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Effect on Vegetative Growth and Economic Feasibility of Potato (*Solanum tuberosum* L.) cv. Kufri Bahar through Foliar Spray of Bulk Chlorocholine Chloride (CCC) & Nano CCC

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment consisting 12 treatments having 3 replications was carried out from November (2020-21 & 2021-22) at Rajasthan College of Agriculture, Udaipur (Rajasthan) to asses' economic feasibility of chlorocholine chloride (CCC) and Nano CCC on potato. CCC-CS NFs (0.04, 0.08, 0.12, 0.16 and 0.20% w/v), CCC (0.04, 0.08, 0.16, 0.20% w/v), bulk chitosan (BCH 0.01% w/v) and control (water) were applied through foliar application at tuber initiation at 25th day and tuber bulking at 45thdays. Pooled data of two years showed that CCC-CS NFs (0.20%) got maximum net return (Rs. 267005.90) and maximum leaves/plant followed by 0.16% CCC-CS NFs (386 leaves) as comparative to rest of treatments. Non-significant difference in leaf area was recorded in all concentration of CCC-CS NFs, CCC, BCH and control.

Keywords: Chitosan; chlorocholine chloride; tuber; nanoformulation.

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is the 3rd most important food crops in the world in terms of quantities produced and consumed [1]. Potato was originated and first domesticated at the Andes Mountains of South America. It is conventionally grown during short days and cool season [2]. It requires optimum air temperature (18-25^{o}C) and soil temp (17-19^{o}C) [3]. Potato is an annual, herbaceous and dicotyledonous vegetative propagated; plant can produce 5-20 tubers, which will be genetic clones of the mother seed plant and can also be propagated through botanical seeds known as true potato seeds (TPS). Potato produces flowers and berries that contain 100-400 botanical seeds [4]. Potato is an important crop for starch industry and many processed products are prepared from potato *viz.,* potato chips, french fries, potato flakes and potato starch [5]. India is the second largest producer of potato contributing to 12% of global production with 53.02 million tons from 2.16 million ha area with an average productivity of 24.54 t/ha [6].

In potato tuber formation is a complex process that is result of differentiation of an underground stolon or modified stem into a specialized storage organ tuber. During tuber formation, significant alteration occurs in physiology, hormonal and biochemistry take place [7] along with increase in starch deposition and in percentage of cells mitosis [8]. Earlier findings concluded that direct or indirect involvement of plant growth substances may involve in tuber formation. Several effects of Chlorocholine chloride (CCC) treatment on potato may account for such an improvement of tuber yield which may due to antagonistic behavior of CCC against GA_3 which may inhibit synthesis of GA_3 and promotes tuber formation in potato [9]. First, CCC treatment could depress the growth of stems, leaves and stolons which might be due to gibberellins inhibition, but promote tuber initiation and tuber bulking because of photosynthetic movement towards the roots [10-13]. Hence, CCC has been immensely used in tuber crop and good choice for obtaining higher yields. Moreover, optimization of lower dose of CCC may help overcome this risk and increase yield and quality of tuber crops.

With the advancements in nanotechnology, the application of nano materials has positively responded to increase the crop yield. In this line various agro-chemical including plant growth regulator have been applied through nano-based technology by using chitosan as a base material. Further, plant growth regulators can also be explored through nanotechnology to increase their efficacy with these remarks. The CCC which has been used in many crops for higher yield can also be a potential candidate for novel nano-based formulations [14]. The aim of the proposed study was to see the effect of nanoformulation of CCC on growth and economics of Kufri Bahar cultivar of potato.

2. MATERIALS AND METHODS

This experiment was done at Department of Horticulture, Rajasthan College of Agriculture (RCA), Maharana Pratap University of Agriculture & Technology (MPUAT), Udaipur (Rajasthan) during 2020-21 & 2021-22. Field experiment was laid out in randomized plots (2.1 × 3 m) with five rows with 7 plants. Tubers were sown on ridge and furrow method at spacing 60 × 30 cm. Plants were subjected to fertilizer application, irrigation, weeding, earthing up and plant protection were followed as per standard agronomic practices [15]. Climatic & weather conditions were suitable and clear during crop growth period except some rainy days, which was appropriate for crop growth. CCC-CS NFs (0.04, 0.08, 0.12, 0.16 and 0.20% w/v), CCC (0.04, 0.08, 0.16, 0.20% w/v), bulk chitosan (BCH 0.01% w/v) and control (water) were applied through foliar application at tuber initiation at 25th day and tuber bulking at 45thday. Economic analysis was done as per local market rates of potato & inputs given during crop duration. Leaf number was measured manually and leaf area through leaf area meter. Statistical analysis of both parameters was analyzed by JMP version-12 using Tukey-Kramer HSD test. Significant difference between treatments (p= 0.05) were calculated.

3. RESULTS AND DISCUSSION

Number of leaves per plant was significantly increased in CCC-CS NFs (0.12% to 0.16%) as compared to CCC (0.04%–0.08%), BCH and control. Pooled data of two years showed that 0.20% CCC-CS NFs recorded maximum (386 leaves) followed by 0.16% CCC-CS NFs (373 leaves) as compared to control (334 leaves) (Table 1). Non-significant difference in leaf area was recorded in all concentration of CCC-CS NFs, CCC, BCH and control (Table 2). However, as per pooled data analysis all the concentrations of CCC-CS NFs got maximum net return over the control, BCH and all concentrations of CCC. The maximum net return received in CCC-CS NFs 0.20% (Rs. 267005.90) followed by CCC-CS NFs 0.16% (Rs. 257799.10) while minimum in control (Rs. 170228.30) (Table 2). On the basis of mean value CCC-CS NFs was more effective plant growth inhibitor Application of CCC-CS NFs significantly improved leaf number as compared to control and bulk CCC. According to previous studies CCC treated plants inhibits gibberellin biosynthesis which shortens the internodes which induce more laterals and leaves. Similar, findings have been observed by Sharma et al. [16] in potato, Zheng et al. [17] *Lilium* Oriental hybrids 'Sorbonne' [18-20] *Coleus forskohlii*.

Table 1. Effect of foliar application of CCC-CS NFs on growth parameters of potato *cv.* Kufri Bahar in field condition

Treatment (%)	No. of leaves/plant			Leaf area (cm²)		
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
Control	332.67 ± 6.02^{g}	335.33 ± 6.02^{f}	334.00 ± 3.50^{i}	$18.93 + 0.26^{a}$	$18.94 + 0.26^{a}$	$18.94 + 0.13^{a}$
BCH (0.01)	337.67 ± 5.13^{fg}	336.33 ± 3.05^{ef}	337.00 ± 4.09^{hi}	$19.00+ 0.35^{a}$	$19.23 + 0.33^{a}$	$19.2 + 0.27^{a}$
CCC						
0.04	347.33 ± 3.51^{defg}	349.67 ± 5.03^{cdef}	348.50 ± 3.50^{fg}	$19.00 + 0.25^{a}$	$19.29 + 1.06^{a}$	$19.25 + 0.40^{a}$
0.08	351.66 ± 8.02^{cdef}	355.67 ± 8.14^{cd}	353.67 ± 5.85^{def}	$19.60 + 0.58^{a}$	$19.41 + 0.13^{a}$	$19.50 + 0.35^{a}$
0.12	357.00 ± 5.00^{bcde}	359.67 ± 2.51^{bcd}	358.33 ± 1.25^{cde}	$19.8 + 0.45^{a}$	$19.59 + 0.22^{a}$	$19.64 + 0.20^{a}$
0.16	362.33 ± 4.50^{bcd}	365.67 ± 4.166^{bc}	364.00 ± 0.50^{c}	$19.86 + 1.67^{a}$	$19.74 + 0.06^{a}$	$19.80 + 0.83^{a}$
0.20	366.00 ± 2.64^{bc}	366.00 ± 2.64^{bc}	366.00 ± 1.32^{bc}	$20.08 + 1.60^{a}$	$20.13 + 0.27^{ab}$	$20.10 + 0.85^{a}$
CCC-CS NFs						
0.04	342.33 ± 3.05^{efg}	345.67 ± 3.05^{def}	344.00 ± 2.64^{gh}	$18.99 + 0.20^{a}$	$19.60 + 1.07^{a}$	$19.30 + 0.53^{a}$
0.08	351.33 ± 5.13^{cdef}	352.67 ± 5.13^{cde}	352.00 ± 1.50^{efg}	$19.05 + 1.15^{a}$	$19.68 + 0.42^{a}$	$19.36 + 0.76^{a}$
0.12	361.00 ± 8.00^{bcd}	363.67 ± 7.38^{bc}	362.33 ± 2.75^{cd}	$19.37 + 0.41^{a}$	$19.85 + 0.33^{a}$	$19.61 + 0.17^{a}$
0.16	372.66 ± 4.72^{ab}	374.33 ± 3.51^{ab}	373.50 ± 1.00^{b}	$20.10 + 1.36^{a}$	$20.08 + 0.340^{a}$	$20.09 + 0.51^{a}$
0.20	384.33 ± 7.09^{a}	387.67 ± 10.0^{a}	386.00 ± 4.09^{a}	$20.24 + 0.54^{a}$	$20.29 + 0.35^{a}$	$20.27 + 0.19^{a}$

The growth parameters were recorded at harvest (100 days after emergence). Each value is mean of triplicate and each replicate consisted of 3 samples. 1st foliar spray was done at 25 days after tuber emergence (tuber initiation stage) & 2nd at 45 days after tuber emergence (tuber bulking stage). Mean ± SE followed by same letter is not significantly different at p = 0.05 as determined by Tukey- Kramer HSD. BCH represents bulk chitosan dissolved in 1% acetic acid

Table 2. Effect of foliar application of CCC-CS NFs on economic feasibility of all treatments

Treatment (%)	Yield (Kg/ha)	Gross return (Rs.)	Fixed cost for treatment (Rs.)	Additional cost of foliar spray (Rs.)	Total cost of cultivation (Rs.)	Net return (Rs.)
Control (water)	27304.83	273048.30	100820.00	2000.00	102820.00	170228.30
BCH 0.01	30104.18	301041.80	100820.00	6100.00	106920.00	194121.80
CCC						
0.04	31550.59	315505.90	100820.00	13600.00	114420.00	201085.90
0.08	33032.91	330329.10	100820.00	27200.00	128020.00	202309.10
0.12	34601.35	346013.50	100820.00	40800.00	141620.00	204393.50
0.16	35336.49	353364.90	100820.00	54400.00	155220.00	198144.90
0.20	37074.41	370744.10	100820.00	68000.00	168820.00	201924.10
CCC-CS NFs						
0.04	34013.10	340131.00	100820.00	9700.00	110520.00	229611.00
0.08	35555.36	355553.60	100820.00	19400.00	120220.00	235333.60
0.12	37488.95	374889.50	100820.00	29100.00	129920.00	244969.50
0.16	39741.91	397419.10	100820.00	38800.00	139620.00	257799.10
0.20	41632.59	416325.90	100820.00	48500.00	149320.00	267005.90

Price of produce taken basis on as per rate of horticulture farm and local mandi rate @ Rs.10 kg

4. CONCLUSION

The present investigation concluded that chitosan-based Chlorocholine Chloride nanoformulations (CCC-CS NFs) effected the growth and economical properties of potato cv. Kufri Bahar. Results showed that higher doses of CCC-CS NFs affected the growth as well as output which ultimately lead to more profit. In future multiple trials of these experiment may be evaluated for stable results and other plant growth regulators also be explored in nano form.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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