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Impact of different irrigation techniques and nitrogen regimes on quality parameters of potato (*Solanum tuberosum* L.)

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Abstract
The present study was conducted at Research Cum Instructional Farm, College of Agriculture, IGKV, Raipur (C.G.) during rabi season 2022-23 and 2023-24. The experiment was conducted using variety Kufri Khyati under split plot design with three replications, keeping five irrigation levels *i.e.* I_1: 75% CPE with drip, I_2: 100% CPE with drip, I_3: 125% CPE with drip, I_4: 150% CPE with drip and I_5: Furrow irrigation as a main plot and four nitrogen doses *i.e.* N_1: 90 kg N ha^{-1}, N_2: 120 kg N ha^{-1}, N_3: 150 kg N ha^{-1} and N_4: 180 kg N ha^{-1} as sub plot. The quality parameters like maximum tuber dry matter content (20.82% and 21.09%), haulm dry matter content (18.35% and 19.27%) and total soluble solid (7.23% and 6.86%) were observed higher under treatment I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) as comparison to other treatments. However minimum quality attributes was recorded under combination of furrow irrigation and lowest regimes of nitrogen.

Keywords: Irrigation, nitrogen regimes, quality and potato

Introduction
Potato (*Solanum tuberosum* L.) having probable centre of origin is South America, where it occupies the largest area. Potato is one of the good sources of human nutrition. The 100 gm of fresh potato tubers contain 70 - 80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9% ash (Bist and Sharma, 1997) [2]. Potato also has some medicinal properties, like anti-scorbutic, aperients, diuretic, nervous sedative, stimulant to gout and antispasmodic (Rai and Yadav, 2005) [16].

The irrigation requirement for potato varies according to the plant growth stages. The irrigation must be applied in three critical stages (Stolon formation, tuber formation and tuber development) each one of which influences growth and yield, these three stages are most critical for soil moisture availability.

The potato crop in Chhattisgarh mainly irrigated through furrow irrigation method. It is the most prevalent method of irrigation, although, this method results in considerable loss of water by deep percolation below the root zone besides the conveyance loss during water distribution. Now a days drip irrigation, more popular among the farmers for leading good crop. Effect of drip irrigation in potato crop generally achieves better crop yield with minimum water losses (Gameh *et al*., 2000) [10]. In potato there is 20-30 percent increase in yield and 40-50 percent saving of irrigation water in drip method compared to surface irrigation (Wang *et al.*, 2011) [18]. Proper irrigation scheduling can arrest crop water stress, improve yield, and ensure efficient use of energy and production cost and it is environment friendly (Gogoi *et al.*, 2020) [11].

Nitrogen, Phosphorous and Potassium are considered as the most significant macronutrients for potato crops. Nitrogen is an integral part of purin- pyrimidins which forms RNA and DNA and also being a component of protoplasm enhances chlorophyll synthesis (El-Ghamriny and Saeed, 2007) [9]. Nitrogen is necessary to the potato from germination to maturity. The demand for this nutrient increases rapidly after germination and falls when 75% of the plant growth has completed. Its applications can increase dry matter content and total tuber yield (Belanger *et al.*,

2002) [3]. Nitrogen is essential for amino acid synthesis, protein synthesis, coenzyme synthesis and in nucleic acid formation, which are responsible for cell division and elongation as a result higher vegetative growth obtained (Najm *et al.*, 2013) [15].

Materials and Methods

The experiment was performed under All India Coordinated Research Project on Potato at Research Cum Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G), during rabi season 2022-23 and 2023-24. This experiment was laid out in split plot design with three replications, keeping five irrigation levels *i.e.* I_1: 75% CPE with drip, I_2: 100% CPE with drip, I_3: 125% CPE with drip, I_4: 150% CPE with drip and I_5: Furrow irrigation as a main plot and four nitrogen doses *i.e*. N_1: 90 kg N ha^{-1}, N_2: 120 kg N ha^{-1}, N_3: 150 kg N ha^{-1} and N_4: 180 kg N ha^{-1} as sub plot.

Results and Discussion

The results of trial pertaining to various aspects of quality attributing parameters of potato tubers are summarized as follows:

Tuber dry matter content (%)

Response of irrigation

The results observed non-significant difference among the treatments of different levels and method of irrigation, during the first year and second year while, significant differ in pooled mean. In first year, second year and in pooled mean highest tuber dry matter content (%) was recorded under the treatment I_4 (150% CPE with drip) of (18.46%, 19.03% and 18.75%) followed by I_3 (125% CPE with drip) of (17.90%, 18.24% and 18.07%) respectively. Whereas minimum tuber dry matter content (%) during first year, second year and in pooled mean were observed under I_5 (Furrow irrigation) of (17.34%, 16.88% and 17.11% respectively).

Although the variation in tuber dry matter content (%) among irrigation treatments was not statistically significant, observable trends suggest that levels of drip irrigation I_4 (150% CPE with drip) tended to support higher dry matter accumulation. Chawla *et al.*, (2009) [6] found that maximum tuber dry matter content (%) was recorded under drip irrigation at 1.0 IW/CPE.

Response of nitrogen

The data indicated significant difference among different nitrogen levels during the first year, second year and in pooled mean. In first year, second year and in pooled mean highest tuber dry matter content (%) was recorded under the treatment N_4 (180 kg N ha^{-1}) of (19.37%, 19.22% and 19.29%) followed by N_3 (150 kg N ha^{-1}) of (17.95%, 18.25% and 18.10%) respectively. Whereas minimum tuber dry matter content (%) during first year, second year and in pooled mean were observed under N_1 (90 kg N ha^{-1}) of (16.28%, 16.86% and 16.57% respectively).

The dry matter content of tuber showed a gradual rise in dry matter accumulation of potato with increasing fertilizer dose. It might be good response of fertilizer by crops resulted more vigorous growth *i.e*., higher plant height, number of compound leaves and total number of leaves which may improve photosynthesis activity resulting in produce more photo assimilates and accumulation to the tuber. Zelalem *et al.*, (2009) [19] found that application of 69 kg N ha^{-1}, it gives higher dry matter content (23.68%).

Interaction (Irrigation X Nitrogen)

The results showed the non-significant difference for interactions of irrigation levels and nitrogen doses in the first year, second year and pooled mean. In first year, second year and in pooled mean highest tuber dry matter content (%) was recorded under the treatment I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) of (20.82%, 21.09% and 20.96%) followed by I_3N_4 (125% CPE with drip + 180 kg N ha^{-1}) of (19.48%, 20.19% and 19.83%) respectively. Whereas minimum tuber dry matter content (%) during first year, second year and in pooled mean were observed under I_5N_1 (Furrow irrigation + 90 kg N ha^{-1}) of (16.01%, 16.49% and 16.25% respectively).

Tuber dry matter content is an important indicator of potato quality, particularly for processing and storage. The significant differences observed in the interaction of irrigation and nitrogen levels in pooled data indicate that both factors influence the physiological processes responsible for dry matter accumulation. Maan *et al.*, (2018) [12] investigated that the treatment comprising of different irrigation method (drip and furrow) and doses of nitrogen (60, 80, 100, 120 and 140% of RDN). The maximum value of tuber dry matter (41.71%) was recorded with 100% of RDN and drip irrigation. Singh *et al*., (2021) [17] found that highest tuber dry matter content (%) recorded with the combined application of 1.0 IW/CPE and 75% dose of nitrogen. Akkamis and Caliskan (2023) [14] found highest dry matter content (20.01%) was observed with the application of 33% irrigation and 200 kg ha^{-1} nitrogen.

Haulm dry matter content (%)

Response of irrigation

The results observed non-significant difference among the treatments of different levels and method of irrigation, during the first year and significant difference in second year and in pooled mean. In first year, second year and pooled mean highest haulm dry matter content (%) (17.39%, 18.35% and 17.82%) were recorded with I_4 (150% CPE with drip) followed by I_3 (125% CPE with drip) of (17.29%, 17.58% and 17.48%). Whereas the minimum haulm dry matter content (%) in the first year (15.78%), second year (15.97%) and pooled mean (15.87%) were obtained with I_5 (Furrow irrigation).

The increase in haulm dry matter content under higher irrigation levels with drip I_4 (150% CPE with drip). Leaves are the major site of photosynthesis and influence the weight of shoot plant^{-1}. It was observed that higher number of shoots and compound leaves was achieved with the increase in levels of irrigation resulted highest haulm dry matter content (%). Similar result was found by Chawla *et al.*, (2009) [6], Chandrakar *et al.*, (2013) [7] and Gogoi *et al.*, (2020) [11].

Response of nitrogen

The data indicated non-significant difference among different nitrogen levels during the first year and second year and significant difference in pooled mean. In first year, second year and pooled mean highest haulm dry matter content (%) (17.60%, 18.06% and 17.83%) were recorded with N_4 (180 kg N ha^{-1}) followed by N_3 (150 kg N ha^{-1}) of (16.60%, 17.46% and 17.03%). Whereas the minimum haulm dry matter content (%) in the first year (15.87%), second year (16.31%) and pooled mean (16.09%) were recorded with N_1 (90 kg N ha^{-1}).

The result of present investigation indicated that the higher haulm dry matter content was observed under higher nitrogen doses. It could be sufficient nutrient availability to the soil which

facilitates the plant for their luxuriant growth in terms of higher plant height, number of shoots and number of compound leaves per plant which ultimately increase the haulm dry matter content. Similar, result reported by Zamil *et al.,* (2010) [20] and Banjare *et al.,* (2014) [4].

Interaction (Irrigation X Nitrogen)

The results showed the non-significant difference for interactions of irrigation levels and nitrogen doses in the first year, second year and pooled mean. In first year, second year and pooled mean highest haulm dry matter content (%) (18.35%, 19.27% and 18.81%) were recorded with I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) followed by I_3N_4 (125% CPE with drip + 180 kg N ha^{-1}) of (18.07%, 18.49% and 18.28%). Whereas the minimum haulm dry matter content (%) in the first year (11.58%), second year (13.37%) and pooled mean (12.47%) were recorded with I_5N_1 (Furrow irrigation + 90 kg N ha^{-1}).

The interaction effect between irrigation levels and nitrogen doses on haulm dry matter content was statistically non-significant, the treatment combinations showed consistent trends across years. The highest haulm dry matter accumulation under I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) suggests that higher water availability coupled with sufficient nitrogen promotes vigorous vegetative growth and biomass accumulation. Maan *et al.,* (2018) [12] reported that different irrigation method and doses of nitrogen, result showed that highest haulm dry matter content (%) was recorded with 100% of RDN and drip irrigation.

Total soluble solid (%)

Response of irrigation

The results observed non- significant difference among the treatments of different levels and method of irrigation, during the first year and in pooled mean and significant difference in second year. In first year highest total soluble solid (%) was recorded with the treatment I_1 (75% CPE with drip) of (6.23%) followed by I_3- (125% CPE with drip) (6.02%). In the second year and pooled mean highest total soluble solid (%) were recorded with I_3 (125% CPE with drip) of (5.98% and 6.00%) followed by I_2 (100% CPE with drip) of (5.92% and 5.94%). Whereas the minimum total soluble solid (%) in the first year (5.63%), second year (5.32%) and pooled mean (5.47%) were obtained with I_5 (Furrow irrigation).

The consistently higher TSS recorded with I_3 (125% CPE with drip) may be attributed to mild water stress conditions that enhance the accumulation of total soluble solids in tubers. I_5 (furrow irrigation) resulted in the lowest TSS values, likely due to over-saturation of the root zone, leading to higher water uptake. Under reduced irrigation, the water content in the tuber is lower, potentially leading to a concentration effect of soluble solids and enhanced carbohydrate accumulation. Abdelshafy *et al.,* (2021) [1] reported that highest TSS was obtained by drip irrigation system and the 1.0 CPE irrigation interval treatment.

Response of nitrogen

The data indicated significant difference among different nitrogen levels during the first year and second year and in pooled mean. In first year and pooled mean highest total soluble solid (%) (6.88% and 6.38%) were recorded with N_4- (180 kg N ha^{-1}) followed by N_1 (90 kg N ha^{-1}) of (5.79% and 5.87%). In second year highest total soluble solid (%) (5.96%) were recorded with N_1 (90 kg N ha^{-1}) followed by N_4 (180 kg N ha^{-1}) of (5.89%).Whereas the minimum total soluble solid (%) in the first year (5.56%) was found with N_3 (150 kg N ha^{-1}), while second year and pooled mean were recorded with N_2 (120 kg N ha^{-1}) of (5.38% and 5.48% respectively).

The highest TSS recorded with N_4 (180 kg N ha^{-1}) suggests that adequate nitrogen supply enhances tuber quality by promoting better photosynthesis, assimilate translocation, and carbohydrate accumulation in tubers. Nitrogen enhances leaf area development and enzymatic activity, which are key to increasing carbohydrate synthesis and its conversion to sugars, ultimately leading to higher TSS content in potato tubers. Devi *et al.,* (2023) [8] reported that maximum total soluble solid (6.04%) was recorded with application of 125% NPK as per recommendation while, the minimum was recorded under without NPK (control).

Interaction (Irrigation X Nitrogen)

The results showed the significant difference for interactions of irrigation levels and nitrogen doses in the first year and pooled mean and non-significant difference in second year. In first year, second year and pooled mean highest total soluble solid (%) were recorded with I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) of (7.23%, 6.86% and 7.05%) followed by I_3N_4 (125% CPE with drip + 180 kg N ha^{-1}) of (7.20%, 6.34% and 6.77%). Whereas the minimum total soluble solid (%) in the first year (4.63%) was recorded with I_5N_1 (Furrow irrigation + 90 kg N ha^{-1}) while in second year (4.52%) and pooled mean (5.15%) were recorded with I_5N_2 (Furrow irrigation + 120 kg N ha^{-1}).

The higher TSS under the treatment I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) suggests that high irrigation frequency through drip, combined with higher nitrogen application, may enhance the concentration of soluble solids in potato tubers. The lower TSS values observed under furrow irrigation with lower nitrogen can be attributed to uneven water distribution. Excess water availability under furrow irrigation may lead to vegetative growth at the expense of tuber quality. Mankotia and Sharma (2022) [13] found that yield and quality parameters of potato were highest at 60% drip irrigation cumulative pan evaporation and 75% RDF highest total tuber yield (25.41t ha^{-1}) and total soluble solids (5.4 °brix).

Table 1: Tuber dry matter content (%), haulm dry matter content (%) and total soluble solid (%) of potato as influenced by different irrigation levels and nitrogen doses

Treatments	Tuber dry matter content (%)			Haulm dry matter content (%)			TSS (%)		
	2022-23	2023-24	Pooled Mean	2022-23	2023-24	Pooled Mean	2022-23	2023-24	Pooled Mean
Irrigation levels									
I1- 75% CPE with drip	17.45	17.74	17.60	16.27	16.60	16.44	6.23	5.44	5.83
12- 100% CPE with drip	17.63	17.64	17.64	16.41	17.49	16.95	5.96	5.92	5.94
I3- 125% CPE with drip	17.90	18.24	18.07	17.29	17.58	17.48	6.02	5.98	6.00
I4- 150% CPE with drip	18.46	19.03	18.75	17.39	18.35	17.82	5.95	5.81	5.88
I5- Furrow irrigation	17.34	16.88	17.11	15.78	15.97	15.87	5.63	5.32	5.47
SE (m) +	0.46	0.46	0.24	0.58	0.41	0.39	0.18	0.13	0.13
CD at 5%	NS	NS	0.80	NS	1.35	1.30	NS	0.43	NS
Nitrogen doses									

N1- 90 kg N ha^{-1}	16.28	16.86	16.57	15.87	16.31	16.09	5.79	5.96	5.87
N2- 120 kg N ha^{-1}	17.43	17.30	17.36	16.44	16.96	16.70	5.59	5.38	5.48
N3- 150 kg N ha^{-1}	17.95	18.25	18.10	16.60	17.46	17.03	5.56	5.56	5.56
N4- 180 kg N ha^{-1}	19.37	19.22	19.29	17.60	18.06	17.83	6.88	5.89	6.38
SE (m)	0.35	0.40	0.26	0.45	0.48	0.33	0.19	0.15	0.12
CD at 5%	1.03	1.18	0.75	NS	NS	0.98	0.54	0.46	0.35
Interaction: (Irrigation levels X Nitrogen doses)									
I1N1- 75% CPE with drip + 90 kg N ha^{-1}	16.04	16.63	16.34	15.35	15.37	15.36	5.43	5.80	5.62
I1N2- 75% CPE with drip + 120 kg N ha^{-1}	17.60	17.01	17.30	16.04	16.18	16.11	6.13	5.18	5.66
I1N3- 75% CPE with drip + 150 kg N ha^{-1}	17.84	18.17	18.01	16.54	17.21	16.87	6.17	6.01	6.09
I1N4- 75% CPE with drip + 180 kg N ha^{-1}	18.33	19.16	18.74	17.18	17.64	17.41	7.17	4.78	5.97
I2N1- 100% CPE with drip + 90 kg N ha^{-1}	16.27	16.80	16.54	15.88	16.41	16.14	7.03	6.18	6.60
I2N2- 100% CPE with drip + 120 kg N ha^{-1}	17.34	17.17	17.26	15.91	17.53	16.72	4.80	5.97	5.38
I2N3- 100% CPE with drip + 150 kg N ha^{-1}	17.48	18.23	17.85	16.28	17.95	17.11	5.23	5.70	5.47
I2N4- 100% CPE with drip + 180 kg N ha^{-1}	19.44	18.36	18.90	17.58	18.06	17.82	6.77	5.83	6.30
I3N1- 125% CPE with drip + 90 kg N ha^{-1}	16.80	16.89	16.85	16.52	16.95	16.73	5.67	6.01	5.84
I3N2- 125% CPE with drip + 120 kg N ha^{-1}	17.08	17.26	17.17	17.86	17.28	17.57	5.97	5.89	5.93
I3N3- 125% CPE with drip + 150 kg N ha^{-1}	18.23	18.61	18.42	17.10	17.59	17.34	5.23	5.69	5.46
I3N4- 125% CPE with drip + 180 kg N ha^{-1}	19.48	20.19	19.83	18.07	18.49	18.28	7.20	6.34	6.77
I4N1- 150% CPE with drip + 90 kg N ha^{-1}	16.26	17.50	16.88	16.51	17.67	17.09	6.17	5.82	5.99
I4N2- 150% CPE with drip + 120 kg N ha^{-1}	17.73	18.25	17.99	17.20	18.21	17.71	5.30	5.32	5.31
I4N3- 150% CPE with drip + 150 kg N ha^{-1}	19.04	19.29	19.17	17.11	18.27	17.69	5.10	5.25	5.17
I4N4- 150% CPE with drip + 180 kg N ha^{-1}	20.82	21.09	20.96	18.35	19.27	18.81	7.23	6.86	7.05
I5N1- Furrow irrigation + 90 kg N ha^{-1}	16.01	16.49	16.25	15.09	15.14	15.11	4.63	5.98	5.31
I5N2- Furrow irrigation + 120 kg N ha^{-1}	17.37	16.83	17.10	15.22	15.61	15.41	5.77	4.52	5.15
I5N3- Furrow irrigation + 150 kg N ha^{-1}	17.18	16.92	17.05	15.96	16.28	16.12	6.07	5.15	5.61
I5N4- Furrow irrigation + 180 kg N ha^{-1}	18.80	17.29	18.04	16.84	16.84	16.84	6.03	5.63	5.83
SE (m) + Factor (B) at the same level of A	0.91	0.97	0.48	1.15	0.82	0.78	0.36	0.26	0.26
CD at 5% Factor (B) at the same level of A	NS	NS	NS	NS	NS	NS	1.29	NS	0.81
SE (m) + Factor (A) at the same level of B	0.83	0.91	0.56	1.05	1.02	0.76	0.41	0.32	0.27
CD at 5% Factor (A) at the same level of B	NS	NS	NS	NS	NS	NS	1.24	NS	0.80

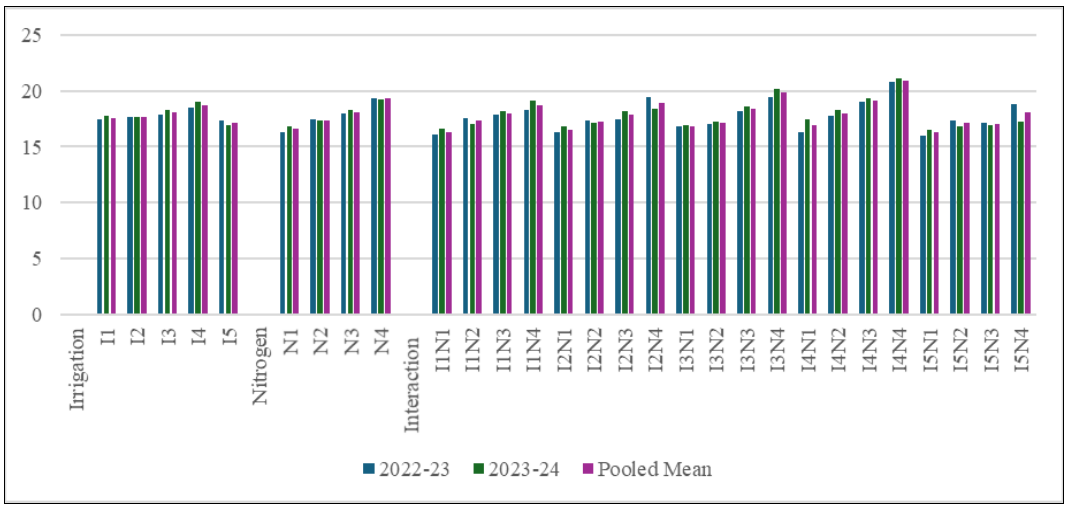

Fig 1: Tuber dry matter content (%) of potato as influenced by different irrigation levels and nitrogen doses and their interactions.

Fig 2: Haulm dry matter content (%) of potato as influenced by different irrigation levels and nitrogen doses and their interactions.

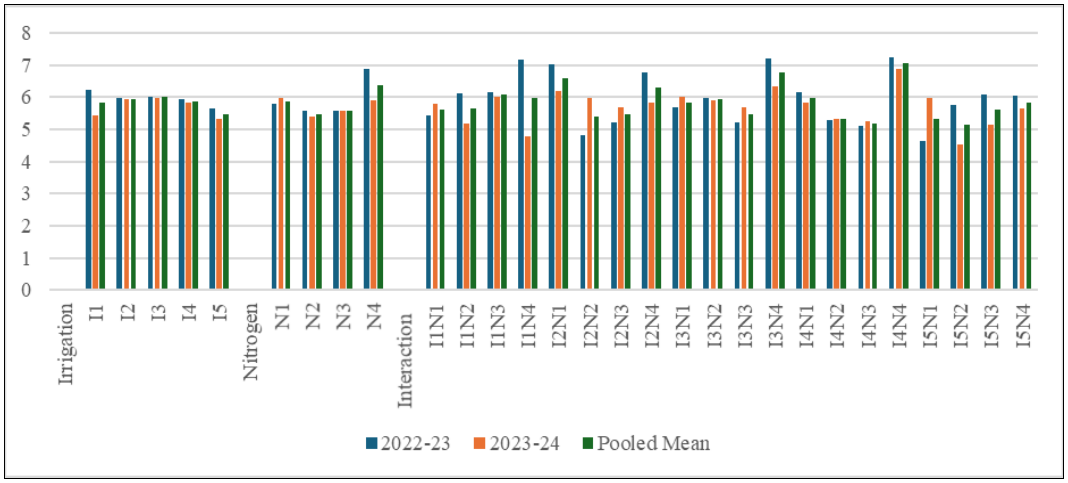

Fig 3: Total soluble solid (%) of potato as influenced by different irrigation levels and nitrogen doses and their interactions.

Conclusion

The following conclusion were presented based on this study, the quality parameters like maximum tuber dry matter content (%), haulm dry matter content (%) and total soluble solid (%) were observed higher under treatment I_4N_4 (150% CPE with drip + 180 kg N ha^{-1}) as comparison to other treatments. So this combination of drip irrigation and nitrogen doses performed better quality characteristics.

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