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Effect of nanofertilizer based INM on yield and economics of chow-chow in Nagaland

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ABSTRACT

A field experiment was conducted in Nagaland University, School of Agricultural Sciences, during winter season in 2022-2023 and 2023-2024 to study the effect of nanofertilizer based integrated nutrient management on yield and economics of chow-chow [Sechium edule (Jacq.) Sw.] in Chumukedima district of Nagaland. Experiments were laid out in RBD with 22 treatments viz. T_1 - Full dose of RDF (N through urea), T_2 - Full dose of RDF (N through nano urea), T_3 - FYM @ 20 t ha^{-1}, T_4 - Vermicompost @ 5 t ha^{-1}, T_5 - Poultry manure @ 10 t ha^{-1}, T_6 - FYM @ 20 t ha^{-1} + microbial consortium, T_7 - Vermicompost @ 5 t ha^{-1} + microbial consortium, T_8 - Poultry manure @ 10 t ha^{-1} + microbial consortium, T_9 - FYM @ 10 t ha^{-1} + ½ of RDF (N through urea), T_{10} - FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea), T_{11} - FYM @ 10 t ha^{-1} + ½ of RDF (N through urea) + microbial consortium, T_{12} - FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea) + microbial consortium, T_{13} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through urea), T_{14} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea), T_{15} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through urea) + microbial consortium, T_{16} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea) + microbial consortium, T_{17} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through urea), T_{18} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea), T_{19} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through urea) + microbial consortium, T_{20} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + microbial consortium, T_{21} - Farmers' practice , T_{22} - Control and replicated thrice. Results revealed that the application of different levels of nutrients either alone or in combination significantly increased yield of chow-chow as compared to control. The highest yield (681.40 q ha^{-1}) was observed in treatment T_{20} [Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + MC]. The same treatment also produced the highest net return (₹ 4,77,528.45) along with cost benefit ratio 1:2.34. These results saved about 50% chemical fertilizers without any compromise on yield and economics of chow-chow. Thus, nanofertilizers showed great potential as a key component of INM and can be recommended to the farmers of Nagaland.

Keywords: Nanoferilizer, INM, chow-chow, yield and economics

INTRODUCTION

Chow-chow [*Sechium edule* (Jacq.) Sw.] is a perennial cucurbitaceous vegetable crop valued for its nutritional profile and adaptability to diverse growing conditions. Recent studies have highlighted its composition of essential amino acids, antioxidants and dietary fibre, making it an important crop for both nutritional security and commercial cultivation. Their abundance in fibre, vitamins and antioxidants promote digestive health, strengthen the immune system and could lower the risk of chronic diseases such as heart disease, diabetes and some malignancies (Bhagya *et al.,* 2021). In India, chow-chow cultivation has been steadily increasing, particularly in the hilly regions of the Northeastern states, Himachal Pradesh, Uttarakhand and parts of South India, where it thrives in cool, humid climates (Pandey *et al.,* 2018). The crop is well-suited for small holder farming systems due to its low input requirements and high yield potential. Chow-chow productivity in India however remains suboptimal despite its adaptability primarily due to inefficient nutrient management practices, with many farmers relying excessively on synthetic fertilizers that degrade soil health over time (Patel *et al.,* 2022). To address these challenges, sustainable nutrient management strategies such as Integrated Nutrient Management (INM) and nanofertilizers have emerged as promising alternatives. INM, which combines organic manures (e.g., farmyard manure, vermicompost), biofertilizers, and chemical fertilizers in balanced proportions, has been shown to improve soil health, enhance nutrient use efficiency, and sustain long-term

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crop productivity (Kanaujia *et al.,* 2016, Longmatula *et al.,* 2021, Walling *et al.,* 2022). Additionally, nanofertilizers - a novel innovation in precision agriculture-offer controlled nutrient release, higher absorption efficiency, and reduced environmental losses compared to conventional fertilizers (Liu and Lal, 2015). Despite these advancements, research on the combined effects of INM and nanofertilizers on chow-chow remains limited, particularly in the Indian context. Given the crop's growing economic importance and the realization of it nutritional benefits; optimizing fertilization strategies for chow-chow could significantly enhance productivity while promoting sustainable farming practices. Therefore, this study aims to evaluate the impact of nanofertilizers based INM on yield and economics of chow-chow, with the goal of providing science-based recommendations for farmers and policy makers. The findings will contribute to the broader discourse on sustainable vegetable production and climate-resilient agriculture.

MATERIALS AND METHODS

The experiments were carried out in the experimental farm of the School of Agricultural Sciences, Nagaland University, Medziphema campus, Nagaland during the two consecutive year 2022-2023 and 2023-2024 to determine the effect of nanofertilizers based INM on yield and economics of chow-chow. The experimental farm is situated in a humid and subtropical climate region, characterized by an average annual rainfall ranging from 2000 to 2500 mm. The mean temperature typically falls within the range of 21-32°C during the summer, and even in winter, it seldom drops below 8°C due to the presence of high atmospheric humidity. The soil pH was recorded acidic pH (4.2-4.5) and higher organic carbon (1.28-1.35%) was reported initially in the soil with low content of available N (172-176 kg ha^{-1}) and K (142-155 kg ha^{-1}) and moderate content of available P (13-16 kg ha^{-1}). The experimental field was laid out in Randomized Block Design (RBD) consisting of three sources of manure, two types of fertilizers and a microbial consortium which were further divided into twenty-two treatments. A total of 66 plots were made and the different treatments were randomly allocated, and the trial was conducted twice. The experiment comprised of 22 treatments *viz.* T_1 - Full dose of RDF (N through urea), T_2 - Full dose of RDF (N through nano urea), T_3 - FYM @ 20 t ha^{-1}, T_4 - Vermicompost @ 5 t ha^{-1}, T_5 - Poultry manure @ 10 t ha^{-1}, T_6 - FYM @ 20 t ha^{-1} + microbial consortium, T_7 - Vermicompost @ 5 t ha^{-1} + microbial consortium, T_8 - Poultry manure @ 10 t ha^{-1} + microbial consortium, T_9 - FYM @ 10 t ha^{-1} + ½ of RDF (N through urea), T_{10} - FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea), T_{11} - FYM @ 10 t ha^{-1} + ½ of RDF (N through urea) + microbial consortium, T_{12} - FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea) + microbial consortium, T_{13} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through urea), T_{14} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea), T_{15} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through urea) + microbial consortium, T_{16} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea) + microbial consortium, T_{17} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through urea), T_{18} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea), T_{19} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through urea) + microbial consortium, T_{20} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + microbial consortium, T_{21} - T_{21} - Farmers' practice (FYM @ 5 t/ha + ash @ 5 q/ha), T_{22} – Control. Treatment farmers practice (T_{21}) is practice adapted by the farmers of Nagaland i.e. application of FYM @ 5 t/ha + ash @ 5 q/ha. The application of organic manures was done at 20 days before sowing and the quantity of manures was added as per the recommended treatments. The chemical fertilizers were incorporated in the soil just before sowing as per the recommended dose i.e., 100:60:60 kg NPK ha^{-1} respectively. N was applied in 2 split doses. Half as basal and remaining half as top dressing at 30 days after sowing. Entire quantity of P and K was applied as basal at the time of sowing. The application of nano urea @ 5 ml l^{-1} was done twice as foliar spray. The first application was done at 6-8 leaf stage and second at 1 week before flowering. Microbial consortium was applied @ 5 ml l^{-1} by mixing with organic manures at 15 days before sowing. The pre germinated chow-chow seeds were treated with Captaf 50% WP, a broad-spectrum fungicide @ 2.5 gm l^{-1} to check the seed borne pathogens just before sowing and was drenched with chlorpyriphos @ 2ml l^{-1} to avoid infestation by termites just after sowing. Data on yield was recorded and statistically analysed as per procedure given by Panse and Sukhatme (1989). Economics of different treatments were also calculated as per prevailing market price of inputs and outputs. Gross income was calculated by yield multiplied by wholesale rate of chow-chow @ Rs 10 kg^{-1}. Net income was estimated by deducting the total cost of cultivation (fixed cost + treatment cost) from gross income of the particular treatment. Cost benefit ratio was worked out by dividing net return from total cost of cultivation.

RESULTS AND DISCUSSION

Integrated application of nanofertilizer, organic manures and microbial consortium alone or in combination has appreciable effect in the altering of yield and economics of chow chow. It is revealed from Table 1 that Treatment T_{20} [Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + MC] recorded the highest yield per ha with a pooled yield of 681.40 q ha^{-1} which was closely followed by treatment T_{12} [FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea) + MC] with pooled yield of 676.88 q ha^{-1}, followed by **T_{16} [**Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea) + MC] with 662.32 q ha^{-1}. Treatment control (T_{22}) recorded the lowest pooled yield (339.99 q ha^{-1}). The treatment difference between T_{20}, T_{12} and T_{16} were found statistically at par. This result indicates positive effects of integrating nano-based urea with organic manures and microbial consortium.

Table 1: Effect of nanofertilizer based INM on yield and economics of the treatment (pooled data)

Treatments	Yield (q ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross income (₹ ha^{-1})	Net income (₹ ha^{-1})	B:C ratio
T_1 - Full dose of RDF (N through urea)	605.56	182103.36	605563.30	423459.94	2.33
T_2 - Full dose of RDF (N through nano urea)	456.93	181340	456932.30	275592.30	1.52
T_3 - FYM @ 20 t ha^{-1}	391.19	235700	391189.73	155489.73	0.66
T_4 - Vermicompost @ 5 t ha^{-1}	370.90	250700	339986.90	89286.90	0.36
T_5 - Poultry manure @ 10 t ha^{-1}	381.36	225700	381362.90	155662.90	0.69
T_6 - FYM @ 20 t ha^{-1} + MC	479.83	236050	479825.03	243775.03	1.03
T_7 - Vermicompost @ 5 t ha^{-1} + MC	385.91	251050	385909.37	134859.37	0.54
T_8 - Poultry manure @ 10 t ha^{-1} + MC	360.15	226050	360152.07	134102.07	0.59
T_9 - FYM @ 10 t ha^{-1} + ½ of RDF (N through urea)	383.57	208901.68	383570.50	174668.82	0.84
T_{10} - FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea)	479.97	208520	479969.17	271449.17	1.30
T_{11} - FYM @ 10 t ha^{-1} + ½ of RDF (N through urea) + MC	503.89	209251.68	503890.77	294639.09	1.41
T_{12} - FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea) + MC	676.88	208870	676882.03	468012.03	2.24
T_{13} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through urea)	405.41	216401.68	405413.33	189011.65	0.87
T_{14} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea)	419.37	216020	419374.67	203354.67	0.94
T_{15} - Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through urea) + MC	518.66	216751.68	518659.00	301907.32	1.39
T_{16} -Vermicompost @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea) + MC	662.32	216370	662324.97	445954.97	2.06
T_{17} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through urea	403.80	203901.68	403802.90	199901.22	0.98
T_{18} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea)	389.34	203520	389343.70	185823.70	0.91
T_{19} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through urea) + MC	509.63	204251.68	509630.53	305378.85	1.50
T_{20} - Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + MC	681.40	203870	681398.45	477528.45	2.34
T_{21} - Farmers' practice	442.44	190700	442440.60	251740.60	1.32
T_{22} - Control	339.99	175700	370898.13	195198.13	1.11
CD (P=0.05)	74.04				

FYM- ₹3000 ton^{-1}, Vermicompost- ₹15000 ton^{-1}, Poultry manure- ₹5000 ton^{-1}, Nano urea- ₹880 L^{-1}

This superior performance was attributed to the synergistic effects of the controlled nitrogen release, organic nutrient supply from poultry manure, and enhanced nutrient use efficiency due to microbial consortia along with the nano fertilizers (Kanaujia and Daniel (2016; Kharga *et al.,* 2020). This also may be due to favourable effect of integrated application of nanourea based fertilizer, organic manures and microbial consortium in supplying all essential nutrients in balanced ratio and also improved the fertility status of soil. Microbial consortium might have played a vital role in increasing the yield. Another reason may be that added vermicompost /FYM/poultry manure in INM would have improved the physical, chemical and biological properties of soil which helps in better nutrient absorption and utilization by plants resulting higher yield. On the contrary, the control treatment T_{22} (no nutrient inputs) exhibited the poorest performance of yield and economics highlighting the critical role of balanced fertilization (Jagraj *et al.,* 2018 and Aravinda *et al.,* 2022). The farmers practice (T_{21}) showed intermediate results, surpassing the control but remaining significantly inferior to T_{20}, likely due to suboptimal nutrient timing and absence of organic-microbial synergies. These results demonstrate that nano urea-based INM (T_{20}) optimizes yield, while unfertilized controls drastically limit productivity. These results are in aligned with Thriveni *et al.* (2015) in bitter gourd and Jagraj *et al.* (2018) in cucumber. It is also evident from the table-1 that the highest net return (₹ 4,77,528.45) and B:C (2.34) was observed in the treatment T_{20} where PM @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + MC was applied followed closely by treatment T_{12} [FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea) + MC] with a pooled net return of ₹ 4,68,012.03 and B:C (2.24). However, the lowest net return was computed in the Treatment T_4 (Vermicompost @ 5 t ha^{-1}) with a pooled value of ₹ 89,286.90 and B:C of 0.36. The significant difference in the B:C ratio in treatment T_{20} [Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + MC] as compared to other treatments may be due to higher yield which might have increased the B:C ratio. The higher B:C ratio in treatment T_1 [Full dose of RDF (N through urea)] may be attributed to the lower cost of cultivation while decrease in B:C ratio despite higher net return in treatment T_{12} [FYM @ 10 t ha^{-1} + ½ of RDF (N through nano urea) + MC] and T_{16} [VC @ 2.5 t ha^{-1} + ½ of RDF (N through nano urea) + MC] may be due to higher cost of inputs (*i.e*., organic manures and microbial consortium). This study is in related with the findings of Moakala *et al.* (2015); Kanaujia *et al.* (2016); Kanaujia and Daniel (2016).

On the basis of findings, it may be concluded that integrated application of Poultry manure @ 5 t ha^{-1} + ½ of RDF (N through nano urea) + Microbial consortium (T_{20}) is considered the best treatment for getting higher yield and economics (net income) in chow chow under Nagaland condition.

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