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The Effect of Cycocel and Different Nitrogen Levels on Performance of Growth, Yield and Quality on Potato (*Solanum tuberosum*) grown under yala season in upcountry of Sri Lanka

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Abstract

Potato (Solanum tuberosum) is a most common edible and starchy vegetable in Sri Lanka. The growth and tuber formation is influenced by Genetic and Environmental factors such as temperature, photoperiod, shade level and light intensity including other factors like nutrients and plant growth regulators, etc. Nitrogen plays an important role in vegetative growth, yield and quality of potato. Cycocel is the one of growth retardants, reduce plant height and increase the number of tuber and yield of Potato. Chlormequat chloride (CCC), also called cycocel, is one of the synthetic growth retardants, it leads to stem elongation and earlier tuberization in potato. An experiment was carried out to find the Effect of cycocel and different levels of nitrogen on growth and yield of potato (Solanum tuberosum). The pot experiment was conducted in poly tunnel at the Agriculture research and Development center, Seetha-eliya, Sri Lanka in Yala season in upcountry of Sri Lanka from June to September 2020. The experimental was arranged in a factorial completely randomized design includes ten treatments and five replicates. The treatments were control (T1), 100Kg N/ha (T2), 150KgN/ha(T3), 200KgN/ha(T4), 250KgN/ha(T5), Cycocel@200ppm+0N(T6), Cycocel @200ppm+100Kg N/ha (T7), Cycocel @200ppm+ 150Kg N/ha (T8), Cycocel @200ppm+200Kg N/ha (T9), Cycoel @200ppm+250Kg N/ha (T10). Urea was used as a nitrogen source and Albert solution was used as fertilizer. The analysis was carried out using the Minitab 17 software to determine significant difference among the treatments. Treatment means were compared using the Tukey's test at the P=0.05 (5%) probability level. The experiment revealed that growth, yield and quality of potato were significantly (P<0.05) influenced by cycocel and different nitrogen level. The cycocel and different levels of nitrogen performed interaction effect on tuber yield. Cycocel had exposed significant difference in various N levels on plant height. This study presumed that cycocel and different levels of nitrogen had presented multifarious effect on potato growth, yield and quality.

Keywords: Cycocel, Growth regulators, Nitrogen, Plant growth retardant, Tuberization.

Introduction

Potatoes (*Solanum tuberosum*) are the edible, starchy vegetable crops. It belongs to Solanaceae family. It is fourth important crop after the rice, maize and wheat based on yield due to the crop's agronomic plasticity[1]. The potato is typically grown in temperate climate zone and does not perform well in heat. Potato contains more calories and good source of carbohydrates, several vitamins and minerals. Potato is the most popular crop of upcountry farmers due to it is high net return. At present potato is cultivated high extent in Nuwara Eliya (up country wet zone) and Badulla district (up country intermediate zone), and lesser extent grown in Jaffna and Puttlam district. Genetic factors, Environmental factors such as temperature, photoperiod, shade level and light density, other factors are nutrition and plant growth regulators are regulating growth and tuber formation of potato[2].

Nitrogen plays an important role in vegetative growth, yield and quality of potato. The time and rate of nitrogen application is critical factor to optimize the potato tuber and yield. The most favorite results are derived from nitrogen as 50-60% applied in planting time and remain in tuber formation time[3]. Root growth was accelerated by quick availability of nitrogen in the soil[4].

Plant growth regulators are natural, or synthetic substances and directly apply to crop to alter some structural process. These alterations modifying hormonal balance and growth leading to increased yield, improved crop quality and facilitating harvesting[5]. Some growth regulators are reducing unwanted longitudinal shoot growth without lowering plant productivity in agronomic and horticultural crops[6]. Those are called growth retardants. Example for growth retardants are AMO1618, Phosphon–D, Chlormequatchloride (CCC), MC and Alar. Among that Chlormequatchloridse (2-chloroethyl trimethyl ammonium chloride) called as cycocel. It is among of reliable and wildly used plant growth retardants on the market nowadays.

They usually bind to the special receivers in plants and induce a series of cell changes affecting initiation or modification of organ or tissue development. Since plant growth retardants are usually modifying their metabolism due to antagonist to gibberellins[7].

Improvement in crop germination and growth realized under cycocel priming was attributed to increase nutrient remobilization through increased physiological activities and also enhanced root proliferation[8]. Cycocel treatment was found increase the thickness of walls and increase the number of vascular bundles. It could be absorbed by roots or stem to achieve higher efficiency, it should be applied to the leaves[9]. It foliar application has been reported to improve growth and yield in numerous crops[10]. The gradual rise in CCC concentrations caused significant reductions in the length of potato plants.

1.5 and 2g/L cycocel treatments increased the activity of enzymatic antioxidants such as superoxide dismutase, peroxidases and catalase in potato leaves. Potato plants sprayed with 250 $mg.L^{-1}$ of cycocel, at 30, 45 and 60 days after planting, had greater tuber yield without affecting their size or sugar and starch content[11]. Foliar spraying of CCC could noticeably decrease GA and abscisic acid (ABA) contents in potato leaves, which in turn increased chlorophyll contents and stimulated photosynthetic rate[12]. In glass house conditions, the major constraints in the productivity of potato mini tuber is excessive growth of haulm at the cost of stolen formation, tuberization & tuber bulking. There are many plant growth regulators (PGRs) especially plant growth retardants are inhibiting excessive growth of vegetative parts of plants including potato[13]. According to these information effect of cycocel and different nitrogen levels on potato plant not have been recorded yet in Sri Lanka. Therefore, this research conducting by analysis effect of cycocel and different nitrogen levels on potato plant. Main purpose of this research is identity the effect of cycocel and different nitrogen levels on performance of growth, yield and quality on potato plant.

Materials and Methods

Experimental Site: The pot experiment was conducted to examine "Effect of cycocel and different levels of nitrogen on growth and yield of potato (*Solanum tuberosum*) grown under Yala season in upcountry of Sri Lanka" in poly tunnel at the Agriculture research and Development center, Seetha-eliya, Sri Lanka from June to September 2020. It is located in the latitude of 60 58'N and the longitude of 800 46'E. It belongs to the agro ecological zone of up-country wet zone in Sri Lanka. The mean annual rainfall ranges from 2000 mm to 2500 mm and temperature varies from 11ºC to 25ºC, Relative humidity is 55% to 95%. The main soil type of this region is red yellow pod regosol.

Experimental design: The experimental was arranged in a factorial completely randomized design includes ten treatments and five replicates. Fifty pots were maintained for this experiment under poly tunnel. The treatments were as follows in Table-1.

Table-1: Description of treatments.

Treatments	Details	Nitrogen (kg/ha)
T1	Without applied nitrogen	0
T2	Albert solution	100
T3	50Kg/ha N of urea + Albert solution	150
T4	100Kg/ha N of urea + Albert solution	200
T5	150Kg/ha N of urea + Albert solution	250
T6	Applied cycocel @150ppm	0
T7	Cycocel @250ppm + Albert solution	100
T8	Cycocel @250ppm + 50Kg/ha N of urea +Albert solution	150
T9	Cycocel @250ppm + 100Kg/ha N of urea +Albert solution	200
T10	Cycocel @250ppm + 150Kg/ha N of urea + Albert solution	250

Albert solution was applied for all treatment except treatment 1 and 6.

Agronomic practices: Pot preparation: Plastic pots which have 14cm in diameter and 20cm in height were used. Each pot was filled by potting media of paddy husk and tea waste at the rate of 3:2. The potting mixture of 1kg was added for each pot in half level of pots.

Planting: Tuber weighing 10-15g of variety 'Granola' were planted on 19th June 2020. Prior to planting tubers were treated with the captain fungicide for the protection against fungal disease of seed potatoes. Tuber were planted at the depth of 3cm by hand.

Fertilizer application: Two days before planting the half rate of urea was incorporated with the potting mixture as basal fertilizer according to treatments. Top dressing was done in three weeks after planting to tuber initiation stage. 100Kg/ha N applied by Albert solution and balance 50Kg/ha, 100Kg/ha, 150Kg/ha N were applied by urea. Albert solution @90ml was applied each week for all treatment expect control (T1 & T6).

Preparation of Albert solution: Albert solution contains 10% of nitrogen. To prepare the 100Kg nitrogen for hectare required Albert was 1000kg (100/10*100 = 1000Kg). For 10 weeks of period needed of albert was 100Kg Albert/ha (1000Kg/10 = 100kg Albert/ha).

My experimental pot area was $0.01767m^2$. So, pot area required amount of Albert was 0.1767g (100Kg/10000ha*0.01767m2 = 0.1767g). Recommended rate of Albert for one liter is 2g. 0.1767g Albert as diluted in 90ml water.

Irrigation: Thrice a day irrigation was done depend upon requirement of crop by using measuring cylinder to maintain optimal moisture for growth. The increase of moisture content was delayed the tuber formation.

Earthing up: After two and three weeks of planting earthing up was done to supported plant growth and tuber initiation.

Pest and disease management: At the time of active growth period, the crop was attacked by white fly and it was controlled by spraying Evisect @ 2g per one liter of water for three times at an interval of 15 days. For protection against the blight disease Tizca @ 1ml per one liter was sprayed three times at an interval of 10 days.

Application of cycocel: The cycocel was purchased in commercial shop. The cycocel @125ppm was applied for to time of period. To obtain the 250ppm cycocel required 0.5ml cycocel was diluted in 2L (For hectare required 350ml of cycocel). For that first application cycocel @125ppm was done at 40 days of after planting and second application (balance 125ppm cycocel) was done in 15days after first application.

Harvesting: The plant was harvested at 75 days after planting. The plants were removed from potting media and tuber potatoes were collected.

Measurements: The Fresh weight of shoot and root, dry weight of shoot and root, number of tuber, tuber yield, marketable tuber number, marketable tuber yield, non-marketable tuber number, non-marketable tuber yield, starch content and specific gravity of tuber were measured at harvesting time.

Data analysis: Collected data were statistically analyzed using the statistical software Minitab 17, and the mean comparison within treatments was performed by Tukey's test at 5% significant level.

Results and Discussion

Fresh weight of shoots (g/plant): The Table-2 described the effect application of cycocel and different nitrogen levels on fresh shoot weight of plant. The effect of nitrogen levels on fresh shoot weight was significantly differences ($P<0.05$). But effect of cycocel application and interaction of cycocel and nitrogen levels was not significant differences ($P>0.05$) on fresh shoot weight.

The fresh shoot weight means ranged from 30.2 to 67.9 g/plant. The greater fresh shoot weight was obtained by application of N 250kg/ha and the lowest fresh shoot weight was obtained by control. The application of cycocel was slightly increased the fresh shoot weight. However, application of cycocel did not show the significant difference on fresh shoot weight.

Table-2: Effect of cycocel and different levels of nitrogen on fresh shoot weight (g/plant).

Nitrogen & CCC	Mean fresh shoot weight
Control	30.2±2.65c
100kg/ha	42.8±2.44b
150kg/ha	58.6±1.83a
200kg/ha	60.3±2.39a
250kg/ha	67.9±3.05a
0ppm	51.7±3.64 a
250ppm	52.2±2.63a
Nitrogen	P<0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

Fresh shoot weight increased with increasing of N levels. It might be due to increasing the vegetative growth by increasing of nitrogen rate. The results are agreement with the findings of to Bhattarai[16] and Malik et al.[17] who reported that fresh shoot weight of foliage increased with the increasing rate of nitrogen. And Sinha[18] found the maximum fresh weight of shoots per plant was recorded with highest nitrogen level 300 kg.

This increase in fresh shoot weight was due to increasing of photosynthetic activity of plant enhance with supply of nitrogen. The similar results found by Singh and Raghar[14] and Haris Wijaya et al.[15] said CCC on fresh shoot not significantly effect.

Dry weight of shoots (g/plant): The interaction of cycocel and different nitrogen levels on dry shoot weight is presented in Table-3. The different levels of nitrogen application significantly affected ($P<0.05$) the dry shoot weight. But the application of cycocel and interaction of cycocel and nitrogen was not significantly varied ($P>0.05$) on dry shoot weight. The mean dry shoot weight varied from 2.9 to 5.8g/plant. The highest shoot dry weight recorded at N application rate 250kg/ha compared with dry shoot weight obtained at N application 0, 100kg/ha, 150kg/ha and 200kg/ha. The lowest dry shoot weight obtained at control. Application of CCC increased the dry weight shoot from 4.2 to 4.3g. However cycocel was not significantly ($P>0.05$) affect the dry tuber weight.

Based on the results 250kg/ha N application as increased the dry shoot weight. It might be due to nitrogen increase the vegetative growth, therefore dry weight of tuber is increasing. The similar results explained by Sekon and Singh[19], who denoted that increase in the dose of nitrogen increasing dry weight of shoots. Das Guptaand Ghosh[20], as well as Kumar et al.[21], found similar results of present study.

Table-3: Effect of cycocel and different levels of nitrogen on dry shoot weight (g/plant).

Nitrogen & CCC	Mean dry shoot weight
Control	2.9±0.24c
100 kg/ha	3.7±0.36bc
150 kg/ha	3.9±3.94bc
200 kg/ha	4.8±0.32ab
250 kg/ha	5.8±0.26a
0ppm	4.2±0.31a
250ppm	4.3±0.23a
Nitrogen	P<0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

Fresh root weight (g/plant): The Table-4 explained the effect of cycocel and different levels of N on fresh root weight. The effect of nitrogen and CCC had significant impact (P<0.05) on fresh root weight. The interaction of N levels and CCC was significantly varied (P<0.05) on fresh root weight. The highest fresh shoot weight recorded at application N rate 250kg/ha. The lowest fresh shoot was recorded at control. The mean fresh root varied from 5.8 to 9.5 g/plant.

Dry root weight (g/plant): The Table-5 explained effect of cycocel and different levels of nitrogen on dry root weight. Different N levels, cycocel and interaction of cycocel and different levels of nitrogen on dry root weight was not significant (P>0.05). The mean dry root varied from to 1.4 to 1.7 g/plant.

The highest dry root weight obtained in rate of 250Kg N/ha. The lowest dry root weight obtained in control (0 N). The similar results finding by Sinha[18], that the high nitrogen levels N/ha recorded highest dry weight of roots than the other levels of nitrogen. However N application was not significant on dry weight of roots.

Table-4: Interaction effect of cycocel and different levels of nitrogen on fresh root weight (g/plant).

Nitrogen(kg/ha)	Application of CCC (ppm)	Mean fresh root weight
Control	0	5.8±0.787b
	250	7.2±0.968a
100	0	7.3±0.435a
	250	7.9±0.375a
150	0	7.5±0.451b
	250	9.2±0.554a
200	0	8.1±0.532b
	250	9.4±0.169a
250	0	8.2±0.412a
	250	9.5±0.888a
P value	Nitrogen	P<0.05
P value	Cycocel	P<0.05
P value	Nitrogen*cycocel	P<0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the nitrogen level not significant different at 0.05 probability level

Table-5: Effect of cycocel and different levels of nitrogen on dry root weight (g/plant).

Nitrogen & CCC	Mean dry root weight
Control	1.4±0.11 a
100	1.4±0.17 a
150	1.5±0.15 a
200	1.6±0.21 a
250	1.7±0.23 a
0ppm	1.5±0.11 a
250ppm	1.6±0.12 a
Nitrogen	P>0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05 probability level.

Number of tuber: The effect of cycocel and different nitrogen levels on total number of tuber per plant described in Table-6.

Different levels of nitrogen application significantly affect (P<0.05) the number of tuber. The effect of CCC on number of tuber was not significant (P>0.05). The interaction effect of CCC and nitrogen on number of tuber was not significant (P>0.05). The N application rate of 250kg/ha had highest tuber number compared with tuber number obtained at N application rate 0, 100kg/ha, 150kg/ha and 200kg/ha. The minimum number of tuber was recorded at without N application rate. The number of tubers increased with increasing nitrogen rates. Application of cycocel increase the number of tubers from 7.3 to 8.6. Thus it did not show significant different (P>0.05) on number of tubers.

According to results clearly identify number of tubers was increased at rate of 250kg/ha it presumed be due nitrogen has a decisive impact on the number of emerging leaves and the rate of leaf expansion, and, therefore, on the canopy development of the plant, it increases the photosynthesis reaction and the partitioning of assimilates by increasing of nitrogen rate stated by Ospina et al.[23]. The proximately relevant results found by Patel and Patel[24] who reported that the increase in nitrogen level up to 250 kg/ha resulted in significant increase in number and fresh weight of tubers per plant.

Table-6: The effect of cycocel and different nitrogen levels on number of tuber/plant.

Nitrogen and CCC	Number of tuber
Control	6.3±0.616b
100kg/ha	7.1±0.586b
150kg/ha	7.7±0.943b
200kg/ha	8.5±0.543ab
0 ppm	7.3±0.409a
250ppm	8.6±0.580a
Nitrogen	P<0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level

Tuber yield (g/plant): The effect of cycocel and different levels of nitrogen on tuber yield is shown in Table-7. The effect of nitrogen and cycocel (CCC) had significant on tuber yield (P<0.05). The interaction of CCC and N on tuber yield was significant (P<0.05). According to results the mean tuber yield values ranged from 33.7 to 119.3 g/pot. The highest tuber yield obtained by highest level of nitrogen rate (250kg N/ha) with CCC application. The lower tuber yield was recorded by control which was not treated with CCC.

At N application rate 100kg N/ha and 200kg N/ha, CCC application significantly increased the tuber yield from 56.1 to 72.8 and from 96.3 to 112.8 respectively. However, CCC application did not increase the tuber yield in other N application rates. According to results clearly observed at application of N 200kg/ha with cycocel increased the tuber yield it might be that the effectiveness of photosynthate translocation depends on the distance between the source and the user, the low height of the plant will shorten the distance between the source and the user thereby increasing photosynthate translocation. This statement supported by Eristo and Ichwan[25]. The similar results found by Anabousi et al.[26] who reported that increasing N application rates up to 250 kg N per ha resulted in significant increases in medium tuber yields. Zebarth et al.[27] reported that increasing rates of N fertilization increased tuber yield. Shukla and Singh[28] who found that the application of 200 Kg N/ha was to be the most effective rate of nitrogen. Ingrodia[29] found that application of CCC (250 and 500ppm) significantly increasing tuber yield over control. Patel et al.[30] who reported that the treatment cycocel@250 ml/L recorded significantly the highest tuber yield CCC reduce the vegetative growth, therefore it increase the reproductive growth.

Table-7: The effect of cycocel and different nitrogen levels mean tuber yield.

Nitrogen (kg/ha)	Application of CCC (ppm)	Mean tuber yield
Control	0	33.7±3.90a
	250	48.9±6.61a
100	0	56.1±4.68 b
	250	72.8±4.16a
150	0	78.67.74a
	250	92.5±5.76a
200	0	93.6±1.08b
	250	112.8±6.34a
250	0	109.2±4.74a
	250	119.3±3.67a
P value	Nitrogen	P<0.05
P value	Cycocel	P<0.05
P value	Nitrogen*cycocel	P<0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the nitrogen levels are not significant different at 0.05probability level.

Gibberell in acid (GA) reduce the tuber growth of root vegetable. The cycocel limits the function of GA, therefore tuber yield is increase by cycocel. Mansuroglu et al.[31] reported that cycocel compounds are able to increase the partitioning of assimilates to yield through the inhibition of gibberellin biosynthesis. It might be the reason for increase the tuber yield by cycocel. At application of 250kg/ha, CCC did not increase the tuber yield. N has a positive impact on photosynthesis efficiency by increasing the interception rate of radiation and photons and, as consequence, on dry matter partitioning to the tubers, tuber bulking and, finally, on tuber yield formation denoted by Mauromicale et al.[32]. It might be increased the tuber yield. CCC might induce higher tuber production by causing an increase in chlorophyll content and photosynthesis Sharama[33].

Marketable tuber number: The Table-8 illustrated the effect of cycocel and different levels of nitrogen on marketable tuber number. Effect of cycocel and nitrogen on marketable tuber number were significant (P<0.05). But the interaction effect of cycocel and nitrogen on marketable tuber number was not significant (P>0.05).

Table-8: Effect of Cycocel and different levels of nitrogen on marketable tuber number.

Nitrogen & Cycocel	Mean marketable tuber number
Control	1.2±0.44d
100kg/ha	3.1±0.433c
150kg/ha	4.4±0.34bc
200kg/ha	5.2±0.442b
250kg/ha	7.3±0.396a
0ppm	3.5±0.45b
250ppm	4.9±0.47a
Nitrogen	P<0.05
Cycocel	P<0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

The N application rate 250kg/ha had highest marketable tuber number compared with marketable tuber number obtained at N application rate 0, 100kg/ha, 150kg/ha, 200kg/ha. The lowest marketable tuber number was recorded from control. The marketable tuber numbers mean ranged from 1.2 to 7.3. The cycocel application was exposed significantly variance on marketable tuber number. Application of CCC increased the marketable tuber numbers from 3.5 to 4.9.

According to the results marketable tuber yield increased with N application rate and 250ppm CCC increased the marketable tuber numbers. It presumed be due to increase of marketable yield due to increased absorption of nutrients which would have increased photosynthetic activity as well as translocation of photosynthesis for formation of tubers. The comparable results obtained by Sharmaetal[34], who reported that cycocel increasing the number of tubers at the rate of application 200ppm, 250ppm and 500ppm. According to Kashid et al.[35] Application of cycocel increased the number of tuber might be retardant applications results in shorter plant height, but is very useful in the efficiency of increasing translocation of photosynthate results to food storage.

Marketable Tuber yield (g/pot): The Table-9 the effect of cycocel and different levels of nitrogen of marketable tuber yield (g/plant). Different levels of nitrogen application significantly affect the marketable tuber yield. The application of cycocel on marketable tuber yield was not significant (P>0.05). The interaction effect of CCC and nitrogen on marketable tuber yield was not significant (P>0.05). Marked variation was observed on marketable tuber yield in between different nitrogen levels. The maximum marketable tuber yield was recorded in rate of 250Kg N/ha (93.2g/pot). The lowest marketable tuber yield was received in rate of control (15.47g/pot). Application of CCC increase the marketable yield from 53.6 to 68.6g.

Based on the results N application of 250kg/ha was obtained highest marketable yield and 250ppm of CCC increased the marketable yield. It might be due to Sharma and Arora[36] who indicated that the increase in the weight of tubers with the supply of fertilizer could be due to more luxurious growth, more foliage and leaf area and higher supply of photosynthetic that helped in producing bigger tubers resulting in higher yields. The similar results supported by Sriom et al.[37]. Zebarth et al.[27] reported that increasing rates of N fertilization increased tuber yield and tuber size. Nitrogen increase the carbohydrate and protein contain of tuber weight. Therefore increase nitrogen is increasing the marketable tuber yield.

The Table-10 revealed the effect of different nitrogen level and cycocel on non- marketable tuber number. The effect of nitrogen, cycocel and interaction effect of cycocel and nitrogen on marketable tuber number were not significant (P>0.05). The mean non marketable tuber numbers ranged from 3 to 5.3.

The highest non marketable tuber number obtained from without application of N (control). The lowest non marketable tuber number obtained from rate of 200kg/ha. It was lesser than application of N 250kg/ha. It might be due high N level increase the vegetative growth. The non-marketable tuber number decrease while increase of N rate. It might be due to availability of nitrogen did not sufficient to increasing the marketable tuber number. CCC increase photoassmilate to the tubers so marketable tuber number increase it presumed non marketable tuber number decreased.

Table-9: Effect on cycocel and different nitrogen levels on marketable tuber yield (g/pot area).

Nitrogen and cycocel	Mean marketable tuber yield
Control	15.5±5.87d
100kg/ha	40.0±5.79c
150kg/ha	64.8±2.92b
200kg/ha	91.9±4.65a
250kg/ha	93.2±5.29a
0ppm	53.6±6.9a
250ppm	68.6±6.48a
Nitrogen	P<0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

Table-10: Effect of cycocel and different nitrogen levels on non-marketable tuber number.

Nitrogen & cycocel	Mean non-marketable tuber number
Control	5.3±1.43a
100kg/ha	4.4±1.85a
150kg/ha	3.5±5.19a
200kg/ha	3.0±3.77a
250kg/ha	3.5±4.80a
0ppm	4.4±2.11a
250ppm	3.5±2.87a
Nitrogen	P>0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

Non-marketable tuber yield (g/pot): The Table-11 described the effect of cycocel and different nitrogen levels on non-marketable tuber yield. Different levels of nitrogen application was significantly affect then on-marketable yield. The CCC did not significant (P>0.05) on non-marketable tuber yield. The interaction effect of CCC and nitrogen on non-marketable was not significant (P>0.05). The minimum on-marketable tuber yield was recorded at N the application rate 200kg/ha (11.2g/plant).

The maximum non marketable tuber yield was obtained from without N application. The same result was explained by Sinha[18] that the highest unmarketable tuber yield was recorded by the lowest levels of nitrogen was compared to the treatment having higher dose of nitrogen. CCC on non-marketable yield was not significant it might be CCC increases the marketable tuber number and yield.

Table-11: Effect on cycocel and different levels of nitrogen on non-marketable tuber yield.

Nitrogen & cycocel	Mean non-marketable tuber yield
Control	25.8±1.43a
100kg/ha	23.89±1.85a
150kg/ha	19.3±5.19ba
200kg/ha	11.2±3.77a
250kg/ha	13.5±4.80a
0ppm	21.1±2.87a
250ppm	16.8±2.11a
Nitrogen	P<0.05
Cycocel	P>0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

Starch Content of potato tuber (%): The Table-12 illustrated the effect of cycocel and different levels of nitrogen on starch content in potato. Application of different levels of nitrogen and cycocel had significantly affect (P<0.05) on starch content of tuber. The interaction of CCC and N on starch content of potato tubers was not significant (P>0.05). The starch content mean value ranged from 8.4-14.5%. The lowest starch content recorded at N application 250kg/ha. Simultaneously highest starch content recorded in control treatment.

Based on the results clearly identify the starch content was decreased by increase application of nitrogen rate. Starch content was estimated through the co-relation with the dry matter content. Therefore starch content decrease with increasing nitrogen rate and increase with dry tuber weight. The similar researchers Sarker and Singh[38] and Lin et al.[39] also found similar results on starch content. As well reported that CCC application is significant effect on starch content. Plant growth retardants are considered as tuberization promoters; in fact, foliar application of CCC increase starch content in potato[40].

Table-12: Effect of cycocel and different levels of nitrogen on starch content of tuber (%).

Nitrogen & CCC	Mean starch content of tuber (%)
Control	14.5±0.706a
100kg/ha	12.3±0.136b
150kg/ha	11.8±0.374bc
200kg/ha	9.5±0.723cd
250kg/ha	8.4±0.483d
0ppm	10.4±0.541b
250ppm	12.0±0.502a
Nitrogen	P<0.05
Cycocel	P<0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatments are not significant different at 0.05probability level.

Specific gravity of Tuber: The effect of cycocel and different levels of nitrogen on specific gravity of tuber is shown in the Table-13. Different levels of nitrogen and cycocel was significantly affecting the specific gravity of tuber. The interaction of cycocel and nitrogen on specific gravity of potato tubers was not significant (P>0.05). Starch content mean value varied from 1.062-1.083.

Table-13: Effect of cycocel and different nitrogen levels on specific gravity of tuber.

Nitrogen & cycocel	Mean of specific gravity
Control	1.083±0.0017a
100kg/ha	1.078±0.0006ab
150kg/ha	1.074±0.0015bc
200kg/ha	1.066±0.0032cd
250kg/ha	1.062±0.025d
0ppm	1.069±0.0016b
250ppm	1.075±0.0023a
Nitrogen	P<0.05
Cycocel	P<0.05

Values represent mean ± standard error (n=5). Means followed by the same letter within the treatment not significant different at 0.05 probability level.

The N application rate 250kg/ha had showed lowest specific gravity compared with other treatments, simultaneously the treatment control had showed highest specific content. The specific gravity of tuber was decreased while increase the nitrogen rate. Lin et al.[39] who reported that the specific gravity is decreasing by increasing rate of nitrogen application. Schippers [40] reported a high correlation between specific gravity in tubers and starch content or dry weight of tuber. It might be reason for increase of specific gravity.

Conclusion

This study reviews that more significant effect of different nitrogen levels and cycocel on potato growth, yield and quality. Potato growth and yield were increased by increasing nitrogen levels and quality was decreased. Cycocel was increased the tuber yield. There was interaction effect on tuber yield and fresh root weight. At application N rate 200Kg/ha, cycocel application increased the marketable yield around 112.8g. Thus highest marketable tuber yield obtained in N rate 250kg/ha. However CCC increases the marketable tuber yield. A present study indicated that the cycocel and different levels of nitrogen influenced on potato growth, yield and quality. This study results will be useful for develop the fertilizer management practice on potato. According to this study nitrogen and cycocel was increased the marketable tuber yield.

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