1:2.88	5,438	1:2.84
T8	3,761	1:2.35	4,687	1:2.64	4,719	1:2.60
T9	3,166	1:2.14	4,016	1:2.40	4,048	1:2.37
T10	2,909	1:2.04	3,803	1:2.32	3,835	1:2.29
T11	2,901	1:2.04	3,721	1:2.30	3,753	1:2.27

Conclusion

Based on the results of the current investigation, it can be said that plants cultivated using the hydroponic system with Grow, Micro, and Bloom at intervals of 10 days optimize yield in addition to exhibiting the greatest growth, quality, and yield-contributing features. In comparison to soilless medium and soil, the hydroponic system produced yields that were 15.42% and 34.12% greater, respectively. However, coco peat outperformed soil in terms of yield and qualitative evaluation, with a yield that was 19.8% greater than soil. The application of nutrients (Grow, Micro, and Bloom) also had a substantial impact on production and the availability of nutrients to the plants, suggesting a beneficial effect of foliar spray. Due to the enhanced returns under this treatment, the benefit-cost ratio was also maximized (1:3.09), indicating its advantages in the evolving agricultural environment. In order to fulfill the demand for fresh veggies in cities or other metropolitan regions, this method might be quite helpful. The study's findings may help urban farmers or city residents who want to use the technology in their constrained environment.

The hydroponic system yielded 20.92 per cent and 16.91 per cent higher than soilless media and soil, respectively.

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