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Gopika KT
Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University, Thrissur, Kerala, India

Dr. Sheeba Rebecca Isaac
Regional Agricultural Research Station, Kumarakom, Kottayam. Kerala Agricultural University, Thrissur, Kerala, India

Dr. Shalini Pillai P
Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University, Thrissur, Kerala, India

Dr. Usha C Thomas
Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University, Thrissur, Kerala, India

Dr. Sreelatha AK
Department of Soil Science and Agricultural Chemistry, Rice Research Station Vytilla, Ernakulam. Kerala Agricultural University, Thrissur, Kerala, India

Corresponding Author:
Gopika KT
Department of Agronomy, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University, Thrissur, Kerala, India

Yield and quality in Chinese potato as influenced by reduced tillage and nano nitrogen fertilization

Gopika KT, Dr. Sheeba Rebecca Isaac, Dr. Shalini Pillai P, Dr. Usha C Thomas and Dr. Sreelatha AK

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Abstract
The field experiment to assess the influence of tillage practices and nano nitrogen on the yield and quality in Chinese potato was conducted at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University in 2022-23. The experiment was laid out in split plot design with three replications. The main plot treatments included conventional tillage, reduced tillage (RT) with surface incorporation of green manure cowpea and RT with surface retention of green manure cowpea and the sub plot treatments, different doses of nitrogen along with foliar spray of nano urea at 0.4 percent concentration. The results revealed the significant influence of reduced tillage and nano urea individually on tuber yield while among the combinations, RT + *in situ* green manuring and nano urea spray + RDF was found to yield comparatively better. Nano urea application significantly improved the quality attributes, starch, vitamin C and protein contents while significant variations with tillage methods were evident in vitamin C and protein Content alone.

Keywords: Conservation tillage, reduced tillage, green manure, nano urea, Chinese potato

Introduction
Tuber crops, the third most important food crop after cereals and pulses feed nearly twenty percent of the global population [1]. Chinese potato [*Plectranthus rotundifolius* (Poir.) Spreng.], a minor tuber crop, is rich in dietary fibre, vitamins, starch, minerals and anti oxidants. The crop is primarily grown in the regions of Kerala, Karnataka and Tirunelveli district of Tamil Nadu. As in all tuber crops, the primary economic activity of Chinese potato takes place beneath the soil surface and hence, adoption of conservation agriculture practices can have a favourable influence on both, above and below -ground growth and thus tuberization.
Conservation tillage (CT) combined with effective management inputs facilitates reduced green house gas emissions and enhances C sequestration in the soil- plant system. Reduced tillage (RT), a form of CT, aims to minimize soil disruption, promote soil health, mitigate erosion and decrease environmental harm and when combined with green manuring, functions as a means to sequester C in the soil, act as a C sink and improve soil nutrient availability [2].
Proper nutrient management is essential for enhancing the quality and productivity of crops. Nano nutrition is presently boosted as a suitable technology for enhanced nutrient use efficiency and lowered environmental pollution. In this context, the nano N fertilizer, nano urea, developed by the Indian Farmers Fertilizer Cooperative Limited (IFFCO), assumes significance as an alternative for conventional urea, that fulfills N needs of the crop, particularly during critical growth phases [3]. Foliar application of nano urea facilitates effective absorption and penetration of N into the leaves. The low quantum requirements and the gradual release of nutrients reduce environmental wastage also. Chinese potato is a short Statured, shallow rooted crop and provides an adequate ground cover at its active growth stage making it amenable for reduced tillage practices and foliar nutrition. Keeping this in view, an experiment was attempted to assess the influence of CT and nano N on the quality of Chinese potato tubers.

Materials and Methods

The field experiment was conducted at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University in 2022-23. The site enjoys a warm humid tropical climate, and during the cropping period received a total rainfall of 42.60 mm. The maximum temperature ranged from of 31oC to 34oC and the minimum temperature, 18oC to 24oC. Based on USDA taxonomic system, the soil was classified as sandy clay loam in texture and was medium in organic C (1.05%), available N (300.70 kg ha^{-1}) and available K (192.64 kg ha^{-1}), and high in available P (38.67 kg ha^{-1}).

The experiment was laid out in split plot design with three levels of tillage as main plot treatments [conventional tillage (c1), RT+ surface incorporation of GM cowpea (c2) and RT + surface retention of GM cowpea (c3)] and four levels of N management [100% RDN+ nano urea (n1), 75% RDN + nano urea (n2), 50% RDN + nano urea (n3) and 100% recommended dose of fertilizers (RDF)] as sub plot treatments, replicated thrice. In RT, after initial basal ploughing, the secondary ploughing was done in the row zone alone. The cowpea variety Aiswarya was planted in conservation tilled plots as green manure crop @ 20 kg seeds ha^{-1}, during the first week of December 2022. At flowering stage, the cowpea plants were incorporated/ retained as surface mulch as per treatments. Stem cuttings of Chinese potato variety Suphala were planted in the field two weeks after green manure application at a spacing of 30 cm x 15 cm.

Foliar spray of nano urea @ 4 mL L-1 was given twice, at 20 and 40 DAP. Nitrogen, P_2O_5 and K_2O @ 60:60:100 ka ha^{-1} formed the recommended dose of nutrients with the entire dose of P applied as basal, and N and K_2O, in two equal splits, basal and 45 days after planting (DAP). Crop was harvested at 140 DAP, yields recorded and nutrient content (N, P and K), quality attributes (starch, protein and vitamin C) in tubers were analysed following standard procedures: N (microkjeldahl method), P (single acid digestion and spectroscopy using barton reagent), K (single acid digestion and flame photometry), starch (titrimetric method), crude protein (N content in tuber estimated by microkjeldahl method multiplied with a factor of 6.25), vitamin C (volumetric method using 2,5-dichlorophenol indophenol dye). The tubers were graded based on individual weight into marketable (>5g) and less marketable (<5g) and the former was weighed separately to compute percentage of marketable tuber yield per plant.

Results and Discussion

Yield: The variations in tuber yield due to the treatments are presented in Tables 1a and 1b. There was no marked variations in the tuber yield per plant under different methods of tillage but was comparatively higher with RT. Nevertheless, the marketable tuber yield, tubers weighing more than 5 g (130.67 g per plant) wase significantly higher in reduced tillage + surface incorporation of GM cowpea (c2) and on par with c3 (RT +surface retention of GM cowpea), 116.01 g per plant.

Reduced tillage minimizes the disturbances in soil and this is not generally ideal for tuber cultivation. Nevertheless, coupled with conservation practices of mulching/ organic matter accretions, the soil properties can be modified to make them amenable for tuber development. In the present study, land preparation was confined to initial ploughing and secondary tillage at row zone alone, along with *in situ* green manuring with cowpea. The incorporation can provide some amount of tilling to loosen the soil, and consequent green matter decomposition and microbial activity can make it friable for tuber formation and bulking. Tuber bulking in the crop was seen after 60 DAP which coincided with the time of peak period of decomposition in green manure cowpea (6-8 weeks) [4], which would have contributed to better soil aggregation and nutrient release that favoured tuber development. Conventional tillage leads to inversion and loosening the soil but the advantages of an enhanced soil fertility with the legume and green manure effects were lacking. The total tuber yield was comparable in all tillage methods however the proportion of larger sized tubers which has consumer preference were greater in reduced tillage treatments.

Among the N management practices, tuber yield per plant was the highest (168.12g) at 50 percent RDN+ nano urea (n3) and on par with n2 (160.38 g). The lowest per plant yield g) was recorded by n4 (100 percent RDF). Application of 75% RDN + nano urea (n2) yielded higher marketable tubers (120.97 g per plant) which was comparable with n3 (50% RDN + nano urea) and n1 (100% RDN + nano urea) with marketable tuber yield of 117.54 and 29 g per plant respectively.

The positive influence of foliar application of nano urea is very evident in the study. It is reasoned that the foliar application enhanced nutrient absorption, facilitating rapid nutrient transportation and delivery through plasmodesmata [5]. The advantages of nano urea are attributed to the unique properties of nano urea *viz*., small particle size (20-50 nm), large surface area and the presence of more reactive oxygen that enhances the photosynthetic rate and metabolic activities [6]. The availability at the target sites favourably influenced canopy development, the source strength for photosynthesis. Potassium the major nutrient influencing translocation was applied as per the recommendation for the crop and hence it is assumed that the balanced application ensued a source- sink balance ideal for tuber development and bulking. However, the interaction effect was not significant

Table 1a: Influence of tillage methods and N management on tuber yields in Chinese potato

Treatments	Total tuber yield (g per plant)	Marketable tuber yield (g per plant)
Tillage		
c1	136.68	87.17
c2	166.87	130.67
c3	163.37	116.01
SE (m) (±)	8.09	6.21
CD (0.05)	NS	24.373
N management		
n1	152.83	115.29
n2	160.38	120.94
n3	168.12	117.54
n4	141.23	91.37
SE (m) (±)	5.97	5.89
CD (0.05)	17.727	17.505

Table 1b: Interaction effect of method of tillage and N management on tuber yield in Chinese potato

Treatments	Tuber yield (g per plant)	Marketable tuber yield (g per plant)
c1n1	126.95	91.14
c1n2	126.66	84.63
c1n3	148.32	97.07
c1n4	144.81	75.85
c2n1	160.12	125.03
c2n2	174.37	146.91
c2n3	181.89	142.02
c2n4	137.11	108.71
c3n1	171.41	129.69
c3n2	180.12	131.27
c3n3	174.16	113.53
c3n4	141.78	89.54
SE (m) A/B(±)	10.33	10.20
SE (m) B/A(±)	12.06	10.80
CD (0.05) A/B	NS	NS
CD (0.05)B/A	NS	NS

Quality attributes

The quality of tubers were assessed in terms of the nutrient contents, starch, protein and Vitamin C contents and the analysed data are presented in Tables 2a and b.

The nutrient contents (N, P and K) varied significantly with the method of tillage, N management and their interaction. The N (1.23%) and K (1.34%) contents were the highest in RT + surface incorporation of GM cowpea (c2) comparable with c3 (The treatments RT + surface retention of GM cowpea). The P content (0.31%) was significantly superior in c2. Reduced soil disturbance, combined with the *in situ* addition of GM, is ascertained to have contributed to the enhanced nutrient availability in the soil, leading to increased nutrient uptake by the crop.

Among N management treatments, significantly superior value of N content (1.25%) was recorded at 100 percent RDN+ nano urea (n1) on account of the higher amounts of N made available from the sources (25 to 50%). The subplot treatments n2 (75% RDN+ nano urea) recorded the highest P content comparable with n1. The notable increase in nutrient levels observed in treatments supplemented with nano urea could be attributed to the rapid and consistent nutrient supply. Among the treatment combinations, significant variation was observed in P content only, it was the highest in c2n3.

The starch content in Chinese potato tubers are depicted in Tables 2a and 2b. The conservation treatments, RT + surface retention of GM cowpea (c3) and RT + surface incorporation of GM cowpea (c2) recorded higher starch content, but were comparable with that in conventional tillage.

Protein and vitamin C contents in tubers varied were markedly with the management practices. Reduced tillage + surface incorporation of GM cowpea (c2) recorded the highest protein content (7.65%) which was on par with c3, 7.57 percent. Vitamin C remained comparable in reduced tillage methods, 10.47 x 10-2 and 10.15 x10-2 mg g-1 in c2 and c3 respectively but significantly higher than in conventional tillage. The starch contents remained comparable. It is assumed that the favourable effects of the conservation practices on soil properties and crop growth had a positive impact on the tuber characters in terms of quality. Similar result was documented in potato tubers raised under ZT planting and paddy straw mulching [7].

Among the N management treatments, the quality attributes were significantly higher in the nano urea applied treatments although slight variations as to the significantly highest contents were noted. Starch content (7 6.70%) was the highest in n1, vitamin C (10.76 x10-2 mg g-1) in n3 and protein (7.81%) in n1 (Table 2a). Interaction effects were found significant in starch content alone.

Table 2a: Effect of method of tillage and N management on nutrient content and quality of tubers (dry weight basis)

Treatment	Nutrient content (%)			Quality attributes		
	N	P	K	Starch (%)	Vitamin C x 10-2 (mg g-1)	Protein (%)
Tillage						
c1	1.17	0.24	1.27	74.25	10.09	7.29
c2	1.23	0.31	1.34	76.34	10.15	7.65
c3	1.21	0.28	1.31	75.00	10.47	7.57
SE (m) (±)	0.01	0.00	0.01	0.52	0.06	0.03
CD (0.05)	0.023	0.006	0.045	NS	0.224	0.124
N management						
n1	1.25	0.28	1.32	76.70	10.43	7.81
n2	1.21	0.29	1.32	75.89	10.44	7.54
n3	1.19	0.27	1.30	74.38	10.76	7.45
n4	1.16	0.27	1.30	73.82	9.98	7.22
SE (m) (±)	0.01	0.00	0.01	0.49	0.09	0.06
CD (0.05)	0.029	0.009	NS	1.465	0.269	0.179

Table 2b: Interaction effect of method of tillage and N management on nutrient content and quality attributes of tubers (dry weight basis)

Treatments	Nutrient content				Quality attributes	
	N	P	K	Starch (%)	Vitamin C x 10-2 (mg g^{-1})	Protein (%)
c1n1	1.19	0.24	1.28	75.08	10.42	7.42
c1n2	1.18	0.26	1.29	75.22	10.37	7.40
c1n3	1.18	0.23	1.25	73.89	9.87	7.36
c1n4	1.12	0.24	1.27	72.79	9.69	6.98
c2n1	1.30	0.29	1.33	78.62	10.34	8.15
c2n2	1.21	0.31	1.35	77.23	10.46	7.58
c2n3	1.20	0.34	1.36	75.08	11.76	7.49
c2n4	1.18	0.30	1.33	74.43	10.03	7.38
c3n1	1.26	0.32	1.35	76.40	10.53	7.85
c3n2	1.22	0.29	1.32	75.22	10.48	7.64
c3n3	1.20	0.25	1.28	74.16	10.64	7.49
c3n4	1.17	0.27	1.30	74.24	10.21	7.29
SE (m) A/B(±)	0.02	0.01	0.02	0.85	0.16	0.10
SE (m) B/A(±)	0.02	0.01	0.02	0.90	0.15	0.10
CD (0.05) A/B	NS	0.016	NS	NS	0.466	NS
CD (0.05)B/A	NS	0.016	NS	NS	0.459	NS

The advantages of nano urea over soil application, facilitated the fast and steady absorption and targeted supply of N, which would have led to the enhanced crude protein and starch content in the produce. It was reported greater density and reactive areas of hydroxyapatite nano particles in nano NPK fertilizers that increased the uptake of N, leading to enhanced protein content of the produce [8]. The effect of interaction of treatments showed, the highest starch and protein content in c2n1 (RT+ surface incorporation of GM cowpea+100% RDN+ nano urea) and c2n3 (RT+ surface incorporation of GM cowpea+50% RDN+ nano urea) resulted in highest vitamin C content (11.76 x10-2 mg g-1) (Table 2b).

The apprehensions with regard to global warming are becoming true and strategies for mitigation are being sought in all walks of life. Agricultural practices have immense potential for conserving carbon in reserves and reducing the concentrations in the atmosphere. Conservation agriculture with the prime focus on minimum tillage and crop residue recycling, minimising the load of agrochemicals in environment through nano formualtions as evidenced in the present study can contribute to C neutral farming strategies. The strategy of reduced tillage and green manuring *in situ*, combined with the use of nano urea for foliar nutrition has been found suitable for higher marketable yields of quality tubers in Chinese potato.

Conclusion

The study brings to light the significant influence of conservation tillage practices on the tuber yield and quality in Chinese potato. Reduced tillage and GM cowpea application along with foliar spray of nano N resulted in higher marketable tuber yield and quality in terms of NPK content, starch, protein and vitamin C.

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