

Impact of Nano NPK on Yield Attributes, Soil and Leaf Nutrient Status of Turmeric (*Curcuma longa* L.)

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ABSTRACT

A field study was carried out for two consecutive years (2022–23 and 2023–24) at the Horticultural Research Station, Mondouri, BCKV, to assess the influence of nano NPK on yield attributes, soil fertility, and leaf nutrient status of turmeric cv. Suguna under the agro-climatic conditions of West Bengal. The experiment was arranged in randomized block design with three replications and eight treatments. Different levels of conventional NPK fertilizers were integrated with foliar sprays of 0.4% nano NPK at 45 and 90 days after planting based on treatment combinations. Among the treatments T₈ [40% N+75% P (Basal) → 0.4% nano NPK at 45 DAP → 0.4% nano NK at 90 DAP] recorded the maximum weight of primary fingers (270.50 g), breadth of secondary fingers (2.03 cm), weight, length and breadth of clump (394.44 g, 23.59 cm and 16.50 cm respectively), available soil nitrogen (241.84 kg ha⁻¹), leaf nitrogen (1.74%), phosphorus (0.42%) and potassium (3.19%) content. The treatment also recorded maximum projected yield (34.95 t ha⁻¹) in contrast the plants solely grown under conventional fertilizer (T₁:40% N+100% P as basal → 30% N+50% K at 45 and 90 DAP) recorded minimum yield (24.31 t ha⁻¹), soil and leaf nutrient contains. The study indicated that combining nano fertilizers with conventional fertilizers improved yield traits while sustaining soil fertility in turmeric cultivation.

Keywords

Leaf NPK, nano fertilizers, soil NPK, turmeric, yield.

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Introduction

Turmeric (*Curcuma longa* L.) belongs to the family Zingiberaceae is extensively cultivated in tropical and subtropical regions of the world. The crop is highly valued for its rhizomes, which are widely used as a spice, natural colouring agent, preservative, and traditional medicine. India is the largest producer, consumer and

exporter of turmeric (Sil *et al.*, 2026). Indian turmeric is considered as the best in world market, due to its inherent quality and high content of the important bioactive compound curcumin, responsible for its characteristics yellow colour. Due to the presence of these yellow colour substance and other bioactive compounds, turmeric possesses significant antioxidant, antimicrobial, anti-inflammatory, and therapeutic properties (Rathore *et al.*,

2020). In recent years, the demand for high-quality turmeric has increased considerably due to its expanding utilization in food processing, pharmaceutical, cosmetic, and nutraceutical industries. The productivity and quality of turmeric are greatly influenced by proper nutrient management, as the crop requires a continuous and balanced supply for optimum growth and development (Bairagi, 2022). Though the indiscriminate use of conventional fertilizers has increased crop yields over the years, but it has also resulted in declining nutrient use efficiency resulting in nutrient imbalances, deterioration of soil health, and increased production costs (Guo *et al.*, 2018; Diatta *et al.*, 2020). A considerable amount of conventional fertilizers, particularly nitrogen, phosphorus and potassium are lost through leaching, fixation, runoff, and volatilization, thereby reducing fertilizer use efficiency and increase environmental concerns (Dutta and Bera, 2021). Therefore, the development of efficient and sustainable nutrient management strategies has become essential for maintaining long-term agricultural productivity and soil fertility.

In recent years, nanotechnology has emerged as a promising approach for enhancing fertilizer efficiency and sustainable crop production. Due to nano-scale particle size (< 100 nm), higher surface area, and enhanced reactivity, controlled and targeted nutrient release, nano fertilizers improved nutrient absorption, translocation, and utilization by plants (Tang *et al.*, 2023). Integration of nano NPK with conventional fertilizers can ensure balanced nutrient supply throughout the crop growth period while reducing nutrient losses and environmental hazards. Improved nutrient uptake through nano-fertilizer application is often reflected in enhanced leaf nutrient status, which serves as an important indicator of plant nutritional health and metabolic efficiency. It also contribute towards maintaining soil fertility by improving the availability of soil nitrogen, phosphorus, and potassium. Although nano-fertilizers have shown promising effects in several agricultural crops, there are lack of information regarding the combined application of conventional and nano fertilizers in turmeric cultivation under the New Gangetic Alluvial Zone of West Bengal.

Therefore, the present investigation was undertaken to evaluate the effect of integrated nano and conventional nutrient management on crop productivity, soil fertility status, and leaf nutrient composition, with the objective of developing an efficient and sustainable nutrient management strategy for turmeric cultivation.

Materials and Methods

Experimental site

The experiment was conducted at Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India for two consecutive years (2022-23 and 2023-24). The research station is located at 23°05' N latitude and 89°00' E longitude with an altitude of 9.75 m MSL under subtropical climatic region with an annual mean temperature of 25.99 °C. The soil at the experimental site is characterized by a sandy clay loam texture, which ensures adequate moisture retention along with efficient drainage (Table 1).

Experimental details

The experiment was laid out in randomized block design (RBD) with eight treatments and three replications, evaluating reduced recommended dose of fertilizer combined with foliar application of 0.4% nano N, P, and K at 45 and 90 days after planting (Table 2). Variety Suguna was planted on raised beds of 3.0 m × 1.0 m × 15 cm at a spacing of 30 cm × 25 cm accommodating 40 plants per plot. Seed rhizomes weighing 25–30 g were treated with blitox @ 4 g L⁻¹ for 30 minutes before planting. Planting was done in mid-June and harvesting in late January during both seasons. The recommended fertilizer dose NPK @ 150:60:150 kg ha⁻¹, was supplied through urea, SSP, and MOP. Basal applications of 40% nitrogen, full dose of phosphorus and FYM @ 25 t ha⁻¹ were applied during land preparations while the remaining nitrogen and potassium were applied in two split dose at 45 and 90 DAP as per treatment schedule. Irrigation was applied immediately after planting and thereafter application was done as per soil moisture and weather conditions. Rhizomes were planted at 3–4 cm depth and mulched with paddy straw @ 10 t ha⁻¹. Additional mulching @ 5 t ha⁻¹ was done at 45 and 90 DAP along with earthing up before the second and third mulching. Hand weeding was first performed at 30 DAP, followed by regular weed control to maintain a weed-free crop throughout the season.

Observations

Yield attributes like number, weight, length and breadth of primary and secondary fingers, weight, length and breadth of clump were recorded after harvesting. Post experimental soil analysis was done after collecting the

soil sample separately from each experimental plot at a depth of 0-15 cm. Available soil nitrogen was estimated by the alkaline permanganate method. Soil phosphorus was determined by Olsen's method (as soil pH > 6.0) using 0.5 M sodium bicarbonate (NaHCO₃), followed by colour development and spectrophotometric measurement. Where potassium was estimated using a flame photometer. The results were expressed as kg ha⁻¹ (Jackson, 1973). For estimation of turmeric leaf NPK status at 120 DAP, samples were collected, washed thoroughly, oven dried at 65–70°C, and ground into fine powder. Nitrogen content was estimated by the Kjeldahl method after digestion of the sample in acid. Phosphorus was determined colorimetrically using the vanadomolybdate (yellow colour) reagent, while potassium content was estimated using a flame photometer from the same plant digest. The nutrient contents were expressed on percentage basis (Jackson, 1973).

Statistical Analysis

The observations recorded for each parameter were subjected to statistical analysis by variance procedure as described by Gomez and Gomez (1984). The significance of treatment was tested using Fisher–Senseco's F-test at the 5 % probability level. The critical difference (CD) at the 5% level of significance was calculated with reference to the tables of Fisher and Yates (1953).

Results and Discussion

It was evident from the data presented in Table.3 that the significant differences were observed with number, weight, length and breadth of primary fingers per plant. The maximum number (16.38) and breadth (2.34 cm) of primary fingers were recorded under application of 40% N + 100% P as basal → 0.4% nano N and K at 45 DAP and 90 DAP (T₄). Plants treated with 0.4% nano-N, P and K at 45 DAP + 0.4% nano-N and K at 90 DAP along with 40% N + 75% P as basal (T₈) recorded the highest weight (270.50 g) and length (8.81 cm) of primary fingers. In contrast the control (T₁: 40% N + 100% P as basal → 30% N + 50% K at 45 and 90 DAP) recorded the lowest weight (170.82 g) and length (7.68 cm) of primary fingers whereas the lowest number (11.94) and breadth (1.50 cm) were observed under treatment combinations of T₃ (40% N + 100% P as basal → 30% N + 0.4% nano K at 45 and 90 DAP) and T₂ (40% N + 100% P as basal → 0.4% nano N + 50% K at 45 and 90 DAP) respectively.

The number, weight, length and breadth of secondary fingers differed significantly among the treatments (Table 4). The highest number of secondary fingers (9.85) was recorded under plants treated with 40% N + 75% P as basal → 0.4% nano N and P + 50% K at 45 DAP → 0.4% nano N + 50% K at 90 DAP (T₆) followed by T₄ (9.49), whereas the lowest number (7.75) was observed under treatment combinations of 40% N + 75% P as basal → 30% N + 0.4% nano P and K at 45 DAP → 30% N + 0.4% nano K at 90 DAP (T₇). In case of weight and length of secondary fingers the maximum value (86.57 g and 4.28 cm) were recorded under application of 40% N + 100% P as basal → 0.4% nano N and K at 45 DAP and 90 DAP (T₄) whereas the untreated control (T₁) recorded the minimum weight (52.29 g) and length (3.26 cm) of secondary fingers. The widest breadth of secondary fingers (2.03 cm) was recorded under treatment combinations of 40% N + 75% P as basal → 0.4% nano N, P and K at 45 DAP → 0.4% nano N and K at 90 DAP (T₈) which is statistically *at par* with T₄ (1.96 cm) as compared to lowest breadth (1.45 cm) under T₅ (40% N + 75% P as basal → 30% N + 0.4% nano P + 50% K at 45 DAP → 30% N + 50% K at 90 DAP). The increased primary and secondary finger characteristics under integrated nano-based treatments may be due to enhanced vegetative growth, improved photosynthetic productivity, enzymatic activity, cell division and greater assimilate partitioning to underground storage organs resulting improved bulking, lateral expansion and finger production of rhizomes.

Data presented in Table. 5 revealed that clump characteristics varied significantly among the treatments with the maximum weight (394.44 g), length (23.79 cm) and breadth (16.50 cm) of clump were recorded under T₈ followed by T₄. The lowest clump weight (256.79 g) was recorded in T₁ (40% N + 100% P as basal → 30% N + 50% K at 45 and 90 DAP). The shortest clump length (20.59 cm) was observed under T₇ (40% N + 75% P as basal → 30% N + 0.4% nano P and K at 45 DAP → 30% N + 0.4% nano K at 90 DAP) and the minimum clump breadth (13.08 cm) was recorded under T₃ (40% N + 100% P as basal → 30% N + 0.4% nano K at 45 DAP → 30% N + 0.4% nano K at 90 DAP). The increased clump characteristics under integrated nano-nutrient treatments may be attributed to improved vegetative growth, enhanced carbon assimilation efficiency and greater assimilate translocation to underground organs. The results are in close conformity with the findings of Chavan *et al.*, (2024) who reported that application of conventional fertilizers in combination with 50% nano

urea and 25% nano phosphorus gives significantly higher bulb weight and neck diameter in white onion (*Allium cepa*).

Projected yield varied significantly among the treatments with the highest value (34.95 t ha⁻¹) was recorded under application of 40% N + 75% P as basal → 0.4% nano N, P and K at 45 DAP → 0.4% nano N and K at 90 DAP (T₈), followed by T₄ (40% N+100% P as basal → 0.4% nano N and K at 45 DAP and 90 DAP) [33.34 t ha⁻¹] and T₆ (40% N+75% P as basal → 0.4% nano N and P + 50% K at 45 DAP → 0.4% nano N + 50% K at 90 DAP) [32.68 t ha⁻¹], whereas the lowest yield (24.31 t ha⁻¹) was observed in T₁ (40% N + 100% P as basal → 30% N + 50% K at 45 and 90 DAP). The superior projected yield under integrated nutrient treatments may be attributed to enhanced rhizome biomass accumulation due to balanced nutrient supply, improved root growth, and increased nutrient use efficiency. Nitrogen plays a critical role in chlorophyll synthesis and vegetative growth, phosphorus in root development and energy transfer, and potassium in carbohydrate transport and storage in rhizomes. The synergistic effect of these nutrients results in increased sink strength and higher rhizome yield.

The data presents in Table. 6 revealed significant variations among treatments for available nitrogen (N), phosphorus (P) and potassium (K), indicating that nano NPK formulations influenced soil nutrient dynamics and

nutrient retention capacity. The maximum available soil nitrogen (241.84 kg ha⁻¹) was recorded under T₈ (40% N + 75% P as basal → 0.4% nano N, P and K at 45 DAP → 0.4% nano N and K at 90 DAP) followed by T₆ (40% N + 75% P as basal → 0.4% nano N and P + 50% K at 45 DAP → 0.4% nano N+50% K at 90 DAP) [238.59 kg ha⁻¹]. Where the maximum phosphorus (21.08 kg ha⁻¹) and potassium (225.80 kg ha⁻¹) content in soil were recorded under T₄ (40% N + 100% P as basal → 0.4% nano N and K at 45 DAP and 90 DAP), followed by T₈ (20.74 kg ha⁻¹ and 223.79 kg ha⁻¹ respectively). The lowest nitrogen (223.24 kg ha⁻¹), phosphorus (15.75 kg ha⁻¹) and potassium (211.18 kg ha⁻¹) content in soil were observed in T₁. The increased availability of soil nutrients under nano NPK-integrated treatments may be due to the controlled release of nutrients and reduced losses through leaching and volatilization. Nano phosphorus enhanced P solubilisation and mineralization through improved microbial activity and root exudation (Iqbal *et al.*, 2019), while nano potassium reduced K fixation and leaching losses, thereby improving soil nutrient retention and fertility status (Srinivasan *et al.*, 2016). The improved soil nutrient status under nano fertilizer treatments indicates their potential role in sustainable nutrient management, improving soil fertility and long-term productivity of turmeric. These findings are closely related with earlier studies reporting enhanced soil nutrient availability and nutrient use efficiency under nano-enabled fertilizer applications (Kumar *et al.*, 2020).

Table.1 Baseline physio-chemical attributes of the experimental soil before planting

Soil pH	Organic carbon (%)	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)
6.62	0.67	229.71	18.53	210.65

Table.2 Details of the treatment

Sl. No.	Treatment combination
T ₁	40% N+100% P (Basal) → 30% N+50% K (45 and 90DAP)
T ₂	40% N+100% P (Basal) → 0.4% Nano N+50% K (45 DAP and 90 DAP)
T ₃	40% N+100% P (Basal) → 30% N+0.4% Nano K (45 DAP and 90DAP)
T ₄	40% N+100% P (Basal) → 0.4% Nano N and K (45 DAP and 90DAP)
T ₅	40% N+75% P (Basal) → 30% N+0.4% Nano P+50% K (45 DAP) → 30% N+50% K (90DAP)
T ₆	40% N+75% P (Basal) → 0.4% Nano N and P+ 50% K (45 DAP) → 0.4% Nano N+50% K (90DAP)
T ₇	40% N+75% P (Basal) → 30% N + 0.4% Nano P and K (45 DAP) → 30% N +0.4% Nano K (90DAP)
T ₈	40% N+75% P (Basal) → 0.4% Nano N, P and K (45 DAP) → 0.4% Nano N and K (90DAP)

Table.3 Impact of nano NPK integrated with commercial fertilizers on primary finger

Treatments	Primary finger											
	Number			Weight (g)			Length (cm)			Breadth (cm)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁	10.36	13.82	12.09	158.36	183.27	170.82	7.54	7.81	7.68	1.53	1.49	1.51
T ₂	12.68	15.39	14.04	192.48	214.30	203.39	7.75	8.18	7.97	1.26	1.74	1.50
T ₃	11.36	12.52	11.94	189.54	194.49	192.02	7.78	7.76	7.77	2.02	1.89	1.96
T ₄	15.92	16.83	16.38	235.24	259.68	247.46	8.26	9.10	8.68	2.15	2.53	2.34
T ₅	12.49	17.44	14.97	200.83	221.28	211.06	7.26	7.89	7.58	1.48	1.75	1.62
T ₆	13.81	16.58	15.20	218.67	246.84	232.76	8.65	8.28	8.47	1.95	2.10	2.03
T ₇	14.03	18.61	16.32	217.05	262.03	239.54	8.10	9.02	8.56	1.32	1.67	1.50
T ₈	16.45	16.04	16.25	271.88	269.11	270.50	8.46	9.15	8.81	2.24	2.31	2.28
S.Em. (±)	0.180	0.269	0.194	2.747	3.861	3.658	0.114	0.112	0.139	0.026	0.026	0.024
C.D. (P=0.05)	0.550	0.824	0.594	8.413	11.826	11.202	0.348	0.343	0.427	0.080	0.080	0.074

Table.4 Impact of nano NPK integrated with commercial fertilizers on secondary finger

Treatments	Secondary finger											
	Number			Weight (g)			Length (cm)			Breadth (cm)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁	8.94	8.59	8.77	43.86	60.71	52.29	2.67	3.85	3.26	1.36	1.58	1.47
T ₂	8.29	9.23	8.76	60.52	67.78	64.15	3.19	3.36	3.28	1.28	1.79	1.54
T ₃	8.72	9.38	9.05	63.70	70.82	67.26	3.35	4.02	3.69	1.84	1.62	1.73
T ₄	9.36	9.62	9.49	84.40	88.73	86.57	4.45	4.11	4.28	1.78	2.14	1.96
T ₅	9.21	8.76	8.99	58.76	71.59	65.18	3.37	4.29	3.83	1.46	1.43	1.45
T ₆	9.58	10.11	9.85	72.93	91.20	82.07	3.93	4.38	4.16	1.63	2.06	1.85
T ₇	7.15	8.34	7.75	82.17	69.12	75.65	4.01	3.62	3.82	1.67	1.93	1.80
T ₈	7.61	9.28	8.45	70.01	83.02	76.52	3.78	4.50	4.14	1.89	2.17	2.03
S.Em. (±)	0.123	0.121	0.114	0.922	1.239	1.032	0.054	0.051	0.050	0.021	0.031	0.025
C.D. (P=0.05)	0.376	0.369	0.349	2.824	3.795	3.160	0.164	0.155	0.152	0.064	0.094	0.077

Table.5 Impact of nano NPK integrated with commercial fertilizers on clump and projected yield

Treatments	Clump									Projected yield (t ha ⁻¹)		
	Weight (g)			Length (cm)			Breadth (cm)			2022-23	2023-24	Pooled
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled			
T ₁	237.13	276.44	256.79	19.86	21.86	20.86	12.83	13.89	13.36	22.83	25.80	24.31
T ₂	302.16	318.29	310.23	20.35	21.94	21.15	13.49	14.73	14.11	28.50	30.18	29.34
T ₃	290.92	306.58	298.75	21.26	23.24	22.25	12.52	13.64	13.08	27.95	28.79	28.37
T ₄	360.46	398.16	379.31	22.63	23.05	22.84	15.09	16.93	16.01	31.45	35.23	33.34
T ₅	301.83	341.63	321.73	21.58	22.02	21.80	13.75	14.44	14.10	28.58	32.87	30.72
T ₆	332.05	382.63	357.34	19.71	22.80	21.26	14.52	15.20	14.86	30.28	35.09	32.68
T ₇	336.74	365.95	351.35	20.65	20.52	20.59	14.61	15.77	15.19	30.78	33.71	32.24
T ₈	384.56	404.32	394.44	22.71	24.87	23.79	16.24	16.76	16.50	33.63	36.28	34.95
S.Em. (±)	4.282	5.446	4.660	0.187	0.254	0.209	0.300	0.368	0.289	0.487	0.536	0.510
C.D. (P=0.05)	13.114	16.679	14.273	0.572	0.777	0.641	0.920	1.127	0.884	1.491	1.641	1.561

Table.6 Impact of nano NPK integrated with commercial fertilizers on soil nutrient status

Treatments	Soil nutrient content (kg ha ⁻¹)								
	Nitrogen			Phosphorus			Potassium		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T ₁	219.68	226.79	223.24	14.09	17.41	15.75	207.09	215.27	211.18
T ₂	226.16	226.36	226.26	16.36	17.89	17.13	213.72	216.03	214.88
T ₃	234.17	225.28	229.73	16.47	20.06	18.27	227.64	212.56	220.10
T ₄	223.15	228.14	225.65	21.02	21.13	21.08	221.28	230.31	225.80
T ₅	240.44	232.76	236.60	21.69	18.65	20.17	206.46	223.86	215.16
T ₆	239.32	237.86	238.59	16.23	22.32	19.28	222.09	215.22	218.66
T ₇	234.16	232.54	233.35	16.25	19.94	18.10	217.61	227.09	222.35
T ₈	239.26	244.42	241.84	19.89	21.58	20.74	226.43	221.14	223.79
S.Em. (±)	4.204	2.887	2.901	0.231	0.256	0.246	2.868	2.873	2.836
C.D. (P=0.05)	12.874	8.843	8.884	0.707	0.783	0.754	8.784	8.798	8.684

Table.7 Impact of nano NPK integrated with commercial fertilizers on leaf nutrient status

Treatments	Leaf nutrient content (%)								
	Nitrogen			Phosphorus			Potassium		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
T₁	1.26	1.56	1.41	0.37	0.34	0.36	2.80	2.87	2.84
T₂	1.40	1.67	1.54	0.36	0.39	0.38	2.88	2.95	2.92
T₃	1.68	1.27	1.48	0.35	0.38	0.37	2.98	2.93	2.96
T₄	1.64	1.75	1.70	0.38	0.36	0.37	3.08	3.16	3.12
T₅	1.72	1.59	1.66	0.39	0.40	0.40	3.04	3.08	3.06
T₆	1.53	1.81	1.67	0.41	0.43	0.42	2.95	2.91	2.93
T₇	1.31	1.58	1.45	0.39	0.42	0.41	2.86	2.90	2.88
T₈	1.77	1.71	1.74	0.42	0.41	0.42	3.16	3.22	3.19
S.Em. (±)	0.019	0.021	0.020	0.005	0.005	0.007	0.052	0.042	0.043
C.D. (P=0.05)	0.058	0.065	0.062	0.015	0.015	0.022	0.158	0.130	0.132

Leaf nutrient content at 120 DAP varied significantly among the treatments (Table 7). The highest nitrogen (1.74%), phosphorus (0.42%) and potassium (3.19%) were recorded under application of 40% N + 75% P as basal → 0.4% nano N, P and K at 45 DAP → 0.4% nano N and K at 90 DAP (T₈), whereas plants grown under sole application of conventional fertilizers (T₁) recorded minimum nitrogen (1.41%), phosphorus (0.36%) and potassium (2.84%) content in leaves at 120 DAP. The higher leaf N, P, and K contents observed under integrated nano nutrient treatments may be attributed to improved nutrient availability, controlled release, and enhanced nutrient use efficiency. Nano phosphorus increased nutrient solubility and reduced soil fixation, leading to better root absorption and translocation to leaves, while nano potassium improved nutrient retention and uptake by minimizing leaching losses and enhancing nutrient transport within the plants. The results are in close agreement with earlier reports that nano-enabled fertilizers improve nutrient uptake efficiency and physiological performance in crops by enhancing nutrient availability and reducing losses (Kah *et al.*, 2019).

In conclusion, the enhanced soil and leaf nutrient status under nano fertilizer treatments indicated the positive role of nano fertilizers in improving nutrient absorption, translocation and metabolic activity, which ultimately contributed to enhance yield characteristics of turmeric plant.

Overall, the integration of nano NPK with conventional fertilizers proved to be an efficient and sustainable nutrient management approach for improving productivity and nutrient status of turmeric while supporting long-term soil health.

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Author's Contribution

Field experiment, laboratory analysis, preparation of manuscript and manuscript edit (AS). Conceptualization of research work and methodology, manuscript reviewed (JKH).

Data availability

The data that support the findings of this study are included within the article (and its supplementary materials).

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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