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Effect of Drip Irrigation and Mulching on Fruiting, Yield and Quality Attributes of Litchi (*cv*. Rose Scented) under High Density Planting

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A B S T R A C T

Flood irrigation causes significant water loss due to run off, seepage, evaporation etc. On the other hand, micro-irrigation technique provides a reduction in water consumption by 30-70% with simultaneous augmentation in yield. A suitable drip irrigation level may ensure proper growth and development of trees for obtaining higher marketable yields. The present experiment was conducted to evaluate the effect of different drip irrigation levels in combination with mulching on fruiting, yield and quality attributes of litchi (*cv*. Rose Scented) under high density. During the study, litchi plants were subjected to three levels of drip irrigation i.e. 100 %, 75 % and 50 % of estimated irrigation water requirement, with and without mulching. Among the different treatment combinations, the treatment MDI_3 i.e. application of drip irrigation at 100 % level in tandem with mulching was found most superior over other treatments as well as control.

Introduction

Litchi (*Litchi chinensis* Sonn.) commonly called as the "Queen of fruit crops" is an important crop of sub-tropics belonging to the family Sapindaceae. It is widely cultivated for its attractive red fruits with pleasant aroma which, are largely consumed in fresh, canned and dried forms. The fresh ripe fruits are a good source of vitamins (including vitamin B_1, B_2, B_6, C, E and K) and minerals (i.e. calcium, phosphorus, iron, sodium and potassium) (Emanuele *et al.*, 2017). Litchi also possess immense medicinal value *viz.* hypoglycemic, antibacterial, anticancer, anti-hyperlipidemic, anti-platelet, antipyretic, hemostatic, diuretic, and antiviral activities and is widely used for treatment of cough,

flatulence, stomach ulcers, epigastric and neuralgic pains (Ibrahim *et al.*, 2015).Globally, India ranks second in the area and production of litchi after China (Sahni *et al.*, 2020). The country exhibits 95'000 ha area with an annual production of 727'000 Mt (NHB, 2018). Bihar leads in the area and production of litchi followed by West Bengal. The other commercial litchi producing states are Jharkhand, Assam, Chhattisgarh, Uttarakhand, Punjab, Odisha etc.

The successful litchi cultivation demands fastidious climatic conditions which, often serves as a major setback in area expansion of crop. Recent studies have revealed that the environmental factors *viz.* temperature, light intensity, soil moisture content and atmospheric humidity have a strong influence in its production trends and fruit quality (Kumar, 2014). The prevalence of dry, frost free winters, hot summers with high humidity and abundant rainfall is crucial for commercial crop production. Aberrations in these factors widely influence the vegetative growth, panicle emergence, flowering and fruit development (Kumar and Nath, 2013). According to Cronze and Mostert (2010), soil moisture content plays a fundamental role in litchi production and contributes widely to yield and fruit size. Water deficits during flowering adversely affects the fruit set and retention per cent (Carr and Menzel, 2014). Soil moisture fluctuations during fruit growth cause serious reductions in individual fruit weight and in severe cases may lead to fruit cracking. This reduces the fruit quality and ultimately crop productivity. Irrigating orchards during critical stages of crop growth and conservation of soil moisture reserves are the key interventions for bearing behaviour and quality production in litchi.

Managing soil moisture in the root zone *via* advanced irrigation techniques such as drip irrigation in combination with mulching may aid in soil moisture conservation as well as attainment of higher yields to a great extent. Moreover, in the present scenario such irrigation techniques can also serve as an effective option for conservation of depleting water resources. Constant studies are being conducted to analyse the performance of plants under drip irrigation. But, specific information regarding well suited drip irrigation level for high density litchi orchards under mulching is yet to be optimized. This might be because traditional litchi orchards involve planting trees at wider spacing i.e. 9 m or 10 m × 12 m. The concept of high density planting, particularly in litchi, is relatively new in India. Litchi plantation at closer spacing (such as 4 m × 6 m or 7 m × 3 m) not only ensures higher yields and early returns but also promotes better utilization of resource inputs (Pandey *et al.*, 2015). However, there is lack of sufficient information regarding the effect of drip irrigation and mulching in high density litchi orchards. Keeping this in view, the present study was conducted to assess the performance of litchi under different drip irrigation levels and optimize the suitable irrigation level for improving fruit retention and quality production in high density litchi orchard.

Materials and Methods

The present experiment was conducted at Horticulture Research Center, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Distt. U.S. Nagar (Uttarakhand) during the year 2016 and 2017. The site is situated in the foothills of Himalayas at 29˚ North Latitude and 79.3˚ East longitude. The altitude of the place is 243.84m above mean sea level. The region experiences humid subtropical climate with maximum summer temperature varying from 32˚C to 45˚C and minimum winter temperature ranging from 0˚C to 9˚C.The soil

of experimental site is mollisol with good water holding capacity. It has originated from loamy alluvial sediments with high cation exchange capacity and about 90 per cent base saturation.

The study involved 15-year-old litchi trees *cv.* Rose Scented planted at a spacing of 5 m × 5 m. The experimental plot was laid out in randomized block design with six treatment combinations and one control. Each treatment combination along with control comprised three replications including three trees per replication. The experimental trees were subjected to drip irrigation at three levels *viz.* 100 %(DI_3), 75% (DI_2) and 50% (DI_1) of estimated irrigation water requirement with (M) and without (M_0) mulch application while, the trees under control were irrigated through conventional surface irrigation. The irrigation water requirement was determined on the basis of crop evapotranspiration (in litres/plant) as per the formula suggested by Vermeiren and Jobling (1984):

$$V = E_p \times K_p \times K_c \times K_r \times \text{Ground cover area}$$

Where,
E_p : Pan evaporation (mm/day)
K_p : Pan Coefficient (0.85)
K_c : Crop coefficient (0.65)
K_r : Reduction coefficient (0.1+ per cent ground cover)

The pan evaporation data were collected from agro-meterological observatory located near the experimental site. The pan coefficient and crop coefficient value were adapted as mentioned in FAO-56.In case of drip irrigation, each row of trees was provided with one lateral drip line. The emitting system involved on-line emitters of 4l/hr discharge rate. These emitters were installed at eight locations under the tree canopy. The operating pressure of the drip irrigation system was maintained at 1.2 kg/cm^2.

The data on fruiting and quality attributes were recorded by tagging ten panicles per treatment per replication in each direction of the tree canopy. The data on fruiting, yield and quality attributes were assessed. Thetotal number of fruits per tagged panicle were counted at fruit set stage and the fruit set percentage was worked out. The fruit drop and retention percentage were determined on basis of total number of fruits at the time of fruit set and total number of fruits during harvesting. The fruit cracking percentage was calculated on basis of total number of healthy fruits and cracked fruits per panicle. The harvested fruits were weighed and the yield (kg) per plant was determined. The fruit quality was assessed by analyzing random fruit samples comprising ten fruits from each tagged panicle. The fruit weight was recorded with the help of an electronic balance and expressed in grams. The fruit size (*viz*. length and breadth)was estimated using digital Vernier-Calliper and expressed in mm. The edible portion percentage was worked out as the ratio of pulp weight to total fruit weight and expressed in per cent. The Total Soluble solids were determined using digital hand refractometer and expressed in Brix.

Results and Discussion

The data regarding the effect of drip irrigation in combination with mulching on fruiting attributes of litchi is mentioned in Table 1.

The present study revealed significant variations for fruit set but overall, no direct impact of drip irrigation and mulching was revealed. However, a significant decline in fruit drop percentage with considerable increase in fruit retention was obtained under drip irrigation at higher levels. During the initial year of study, the treatment combination MDI_3 recorded highest fruit retention (i.e.23.14 per cent) and minimum fruit drop (i.e. 76.86 per cent). While, the

second year of study, recorded highest fruit retention (12.49 per cent) and minimum fruit drop (87.50 per cent) under treatment combination M_0DI_3.Further, significant effect of mulch was observed in controlling fruit drop (80.61 and 89.03 per cent) and improving fruit retention percentage (19.38 per cent and 10.97 per cent) over no mulchin respective year of study (Fig 1). The fruit retention was also found higher (22.50 per cent and 11.30 per cent) along with sufficient control in fruit drop percentage (77.49 and 88.86 per cent) under the application of drip irrigation at 100 per cent level in the initial and following year, respectively (Fig 2). In terms of fruit cracking, the minimum cracking percentage (i.e. 8.8 percent during the year 2016 and 7.85 per cent during the year 2017) was recorded in treatment combination MDI_3. On the other hand, the maximum fruit cracking (21.29 per cent in initial year and 22.64 per cent in following year) was observed in treatment M_0DI_1(drip irrigation at 50 % level without mulch application). The trees under control (i.e. conventional surface irrigation) recorded 12.87 and 14.84 per cent fruit cracking in respective years. Significant variations were also revealed for the main effect of mulch and drip irrigation. The fruit cracking in litchi was low under mulched conditions (i.e. 13.34 per cent and 12.91 per cent) over non-mulched (i.e. 16.79 per cent and 17.34 per cent) during the year 2016 and 2017, respectively (Fig 1). The cracking (per cent) was further reduced with increasing irrigation level i.e. 10.32 and 10.26 per cent under DI_3 as compared to DI_1during the first and second year of study, respectively(Table 1 and Fig 2).

The data related to fruit yield are presented in Table 1. During first year of study the treatment combination, mulch application with drip irrigation at 100 per cent level (MDI_3) produced maximum yield i.e. 30.60 kg/tree while, minimum yield was recorded under treatment M_0DI_1 (9.70 kg/plant) and MDI_1 (12.38 kg/plant). A similar pattern was witnessed in following year wherein treatment combination MDI_3 recorded maximum yield (22.50 kg/plant) while, treatment combinations with drip irrigation at low level i.e. MDI_1(9.14 kg/plant)and M_0DI_1 (9.23 kg/plant) obtained minimum yield. The study also revealed that mulched trees produced more yield (i.e. 22.54 kg/tree and 17.07 kg/tree) over non-mulched in the two year course of study, respectively. The yield also augmented with the main effect of drip irrigation level. Application of drip irrigation at 100 per cent level resulted in highest yield i.e. 28.11 kg/tree(in first year) and 20.13 kg/tree (in second year).

The combined effect of drip irrigation with mulching revealed significant impact on fruit quality traits (Table 2). During the study, maximum fruit weight (i.e. 20.36 g in first year and 21.29 g in second year) was recorded in treatment MDI_3 i.e. mulching with drip irrigation at 100 per cent level while, minimum fruit weight (i.e. 16.66 g in first year and 16.25 g in second year) was found in treatment M_0DI_1 i.e. drip irrigation at 50 per cent level without mulch application. In terms of fruit size, the treatment MDI_3(i.e. mulching with drip irrigation at 100 per cent level) was found significantly superior with maximum fruit length (*viz*. 35.43 mm and 35.62 mm)and breadth (*viz*. 32.20 mm and 32.23 mm) during the first and second year, respectively. Also, the individual effect of mulch and drip irrigation level showed significant variations for fruit weight and size. The application of drip irrigation at 100 per cent level produced maximum fruit weight i.e. 20.17 g and 20.86 g in initial and following year of study, respectively. The conjunctive influence of mulch and drip irrigation also recorded significant variation in edible portion percentage. The treatment MDI_3 exhibited maximum edible portion percentage i.e. 75.34

per cent in first and 74.47 per cent in second year of study while, the minimum edible portion percentage (*viz*. 71.99 in initial year and 70.06 per cent in following year)were found in treatment M_0DI_1. Further, the edible portion (per cent) was statistically at par due to the individual effect of mulch during both the years, while the main effect of drip irrigation level showed significant variation. The application of drip irrigation in tandem with mulching also improved the T.S.S content in fruits. The trees subjected to mulching with drip irrigation at 100 % level i.e. MDI_3 exhibited highest T.S.S i.e. 18.20˚B and 19.48˚B in first and second year of study, respectively. On the other hand, the lowest T.S.S (i.e.16.55˚B and 16.65˚B) was found in the treatment M_0DI_1 (i.e. drip irrigation at 50 per cent level without mulch application).The two year study demonstrated significantly higher T.S.S under mulched treatments i.e. 17.66˚B and 18.61˚B, respectively as compared to non-mulched trees. Further, the application of drip irrigation at 100per cent level significantly augmented the T.S.S (17.93˚B and 19.19˚B) in the respective years, irrespective of mulch.

The fruit set in litchi is generally influenced by number of female flowers, pollination, diseases and insect pest infestation (Ghosh, 2001). During the entire course of study, the fruit set varied significantly but no direct effect of drip irrigation and mulching was witnessed. However, direct influence of drip irrigation and mulching was observed for fruit drop and retention percentage.

Table.1 Effect of drip irrigation with mulching on fruiting, yield and cracking in litchi *cv.* Rose Scented

Treatment	Fruit set (%)		Fruit drop (%)		Fruit retention (%)		Fruit cracking (%)		Yield (kg/plant)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
MDI_1	44.63	49.48	87.39	91.22	12.60	8.77	18	17.97	12.38	9.14
MDI_2	48.14	48.71	77.58	87.64	22.41	12.36	13.22	12.92	24.65	19.58
MDI_3	43.89	46.42	76.86	88.22	23.14	11.77	8.8	7.85	30.60	22.50
M_0DI_1	44.98	48.00	89.14	92.86	10.85	7.13	21.29	22.64	9.70	9.23
M_0DI_2	48.84	47.50	81.91	90.97	18.08	9.02	17.25	16.72	20.71	15.17
M_0DI_3	45.95	43.70	78.12	87.50	21.87	12.49	11.84	12.66	25.62	17.76
Control	50.38	45.38	82.50	89.87	17.50	10.12	12.87	14.84	19.23	15.28
C.D.at 5%	1.52	1.37	0.76	1.89	0.76	1.89	0.61	0.49	1.63	1.16
DI_1	44.80	48.74	88.26	92.04	11.73	7.95	19.65	20.3	11.04	9.19
DI_2	48.49	48.11	79.74	89.30	20.25	10.69	15.23	14.82	22.68	17.37
DI_3	44.92	45.06	77.49	87.86	22.50	12.13	10.32	10.26	28.11	20.13
C.D.at 5%	1.07	0.96	0.54	1.33	0.53	1.33	0.43	0.35	1.15	0.82
M	45.55	48.20	80.61	89.03	19.38	10.97	13.34	12.91	22.54	17.07
M_0	46.59	46.40	83.06	90.44	16.93	9.55	16.79	17.34	18.68	14.05
C.D.at 5%	0.87	0.79	0.44	1.09	0.44	1.09	0.35	0.28	0.94	0.67

Table.2 Effect of drip irrigation with mulching on fruit quality attributes of litchi *cv.* Rose Scented

Treatment	Fruit weight (g)		Fruit length (mm)		Fruit breadth (mm)		Edible portion (%)		T.S.S (Brix)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
MDI_1	17.43	17.31	32.84	32.64	29.42	29.43	70.11	72.43	17.00	17.50
MDI_2	18.99	20.08	34.61	35.07	31.49	31.67	72.98	72.73	17.80	18.86
MDI_3	20.36	21.29	35.43	35.62	32.20	32.23	75.34	74.47	18.20	19.48
M_0DI_1	16.66	16.25	32.52	32.37	29.05	29.03	71.99	70.76	16.55	16.65
M_0DI_2	18.93	19.27	34.56	34.69	31.38	31.40	71.37	71.40	17.50	18.25
M_0DI_3	19.99	20.44	35.02	35.30	31.79	31.85	74.85	72.58	17.67	18.91
Control	18.77	18.80	34.52	34.60	31.35	31.38	71.09	69.65	17.50	18.53
C.D.at 5%	0.54	0.36	0.15	0.17	0.31	0.38	2.17	3.05	0.63	0.69
DI_1	17.05	16.78	32.68	32.51	29.23	29.23	71.05	71.59	16.77	17.07
DI_2	18.96	19.68	34.59	34.88	31.43	31.53	72.18	72.07	17.65	18.55
DI_3	20.17	20.86	35.22	35.46	31.99	32.04	75.10	73.53	17.93	19.19
C.D.at 5%	0.38	0.25	0.10	0.12	0.22	0.27	1.54	2.15	0.44	0.49
M	18.93	19.56	34.29	34.45	31.03	31.11	72.81	73.21	17.66	18.61
M_0	18.53	18.65	34.03	34.12	30.74	30.76	72.74	71.58	17.24	17.93
C.D.at 5%	0.31	0.20	0.08	0.09	0.18	0.22	NS	NS	0.36	0.40

Fig.1 Effect of mulching on fruit drop, retention and cracking in litchi *cv.* Rose Scented

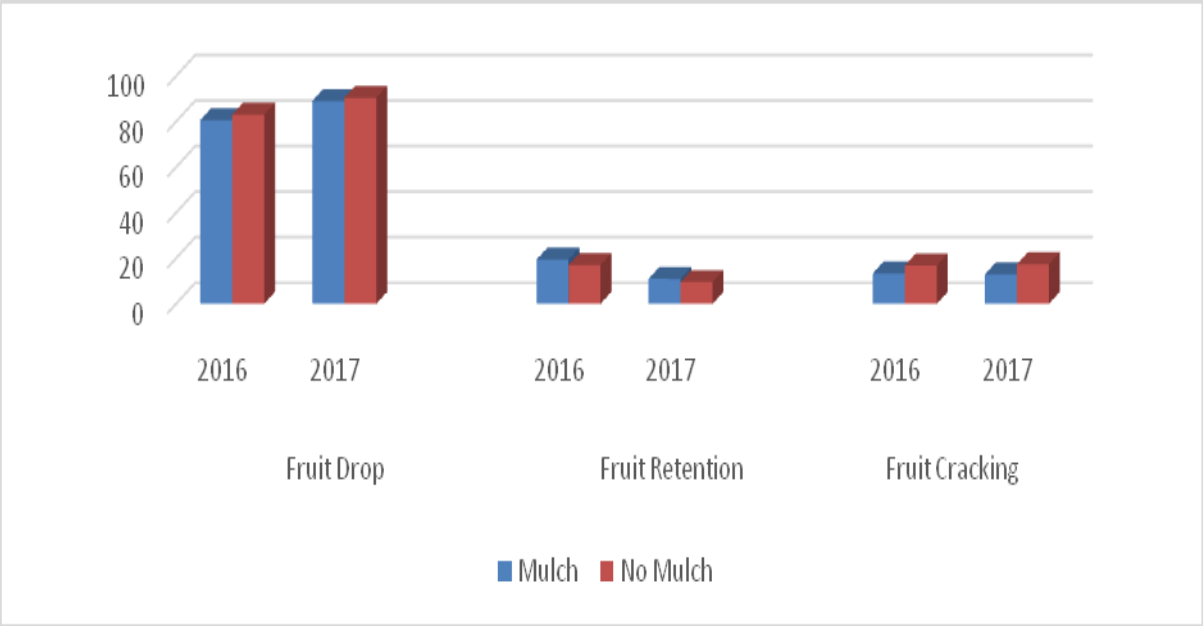
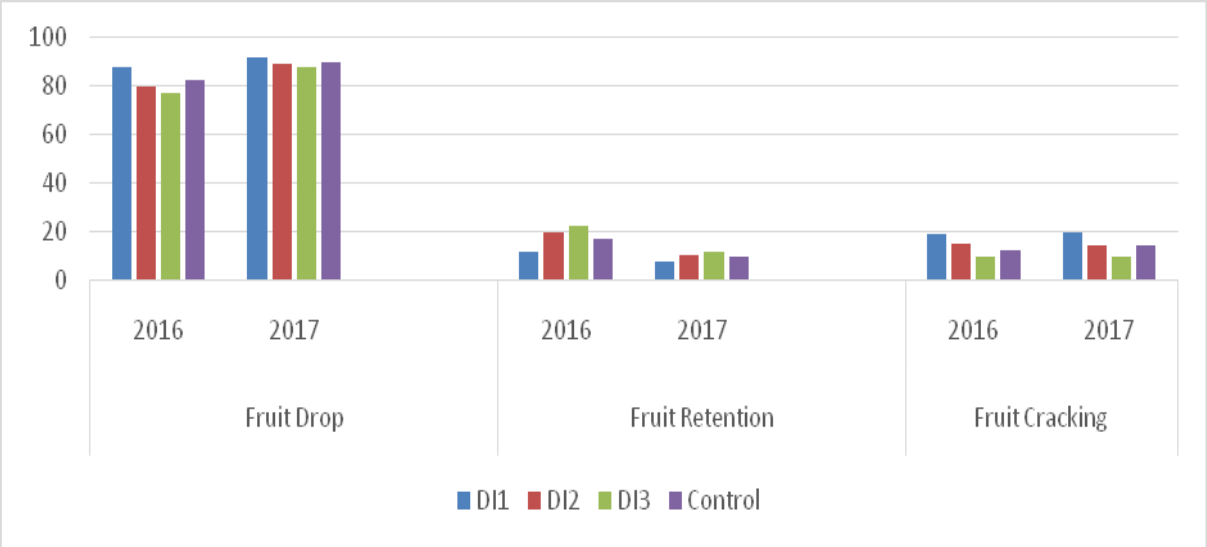


Fig.2 Effect of drip irrigation levels on fruit drop, retention and cracking in litchi *cv*. rose scented



The trees subjected to higher level of drip irrigation in combination with mulching exhibited low fruit drop and higher retention as compared to other treatment combinations and control. The uniform distribution of irrigation water under drip system provides a congenial environment for better absorption and translocation of nutrients which, could have led to better fruit retention percentage under the treatment combinations MDI_3 and MDI_2. In addition to this, better weed control is obtained under the influence of mulch and drip irrigation which might have reduced the competition for soil moisture and nutrients thus, leading to reduced fruit drop and better retention. Similar results were also confirmed by Ghosh and Pal (2010) and Pande *et al.*, (2005). Among the various factors, poor availability of soil moisture mainly attributes to cracking in fruits (Singh and Dwivedi, 2007). This might be the reason that during the present study, the trees under control or without mulch exhibited higher percentage of fruit cracking. Mulching improves the soil moisture and nutrient availability by checking the evaporation losses and controlling the weed growth. These results were in accordance with Joshi *et al.*, (2011) who also found minimum fruit cracking in litchi trees subjected to mulch with drip irrigation at 100 per cent. Likewise, Parvizi *et al.*, (2014) also found that deficit irrigation at 50 per cent crop-evapotranspiration produced highest fruit cracking in pomegranate *cv*. Rabab.

Better nutrient and soil moisture distribution at higher drip irrigation levels in tandem with mulch may be responsible for improved yield performance. On the other hand, the trees subjected to low drip irrigation levels and no-mulch conditions, witnessed heavy fruit drop resulting into lower yields. Similar results were also revealed by Jakhar *et al.*, (2016) Ramniwas*et al.*, (2013); Sadarunnisa *et al.*, (2008); Agrawal and Agrawal (2005) and Shirgure *et al.*, (2003).

Thephysico-chemical attributes of litchi are sensitive to moisture stress. In line with this, the present study also revealed significant differences for fruit weight and size among different treatment combinations. Drip irrigation in association with mulch reduced the water as well as nutrient losses on account of leaching and surface run-off and subsequently augmented their availability and uptake. The application of drip irrigation at higher levels in tandem with mulch

maintained continuous supply of water to the root zone thus, promoting better fruit weight, size and edible portion percentage. Such findings were also confirmed by Kucukyumuk *et al.*, (2012), Ramniwas *et al.*, (2012), Bhanukar *et al.*, (2015) and Singh *et al.*, (2015). Further, the availability of optimum soil temperature, moisture and nutrient supply under MDI_3 might have promoted the enzymatic activity. Improved activity of enzymes may further favour the hydrolysis of metabolites (such as organic acids) resulting into improved T.S.S content. On the other hand; the absence of mulch and prevalence of soil temperature fluctuations and moisture evaporation losses under low drip irrigation level as well as in control could result in poor nutrient uptake and assimilation resulting into lower T.S.S content of fruits. In accordance with these findings, Bhanukar *et al.*, (2015) revealed that mulching contributes to higher T.S.S content in Kinnow fruits. Similar results were also suggested by Iqbal *et al.*, (2015) and Singh *et al.*, (2015).

In conclusion, the present study suggested that application of drip irrigation at 100 % level in combination with mulching can effectively improve the yield and quality in litchi by reducing fruit drop and cracking percentage and augmenting fruit retention. The application of drip irrigation at higher levels in combination with mulching may thus, provide a great potential for favorable yield and quality over conventional irrigation. However, more studies must be conducted in this regard.

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