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Effect of nano-nitrogen, copper and zinc liquid fertilizers on growth, yield and quality of potato (*Solanum tuberosum* L.)

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Abstract
A field experiment was conducted in farmer's field at Madenur village of Hassan district during *Rabi* 2020, to study the "Effect of nano-nitrogen, copper and zinc liquid fertilizers on growth, yield and quality of potato (*Solanum tuberosum* L.)". The experiment was laid out in randomized complete block design comprising ten treatments replicated thrice. The treatment consists of three nano fertilizers *i.e.* nitrogen, copper and zinc liquid fertilizers sprayed either alone or in combinations at 0.4% concentration with and without Recommended Dose of Fertilizers (RDF). The results revealed that significantly higher growth and yield parameters *i.e.* plant height (52.87 cm), number of leaves per plant (107.32), number of tubers per plant (8.62), total tuber yield (28.93 t ha^{-1}) and total dry matter production of potato (5.01 t ha^{-1}) was recorded in treatment T_{10} which received 50% N, 50% Zn and 100% PK application to soil inorganically along with 1st spray of Nano N at 25-30 DAP + 2nd spray of nano Zn after 10-15 days of 1st spray + 3rd spray of nano Cu after 10-15 days of 2nd spray and was on par with treatment RDF (50% N 100% PK) + 2 sprays of Nano Nitrogen (T_7) compared to control (T_1) plot (0% N and Zn, 100% P & K fertilizers).

Keywords: Nano-copper, plant height, tuber yield, starch

1. Introduction
The potato (*Solanum tuberosum* L.) is a starchy tuber and a root vegetable native to the Americas. The plant is a perennial in the night shade family Solanaceae. The vegetative and fruiting parts of the potato contain the toxin solanine which is dangerous for human consumption. Normal potato tubers that have been grown and stored properly produce glycoalkaloids in amounts small enough to be negligible to human health, but, if green sections of the plant are exposed to light, the tuber can accumulate a high enough concentration of glycoalkaloids to affect human health. In 2020, world production of potatoes was 359 million tonnes, led by China with 22 percent of the total. Other major producers were India, Russia, Ukraine and the United States. It remains an essential crop in Europe (especially northern and eastern Europe), where per capita production is still the highest in the world, but the most rapid expansion over the past few decades has occurred in southern and eastern Asia. [1].
There is a big gap among various countries between high and low yields, even with the same variety of potato. Average potato yields in developed economies ranges between 38 and 44 tonnes per hectare. China and India accounted for over a third of world's production in 2010, and had yields of 14.7 and 19.9 tonnes per hectare respectively. The yield gap between farms in developing economies and developed economies represents an opportunity loss of over 400 million tonnes of potato, or an amount greater than 2010 world potato production. Potato crop yields are determined by factors such as the crop breed, seed age and quality, crop management practices and the plant environment. Improvements in one or more of these yield determinants, and a closure of the yield gap, can be a major boost to food supply and farmer incomes in the developing world [2].
The growth and yield of vegetable crops are mainly depending on the quality and quantity of fertilizers used. Loss of mineral nutrients through leaching and runoff to surface and ground water along with abundant volatilization constitute growing concerns owing to economic losses and environmental pollution. The recent use of chemical fertilizers has resulted in many serious, environmental problems such as accumulation of heavy metals in soil and plant systems [3]. Conventional application techniques are resulting in seriously overdosing of chemical fertilizers.

Nanotechnology is a promising field of research which utilizes nano materials of less than 100 nm size, may offer an unprecedented opportunity to develop concentrated sources of plant nutrients having higher-absorption rate, utilization efficacy, and minimum losses. One of the most important uses of nano technology is nano fertilizer, which improves the ability of the plants to absorb nutrients [4].

Nano fertilizers are being prepared by encapsulating plant nutrients into nano materials, employing thin coating of nano materials on plant nutrients, and delivering in the form of nano-sized emulsions. Nano-pores and stomatal openings in plant leaves facilitate nanomaterial uptake and their penetration deep inside leaves leading to higher nutrient use efficiency (NUE). Nano fertilizers have higher transport and delivery of nutrients through plasmodesmata, which are nano sized (50– 60 nm) channels between cells. The higher NUE and significantly lesser nutrient losses of nano fertilizers lead to higher productivity (6– 17%) and nutritional quality of field crops.

2. Material and Methods

A field experiment was conducted in farmer's field at Madenur village of Hassan district near college of agriculture, Karekere, (12.9883635 N 76.2720422 E) during *Rabi* 2020, to study the "Effect of nano-nitrogen, copper and zinc liquid fertilizers on growth, yield and quality of potato (*Solanum tuberosum* L.)". The variety used for the experiment is Kufri Jyothi. The experiment was laid out in randomized complete block design comprising ten treatments replicated thrice. The nano fertilizers used were developed from the IFFCO (Indian farmers fertilizer cooperative) they are, nano-nitrogen, nano-copper and nano-zinc were sprayed at the concentration of o.4% as per the recommendation of IFFCO and the Following are the treatment combinations used in the present study.

2.1 Treatment details

Chart 1: details of treatments imposed

T_1 - Control (0% N and Zn, 100% P & K fertilizers),
T_2 - Control + 2 sprays of water,
T_3 - Control + 2 sprays of Nano Nitrogen @ 0.4%,
T_4 - Control + 2 sprays of Nano Zinc @ 0.4%,
T_5 - Control + 2 sprays of Nano Copper @ 0.4%,
T_6 - RDF (100% NPK and $ZnSO_4$ @ 6 kg ha^{-1}); 125:100:125 NPK kg ha^{-1},
T_7 - RDF (50% N 100% PK) + 2 sprays of Nano Nitrogen,
T_8 - RDF (50% Zn 100% NPK) + 2 sprays of Nano Zinc,
T_9 - RDF + 2 sprays of Nano Copper,
T_{10} - RDF (50% N, 50% Zn & 100% PK) + 1st spray of Nano N at 25-30 DAP + 2nd spray of nano Zn after 10-15 days of 1st spray + 3rd spray of nano Cu after 10-15 days of 2nd spray

Note: Where, RDF was recommended dose of fertilizers (125:100:125 NPK kg ha^{-1}) and 100% P and K is common for all treatment.

The land was brought to a fine tilth through ploughing and tillage. Irrigation channels and bunds were prepared according to layout. The sprouted potato tubers were planted in the field with a spacing of 60 cm row to row and 20 cm plant to plant directly by hand. Light irrigation was given just after planting. Organic manures were applied one week before planting. Full dose of phosphorus, potassium and half dose of nitrogen as per treatments were applied just before planting. The remaining half dose of nitrogen was applied thirty days after planting. First spraying was done 25 days after planting, 2nd spraying at 15 days after 1st spraying and 3rd spraying was done 10 days after 2nd spraying.

All cultural practices were followed regularly during crop growth and observations were recorded on growth parameters *viz*., plant height and number of leaves per plant were recorded at 30, 60 and 90 DAP. The observations on yield parameters *viz*., number of tubers per plant, tuber weight per plant, tuber yield and total dry matter production per plant were recorded at harvest. The total dry matter production and tuber yield of potato were recorded and expressed in tonnes per hectare.

2.2 Statistical Analysis of Data

The comparative study of experimentally collected results was carried out by implementing Fisher's system of measurement of variance as described by Gomez and Gomez (1984) [5]. The significance level ($p<0.05$) used in the 'F' evaluation was offered at 5%. Critical difference (CD) values are presented at a significance level of 5% in the table, wherever the 'F' measure was found to be relevant at 5%.

3. Results and Discussion

It was observed that growth and yield attributing characters like plant height, number of leaves per plant, number of tubers per plant, dry matter production, tuber weight per plant and tuber yield were significantly influenced by different treatments. Application of nutrients through soil application and foliar application in form of nano fertilizers were proved beneficial increasing growth and yield of potato.

3.1 Effect on growth parameters at different stages

3.1.1 Plant height (cm)

Significantly higher plant height was recorded in T_6 (27.13 cm) at 30 DAP which. In case at 60 and 90 DAP, Significantly higher plant height was recorded in T_{10}, throughout the growing period (49.75 cm and 52.87 cm at 60 and 90 DAP, respectively) compared to all other treatments except T_7, T_8, T_6 and T_9 which were found on par and these parameters were recorded lowest in control plot (T_1).

Higher in plant height observed in T_{10} followed by RDF with nano fertilizer treated plots (T_7, T_8, T_6 and T_9) it might be attributed to application of RDF along with application of nitrogen, copper and zinc nano fertilizers. The plant height was found maximum in T_{10} where 50% N, 50% Zn and 100% PK) was applied inorganically to soil along with 1st foliar spray with Nano N, 2nd spray with Nano Zn and 3rd spray with Nano Cu and was significantly differed from control treatment. The plant height was found lowest in T_1. Similar findings related to increase in plant height was reported by Jyothi and Hebsur (2017) [6]. The present findings corroborate with the findings of Abdel wahab *et al.* (2019) [7] in red radish, Ekinci *et al.* (2012) [8] in tomato, Khaveh *et al.* (2015) [9] in corn plant, Tantawy *et al.* (2014) [9] in tomato.

3.1.2 Number of leaves per plant

Significantly higher number of leaves per plant at 30 DAP was recorded in T_6 (35.86). And it is on par with T_9 (34.58) and T_8 (34.38) because at 30 DAP these treatments received equal amount of recommended dose of fertilizers. But in case of 60 and 90 DAP, Significantly higher number of leaves per plant recorded in T_{10} which received 50% N, 50% Zn and 100% PK was applied inorganically to soil along with 1st

spray of Nano Nitrogen at 25-30 DAP, 2nd spray of nano Zinc after 10-15 days of 1st spray and 3rd spray of nano Copper after 10-15 days of 2nd spray, (107.32 and 41.53 at 60 and 90 DAP, respectively). The number of leaves per plant was found lower in T_1, (28.65, 85.81 and 29.73 at 30, 60 and 90 DAP, respectively). However, this treatment was significantly superior over all other treatments at 60 DAP.

Increase in the number of leaves might be attributed to application of recommended dose of fertilizer along with application of first spray of nano nitrogen, second spray of nano zinc and third spray of nano copper liquid fertilizer at early stage of crop development helps in build the leaf number and size of the canopy. The number of leaves and leaf area are vital indicators of photosynthesis due to the existence of chlorophyll. Increases in leaf count indicate a high rate of photosynthesis, and hence, increase in plant growth rate becomes evident. In this study, the concentration dependent increase shows that nitrogen, copper and zinc liquid fertilizers have a positive impact on the number of leaves which resulted in an increase of the rate of photosynthesis. Similar findings by Hafeez *et al.* (2015) [10] showed a positive effect of soil application of CuO NPs on leaf area. The random trend in the leaf count of nano Zinc treated plants might be due to variation in accumulation of this nano particles in the plants. A study by Kisan *et al.* (2015) [11]. reported a concentration-dependent increase in the leaf area due to ZnO NP application. Therefore, the antagonistic action of ZnO and CuO NPs resulted in an increase in the leaf count of *B. nigra*. According to another study on *Pistia stratiotes*, Cu and Zn NP application resulted in an increase in the number of leaves per plant (Olkhovych *et al*., 2016) [12]. In this study, the increase in number of leaves shows that nano nitrogen, copper and zinc have a positive impact on growth and leaf count.

3.1.3 Number of branches per plant

There was a significant difference in the number of branches per plant due to treatments effect of application of nano nitrogen, copper and zinc liquid fertilizer practices at all the growth stages (Table 2).

Significantly higher number of branches per plant at 30 DAP was observed in treatment T_6 (5.08) which received RDF (100% NPK and $ZnSO_4$ @ 6 kg ha^{-1}); 125:100:125 NPK kg ha^{-1}, followed by T_9 (2.64) with RDF + 2 sprays of Nano Copper and T_8 (2.61) with RDF (50% Zn 100% NPK) + 2 sprays of Nano Zinc. However, these treatments were on par with each other. Where, significantly lowest number of branches per plant was recorded in the treatment T_2 which received Control + 2 sprays of water (3.18).

Significantly highest number of branches per plant at 60 and 90 DAP was recorded in T_{10} with RDF (50% Zn, 50% N and 100% PK) + 1st spray of Nano Nitrogen at 25-30 DAP + 2nd spray of nano Zinc after 10-15 days of 1st spray + 3rd spray of nano Copper after 10-15 days of 2nd spray, throughout the growing period (10.4 and 10.55 at 60 and 90 DAP, respectively) over control with 0% N and Zn, 100% P and K fertilizers, (5.5 and 5.83 at 60 and 90 DAP, respectively) and followed by the treatment T_7 with RDF (50% N 100% PK) + 2 sprays of Nano Nitrogen, (9.22 and 9.45 at 60 and 90 DAP and they are significantly superior over the control in the number of branches per plant. This might be due to combined application of nano nitrogen, zinc and copper liquid fertilizers as foliar spray which enhanced the vegetative growth and development of potato plants.

Among the treatments which received nano fertilizer along with RDF would have facilitated in mineralization of nutrients for uptake by potato plant there by increasing in the number of branches of potato crop. Nano fertilizers are formed to release to on demand and helps in regulating the plant growth with help of several enzymes released from organic source and contributing to RNA synthesis which improves the photo systems making the plant to observe and assimilate more amount of nutrients resulting in significant increase in number of branches compare to control. These results are in agreement with the findings of Sheykhbaglou *et al*. (2010) [13], DeRosa *et al.* (2010) [14] and Nair *et al.* (2010) [15].

3.1.4 Days taken for 50% flowering.

There was no significant difference in the days taken for 50% flowering due to treatments effect of application of nano nitrogen, copper and zinc liquid fertilizer practices (Table 2). The shorter number of days taken for 50% flowering observed in treatment T_{10} (51 days) followed by the treatment T_7 with RDF (50% N 100% PK) + 2 sprays of Nano Nitrogen, (52.33 days) and T_9 with RDF + 2 sprays of Nano Copper, (53 days). However, a greater number of days taken for 50 percent flowering was recorded in control (55.33 days).

The combined application of nano nitrogen, zinc and copper liquid fertilizers at 0.4% concentration reduced the time required by the potato plant to attain 50% flowering stage. This result is in line with the findings of Laware and Raskar (2014) [16] and Shukla *et al.* (2017) [17].

3.2 Effect on yield parameters at harvest

3.2.1 Number of tubers per plant

The number of tubers per plant differed significantly among the different treatments imposed. The treatment T_{10} which received 50% N, 50% Zn and 100% PK was applied to soil inorganically along with the application of 1st spray of Nano Nitrogen, 2nd spray of nano Zinc and 3rd spray of nano Copper, showed significantly highest (8.62) number of tubers per plant, which was found superior over all other treatments except T_7 (7.73) which was found on par. Significantly lowest number tuber per plant was recorded in control (4.46).

Increased number tubers per plant might be due to combined application of nano nitrogen, zinc and copper liquid fertilizers as foliar spray at 0.4 percent and the presence of zinc stimulates plant growth by activating the synthesis of tryptophan, the precursor of IAA. Researchers (Harish and Gowda, 2017; El Metwally *et al*., 2018) [18, 19] made a similar observation.

3.2.2 Total tuber yield (t ha^{-1})

Significantly highest tuber yield (28.93 t ha^{-1}) was recorded in treatment T_{10}, which was superior over all other treatment except T_7 (27.85 t ha^{-1}) and T_8 (26.70 t ha^{-1}). However, these treatments found on par. Among the treatments, lowest tuber yield (18.61 t ha^{-1}) was found in T_1.

Higher tuber yield due foliar application of nano nitrogen, copper and zinc liquid fertilizers on potato was mainly due to better supply of nutrients to the target area where in higher concentration of nutrients in the form of nano particles would have enter through the stomata or vascular systems helping higher metabolic activities leading to higher tuber yield. The present finding is in accordance with same type of results obtained by (Khaveh *et al*., 2015) [20]. they revealed that the high concentration of nano fertilizer led to increased yield of

corn Wang *et al*. 2001 reported that nano preparation coated nitrogen fertilizer increased the yield of rice. Zareabyanel *et al*. 2015 [21]. reported that the treatment of nano-nitrogen chelates, sulphur coated nano-nitrogen chelate, sulphur coated urea fertilizers led to increased potato yield by 56.10, 59.61, 49.76% respectively compared to urea application. Similar findings were also reported by, Khanm *et al*. (2017) [22]. in tomato, Jyothi and Hebsur (2017) [6] in cereals, Davarpanah *et al*. (2017) [23] in pomegranate, Gajc-wolska *et al*. (2018) [24] in sweet pepper, Rathnayaka *et al*. (2018) [25] in rice and Meghany *et al*. (2019) [26] in cucumber.

3.2.3 Total dry matter production (t ha^{-1})

Significantly highest total dry matter production was recorded in T_{10} (5.01 t ha^{-1}), it was found superior over all other treatments except T_7 (4.75 t ha^{-1}), However, these treatments found on par. Significantly lower total dry matter production was recorded in treatment T_2 (3.22 t ha^{-1}) and it was found on par with T_1 (3.25 t ha^{-1}).

Nano fertilizers have properties effectively to release nutrients and chemical fertilizers on demand that regulate plant growth and enhance target activity (Nair *et al*. 2010) [27]. Manikandan and Subramanian (2015) [28] recorded that highest dry matter yield obtained from nanozeourea treated soil may be attributed to the increased N availability due to reduced ammonia loss. Sheykhbaglou *et al*. (2010) [13] reported that nano fertilizers increased pod and leaf dry weight and yield of soybean. Their results were in general agreement with ours and in line with our results.

3.3 Potato quality parameters

3.3.1 Starch content (%)

The starch contents significantly differed due to application of nano nitrogen, copper and zinc liquid fertilizers on potato (Table 1). Significantly higher starch content was recorded in the treatment T_{10} (73.27%) followed by treatment T_7 (71.02%) over the control treatment T_1 (64.83%). However, the starch content recorded in treatment T_{10} and T_7 were on par with the treatment T_8 (69.12%) and T_9 (68.27%).

Potato tubers are usually characterized by high dry matter content and starch as their main constituent (Wien., 1997) [29]. The superiority of nano fertilizers is attributed to the traditional because it has a high surface area and a slow release that helps in the speed of absorption of nutrients, speed of penetration, representation and movement. This leads to an increase in the speed of growth and increase the quality of protein and starch by activating and synthesizing the process of photosynthesis (Lal., 2008) [30].

3.3.2 Total soluble sugars (Brix)

TSS levels in potato tubers after harvesting showed that they were non-significant (Table 1). The higher TSS content was recorded in the treatment T_7 (6.65 Brix °) followed by the treatment T_6 (6.57 Brix °) over control treatment T_1 (6.23 Brix °). The lower TSS of tuber was observed in the treatment T_2 which received Control + 2 sprays of water (6.17 Brix °).

Increase in TSS due to application nitrogen to soil as recommended dose as well as plant by foliar application of nano fertilizers showed the higher TSS content. This is in line with results in mango (Sarker and Rahim., 2013) [31] and persimmon (Choi *et al*. 2013) [32]. In pomegranate, soil application of N has been reported to increase significantly TSS. It seems that when foliar nutritionals were used, the photosynthetic activity was stimulated, leading to enhancement of chemical constituents as crude protein, starch, carbohydrate, L-ascorbic acid and T.S.S in shoots of potato (Ibrahim and Mohamed., 2012) [33].

3.3.3 Reducing and Non reducing sugar (%)

The effects of nano nitrogen, copper, and zinc liquid fertilisers on reducing sugar content of potato were found to be significant. (Table 1). Significantly higher reducing sugar content (0.23%) was measured for the treatment T_{10} followed by T_7 (0.21%). However, these treatments were at par each other in reducing sugar content. The lower reducing sugar of potato recorded in the treatment T_1 (0.10%). With respect to non-reducing sugar which was found significant. The maximum amount of sugar observed in the treatment T_{10} (1.95%), which is statistically similar with T_9 and T_8 (1.95) and lower non reducing sugar was observed in the treatment T_1 which was received Control (0% N and Zn, 100% P and K fertilizers).

Results clearly indicate an increase and build-up of stored starch during application of nano fertilizers. These results are in agreement with those obtained by Mokrani *et al*. (2018) [34] who reported that potato accumulated low amount of sucrose and starch under the excess regime in tubers, the levels of reducing sugars and starch in spunta leaves.

Table 1: Effect of Nano nitrogen, copper and zinc liquid fertilizers on plant height (cm) and number of leaves per plant at different growth stages of potato.

Treatments	Plant height (cm)			Number of leaves per plant		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T_1	22.89	39.78	42.44	28.65	85.81	29.73
T_2	23.33	39.93	43.06	30.72	86.80	36.49
T_3	23.27	43.07	47.01	31.60	92.60	35.50
T_4	22.91	41.43	45.87	30.97	87.24	36.93
T_5	23.51	40.65	44.48	29.28	86.86	35.70
T_6	27.13	45.02	48.48	35.86	94.06	40.76
T_7	25.43	48.25	50.58	32.89	102.80	38.45
T_8	26.50	45.08	48.66	34.38	94.83	37.16
T_9	26.38	44.56	48.05	34.58	94.93	37.86
T_{10}	25.13	49.75	52.87	32.56	107.32	41.53
S. Em ±	1.05	1.92	1.88	1.33	1.877	1.79
CD @ 5%	3.12	5.71	5.59	3.94	5.577	5.32

Table 2: Effect of Nano nitrogen, copper and zinc liquid fertilizers on plant height (cm) and number of branches per plant and Days taken for 50% flowering at different growth stages of potato.

Treatments	Number of branches plant^{-1}			Days taken for 50% flowering
	30 DAP	60 DAP	90 DAP	
T_1	3.20	5.5	5.83	55.33
T_2	3.18	5.21	5.74	55.00
T_3	3.27	7.43	7.84	53.33
T_4	3.17	6.82	7.23	54.00
T_5	3.20	6.76	6.84	53.66
T_6	5.08	7.64	7.81	54.00
T_7	4.53	9.22	9.45	52.33
T_8	4.73	7.83	8.07	53.66
T_9	4.75	7.91	8.12	53.00
T_{10}	4.44	10.40	10.55	51.00
S. Em ±	0.46	0.32	0.28	0.88
CD @ 5%	1.37	0.98	0.84	NS

Table 3: Effect of Nano nitrogen, copper and zinc liquid fertilizers on number of tubers per plant, total tuber yield (t ha^{-1}) and dry matter production (t ha^{-1}) of potato at harvest.

Treatments	Number of tubers per plant	Tuber yield (t ha^{-1})	Total dry matter production (t ha^{-1})
T_1	4.46	18.61	3.25
T_2	5.00	18.81	3.22
T_3	5.13	23.07	3.93
T_4	4.73	22.62	3.70
T_5	4.93	20.34	3.58
T_6	5.46	25.62	4.24
T_7	7.73	27.85	4.75
T_8	5.64	26.70	4.43
T_9	5.76	26.55	4.35
T_{10}	8.62	28.93	5.01
S. Em ±	0.48	1.22	0.98
CD @ 5%	1.44	3.63	0.30

Table 4: Effect of nano nitrogen, copper and zinc liquid fertilizers on yield parameters of potato.

Treatments	Biological yield (t ha^{-1})	Economical yield (t ha^{-1})
T_1	3.25	18.61
T_2	3.22	18.81
T_3	3.93	23.07
T_4	3.70	22.62
T_5	3.58	20.34
T_6	4.24	25.62
T_7	4.75	27.85
T_8	4.43	26.70
T_9	4.35	26.55
T_{10}	5.01	28.93
S. Em ±	0.98	1.22
CD @ 5%	0.30	3.63

Table 5: Effect of nano nitrogen, copper and zinc liquid fertilizers on quality parameters of potato.

Treatments	TSS (Brix°)	Reducing sugar (%)	Non reducing sugar
T_1	6.23	0.10	1.39
T_2	6.17	0.11	1.42
T_3	6.30	0.14	1.70
T_4	6.20	0.12	1.64
T_5	6.41	0.11	1.62
T_6	6.57	0.16	1.87
T_7	6.65	0.21	1.94
T_8	6.50	0.18	1.95
T_9	6.43	0.17	1.95
T_{10}	6.47	0.23	1.95
S. Em ±	0.30	0.01	0.09
CD @ 5%	NS	0.03	0.27

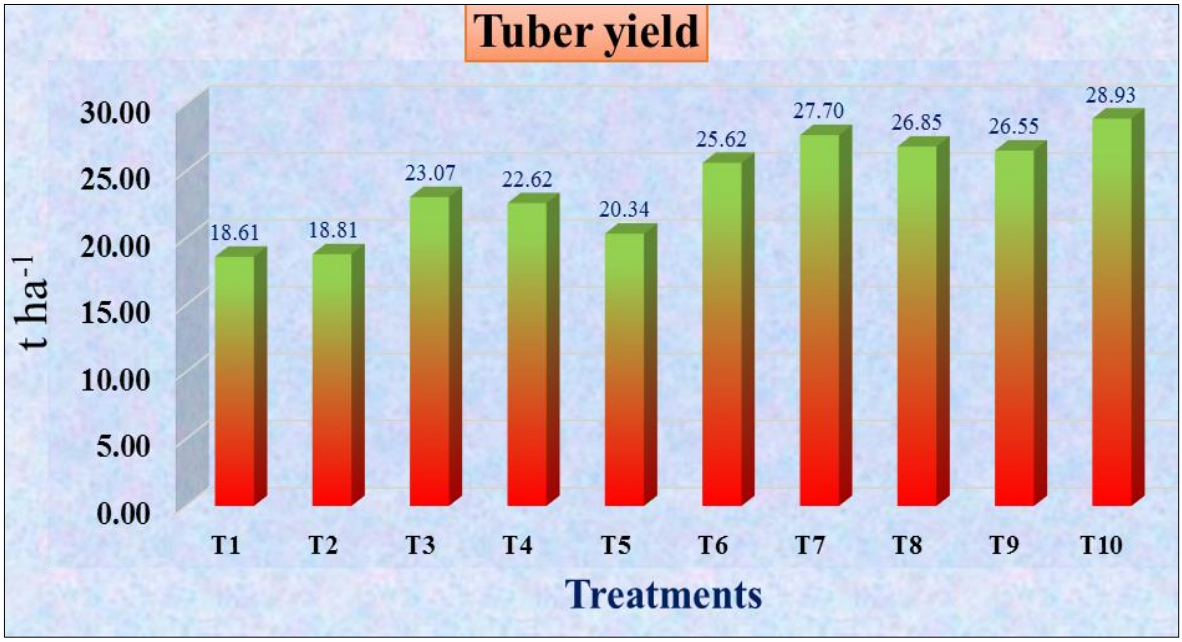

Fig 1: Effect of Nano nitrogen, copper and zinc liquid fertilizers on economical tuber yield (t ha^{-1}) of potato after harvest

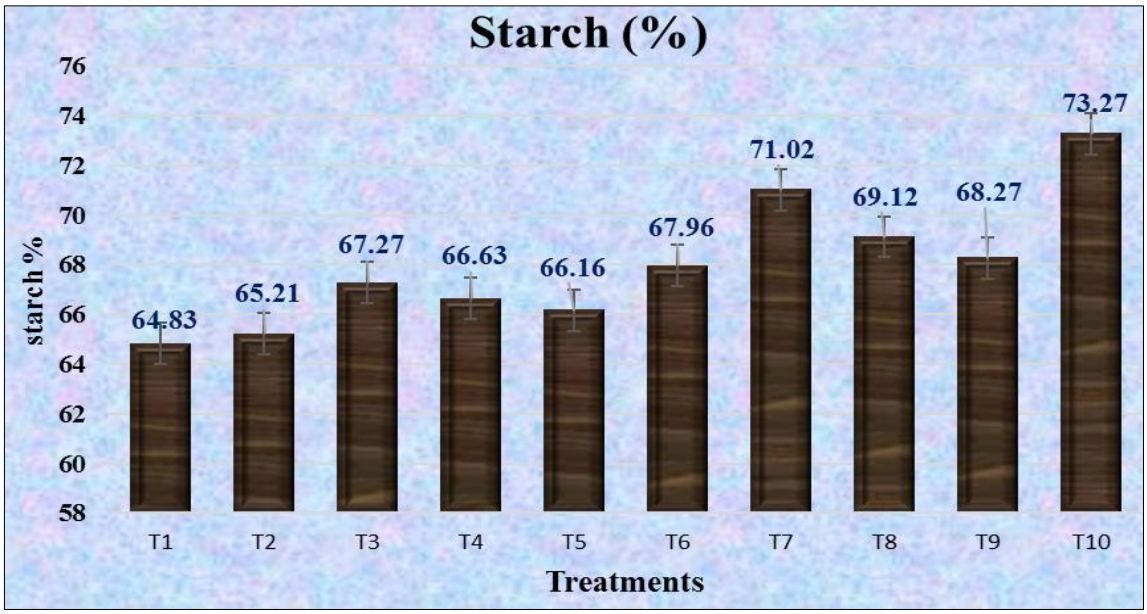

Fig 2: Effect of Nano nitrogen, copper and zinc liquid fertilizers on Starch (%) content of potato after harvest

4. Conclusion

Based on the experiment conducted and results obtained it is concluded that, combined application of nano nitrogen, copper and zinc liquid fertilizers shows increased growth and yield paraments of the potato crop and also improved the uptake of that particular nutrient. It is also concluded that IFFCO nano fertilizers in general, and Nano-N in particular, will successfully help in reducing the consumption of urea to 50% by applying 2 sprays of Nano-N. Other products *viz.*, Nano-Zinc and Nano-Copper would show their effectiveness depending upon the magnitude of deficiencies of these nutrients in soils. As Nitrogen deficiency in Indian soils is universal and so is the response to applied nano-Nitrogen. The Government policy and support to promote IFFCO nano fertilizers will transform Indian agriculture and help in maintaining the sustainability of Indian agriculture.

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