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Study on Irrigation System and Nutrition Management on Large Cardamom (*Amomum subulatum* Roxb.) in the Darjeeling Hilly Terrain of West Bengal, India

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ABSTRACT

Irrigation and nutrient management are one of the important aspects for sustainable growth and development in case of large cardamom. The accessibility and ideal consumption of restricted water and nutrient determines the sustainable yield production to a great extent. To discourse the delinquent, field experiment was conducted during 2015-2018 in hilly terrain of kalimpong West Bengal, India to evaluate the effect of 3 irrigation frequency I_1 = 1.0 crop evapotranspiration (1.0 ETc), I_2 = 0.75 crop evapotranspiration (0.75 Etc), I_0= Rainfed condition and 4 different nutrient level, N_0 = Control, N_1 = 100% Organic manure, N_2 =50% Organic manure + 50% RDF, N_3 =100% RDF. On growth, yield and economic of Large Cardamom (*Amomum subulatum* Roxb.). The experiment result show that the higher irrigation frequency I_1 = 1.0 crop evapotranspiration (1.0 ETc) and N_3=100% of RDF knowingly upsurges the plant height, number of leaves, number of tillers, spike per bunch, spike per plot, capsule per spike, capsule per plot and fresh and dry yield over other treatments. Well managed irrigation and nutrient (I_1N_3) recorded economically suitable as compare to other treatment with better gross profit, net profit and benefit cost ratio.

Keywords *Amomum subulatum,* Growth, Yield attribute, Large cardamom, Economic analysis.

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INTRODUCTION

Large cardamom (*Amomum subulatum* roxb.) is a perennial herb with subterranean rhizomes with leafy shoots. It is known as one of the oldest spices and also used as Ayurveda preparations (Sharma *et al.* 2000). It is a principal cash crop largely cultivated in Sikkim, Darjeeling and Kalimpong district of West Bengal and some parts of North Eastern states of India (Varadarasan and Biswas 2002). India is largest producer of large cardamom alone contributing 54% share in world production and within India Sikkim

alone contributes about 88% of production (Mande *et al.* 1999). Defective crop management practices generate a huge difference in a production capability of the crop as well as washing out of productive nutrient rich top soil due to erosion and poor crop management directly or indirectly impact on crop as well as in a soil health. Though, the sensibly use of chemical and organic fertilizer is found auspicious for crop establishment. In this perception the field trilled was carried out to study the effect of nutrient management on large cardamom in Darjeeling hilly terrain of West Bengal.

MATERIALS AND METHODS

The field trial was carried out on large cardamom at the experiment site of Gitdubling (lower beyong busty) in Kalimpong Block II under jurisdiction of Darjeeling district in West Bengal during three consecutive years of 2015 to 2018. The soils of experimental site were sandy clay loam with good drainage facility and the climate was sub-tropical to temperate. The popular cultivar, Varlang was used for study.

There were 1_2 treatment comprising 3 irrigation frequency and 4 nutrient level was arranged in split plot design with three replications. The following treatment were used for experiment, level of Irrigation I_0 = Rainfed condition, I_1 = 1.0 crop evapotranspiration (1.0 ETc), I_2 = 0.75 crop evapotranspiration (0.75 Etc). Level of nutritional sources (N), N_0 = Control, N_1 = 100% Organic manure, N_2 = 50% Organic manure + 50% RDF, N_3 =100% RDF. Farmyard manure.

Synthetic fertilizers were incorporated as per the treatment and thoroughly mixed with the soil during pit making 15 days before transplanting of large cardamom seedlings. Pits were left open for enduring for a fortnight and then filled with topsoil mixed with farmyard. Pit making and filling operation completed in the third week of May before the onset of pre-monsoon showers. Chemical fertilizers were applied in several splits' doses. Irrigation of plantation was done with limited water derived from adjoining *jhora* as per need of the crop. Pits of size 30 x 30 x 30 cm were prepared on the contour of the hill at a spacing of 1.5 m × 1.5 m during June 2015 and was harvested during October 2018. Other interculture practices like weeding, thinning, earthing up, mulching measured was carried out uniformly as per the recommended practices. Flowering of cardamom commences in the third year after planting. Flower appears during April and May and the capsules mature in September and October. The experiment was conducted in split plot design and data obtained is analyzed using the software's MS Excel and SAS9.3.

RESULTS AND DISCUSSION

Growth attributes: The effect of irrigation and nutrient management on large cardamom showed that the plant height number of leaves and number of tillers per plant were significantly affected (Table 1). Application of irrigation at higher frequency I_1, irrigation at 1.0 crop evapotranspiration (1.0 ETc) gives maximum plant height, number of tiller and number of leaves which was superior to unirrigated rainfed condition and other level of irrigation. Likewise, application of N_3= 100% RDF registered the maximum plant height number of leaves and number of tillers per plant over control, N_0 = Control, N_1 =100% Organic manure and N_2= 50% Organic manure + 50% RD. Interaction effect showed combination of I_1N_3(Irrigation at an interval of 1.0 ETc and 100% RDF) observed respectively highest value conversely the lowest value was recorded in I_0N_0 controlled nutrient and irrigation.

Yield attribution: The irrigation regimes and nutrient management significantly influences on yield attributing characters of plant viz., number of spikes per bunch, number of spikes per plot, number of capsules per spike and number of capsules per plot (Table 2). As per observation it is clearly reveal that application of different level of nutritional proportion significantly influences in yield attribution. According to data recorded the maximum number of spikes per bunch, number of spikes per plot, number of capsules per spike and number of capsules per plot recorded in N_3=100% RDF. Data presented in table below, clearly showed the significant variation among different combination of irrigation level during whole growing stages respectively, as per observation maximum number of spikes per bunch, number of spikes per plot, number of capsules per spike and number of capsules per plot was recorded at higher frequency I_1, irrigation at 1.0 crop evapotranspiration

Table 1. Effect of different level of nutrient and irrigation on growth attribution of large cardamom. I_1 = 1.0 crop evapotranspiration (1.0 ETc), I_2 = 0.75 crop evapotranspiration (0.75 Etc), I_0= Rainfed condition and level, N_0 = Control, N_1 = 100% Organic manure, N_2 =50% Organic manure + 50% RDF, N_3 =100% RDF.

Treatment	Plant height (m)					Number of leaf plant-					Number of tillers				
	Transp-lanting	365 DAT	730 DAT	1095 DAT	1185 DAT (Harve-sting)	Transp-lanting	365 DAT	730 DAT	1095 DAT	1185 DAT (Harve-sting)	Transp-lanting	365 DAT	730 DAT	1095 DAT	1185 DAT (Harve-sting)
Nutritional levels															
N_0	0.53	1.18	1.49	1.91	1.92	4	5.67	6.78	7.78	8.33	3	6.78	11.56	14.56	15.44
N_1	-	1.19	1.56	2.00	2.00	-	5.67	7.22	8.67	9.11	-	8.00	12.78	15.33	16.89
N_2	-	1.28	1.61	2.06	2.12	-	5.67	7.44	9.00	9.67	-	8.67	13.33	16.33	17.33
N_3	-	1.40	1.66	2.09	2.13	-	6.11	8.00	9.78	10.78	-	9.33	14.78	17.22	18.22
SEm (±)	-	0.03	0.02	0.01	0.01	-	0.06	0.11	0.20	0.09	-	0.29	0.09	0.10	0.12
CD at 5%	-	0.09	0.07	0.04	0.04	-	0.17	0.32	0.61	0.25	-	0.85	0.27	0.30	0.37
Irrigation levels															
I_0	-	0.90	1.24	1.78	1.79	-	5.33	6.33	7.25	7.75	-	7.00	10.75	13.33	14.33
I_1	-	1.53	1.86	2.18	2.23	-	6.25	8.42	10.33	10.92	-	9.25	15.58	17.92	18.83
I_2	-	1.36	1.63	2.08	2.12	-	5.75	7.33	8.83	9.75	-	8.33	13.00	16.33	17.75
SEm (±)	-	0.02	0.02	0.02	0.01	-	0.05	0.17	0.30	0.05	-	0.29	0.08	0.13	0.13
CD at 5%	-	0.08	0.09	0.08	0.03	-	0.19	0.70	1.20	0.19	-	1.18	0.31	0.51	0.51
Interaction effect															
I_0N_0	-	0.77	1.10	1.60	1.60	-	5.00	6.00	6.67	7.00	-	5.00	9.00	12.00	13.00
I_0N_1	-	0.90	1.23	1.73	1.70	-	6.00	7.00	7.67	8.00	-	7.33	11.00	13.00	14.00
I_0N_2	-	0.93	1.30	1.87	1.90	-	5.00	6.00	7.33	8.00	-	7.67	11.00	14.00	15.00
I_0N_3	-	1.00	1.33	1.90	1.97	-	5.33	6.33	7.33	8.00	-	8.00	12.00	14.33	15.33
I_1N_0	-	1.40	1.70	2.10	2.10	-	6.00	7.33	9.00	9.00	-	7.67	14.00	17.00	17.00
I_1N_1	-	1.40	1.93	2.17	2.20	-	6.00	7.67	9.33	10.33	-	8.67	15.33	17.00	18.67
I_1N_2	-	1.60	2.07	2.20	2.27	-	6.00	9.00	10.67	11.00	-	10.00	16.00	18.00	19.00
I_1N_3	-	1.70	1.73	2.27	2.33	-	7.00	9.67	12.33	13.33	-	10.67	17.00	19.67	20.67
I_2N_0	-	1.37	1.67	2.03	2.07	-	6.00	7.00	7.67	9.00	-	7.67	11.67	14.67	16.33
I_2N_1	-	1.27	1.50	2.10	2.10	-	5.00	7.00	9.00	9.00	-	8.00	12.00	16.00	18.00
I_2N_2	-	1.30	1.60	2.10	2.20	-	6.00	7.33	9.00	10.00	-	8.33	13.00	17.00	18.00
I_2N_3	-	1.50	1.77	2.10	2.10		6.00	8.00	9.67	11.00	-	9.33	15.33	17.67	18.67
SEm (±) N × I	-	0.04	0.04	0.04	0.02	-	0.10	0.35	0.60	0.10	-	0.59	0.15	0.26	0.26
CD at 5% N× I	-	0.05	0.13	0.08	0.07	-	0.05	0.13	0.08	0.07	-	N/A	0.51	0.60	0.72

(1.0 ETc). Significant variation was observed among the interaction effects between irrigation level and nutritional sources. As per observation yield of maximum number of spikes per bunch, number of spikes per plot, number of capsules per spike and number of capsules per plot was recorded in I_1N_3 (Irrigation at an interval of 1.0 ETc and 100% RDF) and minimum was observed in I_0N_0 (control plot).

Test weight of fresh and dry capsules of large cardamom (gm): Test weight is an important factor to consider quality and value of crop. It is the weight in gram of 100 capsules of large cardamom but size of capsule may vary from one to another. According to experiment it is clearly revealing that application of different level of nutritional proportion significantly influences the yield in cases of fresh or dry weight (Table 3). As mention in a given table maximum yield of fresh and dry weight was recorded in N_3 (100% RDF) i.e., (573.11g and 98.56 g). While lowest weight was observed (483.89g and 64.33g) in N_0 i.e., in control plot receiving no form of nutrient.

Table 2. Effect of different level of nutrient and irrigation on number of spikes of large cardamom.

Treatment	Number of spikes bunch^{1}	Total number of spikes plot^{1}	Average number of capsule spike^{-1}	Total number of Capsule plot^{1}
Nutritional levels				
N_0	13.67	52.26	7.28	399.11
N_1	15.45	61.73	8.23	519.67
N_2	16.44	65.01	8.60	591.11
N_3	17.71	67.97	9.36	635.00
SEm (±)	0.20	0.45	0.12	4.62
CD at 5%	0.59	1.36	0.35	13.83
Irrigation levels				
I_0	12.78	48.97	6.58	334.08
I_1	17.89	69.30	9.48	675.75
I_2	16.78	66.96	9.06	598.83
SEm (±)	0.28	1.05	0.09	8.69
CD at 5%	1.12	4.25	0.36	35.02
Interaction				
I_0N_0	9.11	31.07	4.87	151.67
I_0N_1	12.45	49.73	6.53	324.67
I_0N_2	13.78	55.07	6.87	377.67
I_0N_3	15.79	60.00	8.03	482.33
I_1N_0	16.00	61.73	8.77	535.67
I_1N_1	17.56	69.73	9.30	652.00
I_1N_2	18.67	72.00	9.73	771.00
I_1N_3	19.33	73.73	10.10	744.33
I_2N_0	15.89	63.97	8.20	510.00
I_2N_1	16.33	65.73	8.87	582.33
I_2N_2	16.89	67.97	9.20	624.67
I_2N_3	18.00	70.17	9.95	678.33
SEm (±)				
N × I	0.56	2.11	0.18	17.37
CD at 5%				
N × I	1.18	2.93	0.64	29.02

Application of different level of irrigation in crop made significant influences test weight. This might be due to the fact that during vegetative to productive period crop received irrigation frequently based on evaporative demand of atmosphere. As per data the highest yield of fresh and dry weight of capsule was recorded (576.75gm and 105.75gm) in I_1 (1.0 ETc) while lowest weight of capsule was observed (432.50 g and 50.42g) in (I_0) receiving no irrigation. Different interaction level among irrigation and nutritional sources showed significant variation with respect to test weight. The highest fresh and dry weight was found in in I_1N_3 (Irrigation at an interval of 1.0 ETc and 100% RDF) i.e., (596.00 gm and 131.67gm). Significantly lowest weight (334.00 gm and 33.67gm) was observed in I_0N_0 (control plot).

Yield of large cardamom fresh and dry weight kg/plot: Yield weight of large cardamom capsule showed significant variation among different levels irrigation levels and nutritional sources as mention in (Table 3). The highest weight of fresh and dry capsule plot^{1} (0.62 kg/plot and 0.26 kg/plot) were obtain from N_3 (100% RDF) which is superior to the remaining. On the contrary, lowest fresh and dry weight (0.34 kg/plot and 0.12kg/plot) were observed in control plot N_0. It is clear from table data that the application of irrigation in different level enhanced the yield. Irrigation at 1.0 ETc (I_1) exhibited the maximum fresh and dry yield attributes (0.61kg/plot and 0.26kg/plot) compare to the remaining two irrigation frequencies. The lowest weight of fresh and dry yield (0.35kg/plot and 0.14kg/plot) was recorded in I_0 no irrigation. The interaction of I_1N_3 (Irrigation at an interval of 1.0 evapotranspiration and 100% RDF) was found superior as a result maximum number of yield was found (0.76 kg/plot and 0.34 kg/plot). The trend was same lowest yield (0.29 kg/plot and 0.34 kg/plot) was registered at I_0N_0 (control plot) respectively.

Yield of large cardamom fresh and dry weight kg/ha: Data present (Table 3) revealed that the highest projected yield of fresh and dry capsule ha^{1} (686.87 kg/ha and 293.15 kg/ha) were obtain from N_3 (100% RDF). On the contrary, lowest projected yield of fresh and dry capsule ha^{1} (381.86kg/ha and 129.52kg/ha) were observed in control plot N_0. Study showed that the application of irrigation in different level enhanced the yield. Irrigation at 1.0 ETc (I_1) exhibited the maximum fresh and dry yield attributes (672.83 kg/ha and 282.03 kg/ha) and the lowest yield of fresh and dry weight (381.16 kg/ha and 129.52 kg/ha) was recorded in I_0. As interaction levels are concerned, significantly difference was observed in case of yield attribution of fresh and dry weight of capsule ha^{1}. The interaction of I_1N_3 (Irrigation at an interval of 1.0 ETc and 100% RDF) was found superior as a result highest projected yield (882.81kg/ha and 387.78 kg/ha). The trend was same lowest yield (317.64 kg/

Table 3. Effect of different level of nutrient and irrigation on yield attribution of large cardamom.

Treatment	Test weight		Weight plot^{-1}		Weight ha^{-1}	
	Fresh weight (g)	Dry weight (g)	Fresh weight (kg plot^{-1})	Dry weight (kg plot^{-1})	Fresh weight of capsule (kg ha^{-1})	Dry weight of capsule (kg ha^{-1})
			Nutritional levels			
N_0	483.89	64.33	0.34	0.12	381.16	129.52
N_1	516.78	79.44	0.44	0.21	491.77	237.03
N_2	527.45	89.56	0.50	0.24	553.82	264.11
N_3	573.11	98.56	0.62	0.26	686.87	293.15
SEm (±)	5.42	0.88	0.00	0.001	3.51	0.95
CD at 5%	16.22	2.65	0.01	0.004	10.50	2.84
			Irrigation levels			
I_0	432.50	50.42	0.35	0.14	388.45	155.98
I_1	576.75	105.75	0.61	0.26	672.83	282.03
I_2	566.67	92.75	0.47	0.23	523.94	254.84
SEm (±)	5.58	0.61	0.00	0.001	3.58	1.45
CD at 5%	22.51	2.45	0.01	0.003	14.42	5.83
			Interaction			
I_0N_0	334.00	33.67	0.29	0.10	317.64	111.97
I_0N_I	416.33	49.33	0.31	0.14	340.40	155.48
I_0N_2	431.67	56.00	0.35	0.15	390.79	167.79
I_0N_3	548.00	62.67	0.45	0.17	504.97	188.68
I_1N_0	563.00	81.67	0.38	0.13	423.21	143.53
I_1N_1	569.00	96.33	0.59	0.24	651.04	273.67
I_1N_2	579.00	113.33	0.66	0.31	734.26	332.15
I_1N_3	596.00	131.67	0.79	0.34	882.81	378.78
I_2N_0	554.67	77.67	0.36	0.12	402.63	133.07
I_2N_1	565.00	92.67	0.44	0.25	483.88	281.94
I_2N_2	571.67	99.33	0.48	0.26	536.41	292.38
I_2N_3	575.33	101.33	0.61	0.28	672.83	311.98
SEm (±)						
N × I	11.17	1.22	0.01	0.002	7.16	2.89
CD at 5%						
N × I	31.22	4.86	0.02	0.007	20.17	5.78

ha and 111.97 kg/ha) was registered at I_0N_0 (control plot) respectively.

Economic analysis: Field experiment study clearly show that the highest gross returns from the sale of produce were under treatment I_1N_3 (Irrigation at 1.0 ETc + 100% RDF) i.e., 2,27,268 Rs ha^{-1}, Minimum gross return was found under rainfed condition with combine treatment with no nutrient supply I_0N_0 with the value 67182 Rs ha^{-1} respectively as it is explane in (Table 4). Highest net return was found at treatment I_1N_3 (1.0 ETc + 100% RDF) as compare to control treatment. (1,48363.5 Rs.ha^{-1}). Lowest net returns were observed under I_0N_0 (rainfed + no nutrient supply) with the value of 26,663 Rs ha^{-1} respectively. Benefit cost ratio was determined to be highest in I1N3 (1.0 ETc + 100% RDF) with the value of Rs. 2.88 respectively, and the minimum was recorded in I_0N_0 (irrigation at 0.75 ETc + no nutrient supply) with the value of 1.19 respectively. The possible reason for higher benefit was due to increase in yield tied with timely irrigation and nutrient application with proper crop management practices. Our findings are in close conformity with the reports of Pandit *et al.* (2017), Gudade *et al.* (2015), Kumar *et al.* (2009) and Lepcha *et al.* (2017) where they reported the effective use of nutrients and moisture for sustainable production of large cardamom.

Table 4. Cost of cultivation and benefit under different irrigation and nutrient level. *Organic manure: FYM= 0.61%N, 0.33%P_2O_5 and 0.78% K_20. *Fertilizer: Urea= 46% N. @ 43.40 kg year^{-1}, Bone meal= 16% P_2O_5 p @187.540 kg year^{-1}and MOP=60 % K_20 @ 66.60 40 kg year^{-1}.

Treatments	Labor for land preparation, seedling cost	Irrigation cost	Nutritional cost	Total Cost of cultivation	Total Yield (kg ha)	Gross return (kg ha)	Net profit (kg ha)	Benefit cost ratio
(I_ON_0)	40546.00	0	0	40546	111.97	67182	26636	1.66
(I_ON_1)	40546.00	0	14250	54796	155.48	93288	38492	1.70
(I_ON_2)	40546.00	0	12304	52850.25	167.79	100674	47823.75	1.90
(I_0N_3)	40546.00	0	10358.5	50904.5	188.68	113208	62303.5	2.22
(I_1N_0)	40546.00	28000	0	68546	143.53	86118	17572	1.26
(I_1N_1)	40546.00	28000	14250	82796	273.67	164202	81406	1.98
(I_1N_2)	40546.00	28000	12304	80850.25	332.15	199290	118439.75	2.46
(I_1N_3)	40546.00	28000	10358.5	78904.5	378.78	227268	148363.5	2.88
(I_2N_0)	40546.00	26750	0	67296	133.07	79842	12546	1.19
(I_2N_1)	40546.00	26750	14250	81546	281.94	169164	87618	2.07
(I_2N_2)	40546.00	26750	12304	79600.25	292.38	175428	95827.75	2.20
(I_2N_3)	40546.00	26750	10358.5	77654.5	311.98	187188	109533.5	2.41

REFERENCE

Gudade BA, Harsha KN, Vijayan AK, Chhetri P, Deka TN, Babu S, Singh R (2015) Effect of *in situ* soil moisture conservation practices on growth of large cardamom (*Amomum subulatum* Roxburgh) under rainfed conditions in North Sikkim, India. *Int J Farm Sci* 5(3): 145-150.

Kumar MD, Devaraju KM, Madaiah D, Shivakumar KV (2009) Effect of integrated nutrient management on yield and nutrient content by cardamom (*Elettaria cardamomum* L. Maton.). *J Agric Sci* 22(5): 1016-1019.

Lepcha R, Ray R, Patra SK, Yonzone R, Bhutia PH, Devi MS (2017) Effects of irrigation and organic manure levels on growth, yield and water use efficiency of large cardamom in Darjeeling. *Green Farm* 8 (2): 417-421.

Mande S, Anil K, Kishore VVN (1999) A study of large cardamom curing chambers in Sikkim. *Biomass Bio-energy.*16:463-473

Pandit TK, Dhiman M, Sarkar RK (2017) Influence of organic and inorganic nutrients on large cardamom (*Amomum sub ulatum* Roxb.) under Darjeeling sub-Himalayan region of West Bengal. *Agric Exten J* 1(3): 107-115.

Sharma E, Sharma R, Singh KK, Sharma G (2000) A boon for mountain populations. Large cardamom farming in the Sikkim Himalaya. *Mount Res Dev* 20 (2): 108-111.

Varadarasan S, Biswas AK (2002) Large Cardamom (*Amomum subulatum* Roxb.). 1st ed, Book, Cardamom pp 31