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Profitability Prospects: Assessing Nano Urea and *Azotobacter* Combined Application in Strawberry Farming

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Abstract

An experiment was performed to evaluate the effect of nano urea in combination with *Azotobacter* on growth, yield and quality of strawberry dv. Winter Dawn. Nano urea, though relatively a new nanotechnology product, has been in use in different crops and ha s reportedly yielded positive results on growth, yield and quality. However, this study also evaluated the impact of reduced conventional application of the chemical fertilizers along with introduction of the nano urea and *Azotobacter* on benefit cost aspects of strawberry cultivation. It was observed that applying 25 per cent of recommended dosage of nitrogen with 400 ppm nano urea along with Azotobacter resulted in maximum benefit cost ratio whencalculated at the prevailing market prices. However, other treatments marked increased cost of cultivation as compared to treatments where reduced RDF of nitrogen was applied. It is evident from the results obtained that application of nano urea can cut down on cultivation expenses and yield good returns in strawberry.

Key words: Benefit cost ratio, economics, strawberry, cultivation, net returns

Introduction

The cultivation of strawberries is a global phenomenon (Bengtsson 2021), with production occurring across diverse climates and regions worldwide (Scanes et al., 2020). The optimal cultivation conditions for strawberries typically include well-drained, sandy loam soils with adequate moisture and sunlight (Kovalenko et al., 2023). Cultivation methods vary depending on the geographic location and available resources (Galati, et al., 2020), but commonly involve planting strawberries in raised beds or mounds to improve drainage and prevent diseases (Desaeger et al., 2022). In regions with temperate climates, such as North America, Europe, and parts of Asia, strawberries are often grown as annual or perennial crops (Hancock, 2020).

The economic status of strawberries worldwide is akin to a vibrant tapestry woven from threads of agricultural innovation, market dynamics, and consumer preferences. With a global market value reaching billions of dollars annually (Arias et al., 2020), strawberries hold a prominent position in the agricultural sector (De et al., 2018). This economic landscape is characterized by a mosaic of large-scale commercial operations, small family farms, and innovative niche producers catering to local and international markets alike. However, beneath this surface of prosperity lie nuanced challenges, including fluctuating prices, labour shortages, and environmental sustainability concerns (Kaushik et al., 2023). The economic landscape of strawberries in India presents a dynamic narrative interwoven with both challenges and opportunities (Mahawar et al., 2019). While strawberries hold immense potential for bolstering agricultural diversification and rural livelihoods (Evans, 2013; Mok et al., 2014), their cultivation in India faces multifaceted hurdles. From climatic constraints to infrastructural inadequacies, the journey of strawberries from field to market is fraught with complexities. However, amidst these challenges, there exists a glimmer of hope.As consumer preferences veer towards healthier food choices (Kowalska et al., 2019), the demand for strawberries is steadily on the rise (Kafkas and Oğuz, 2023). This burgeoning demand not only offers a lucrative market for growers but also stimulates innovation in cultivation (Sashika et al., 2024) techniques and value-added products (Susila et al., 2024). Moreover, strategic interventions by governmental and non-governmental entities are gradually reshaping the economic trajectory of strawberries (Song at al., 2022; Candiz et al., 2023), ushering in a new era of growth and sustainability. Thus, while the economic status of strawberries in India may currently tread a precarious path (Fischer, 2023), it holds the promise of blossoming into a flourishing industry with the right blend of perseverance, innovation, and support (Weltjen, 2021).

Material and methodology

The research investigation took place within the experimental site of the Horticulture department at Lovely Professional University in Punjab, India, spanning two years i.e. 2022 and 2023. Runner-propagated seedlings of the strawberry cultivar 'Winter Dawn' were sourced from ICAR Research Station, Shimla to ensure uniformity and consistency in the experimental setup. Employing a randomized block design (RBD), the study comprised 16 distinct treatments detailed (below), each meticulously replicated thrice to ensure robustness and reliability of the results. The planting methodology involved allocating beds, with a precise spacing of 45 cm x 30 cm between individual strawberry plants. Within each replication, a cohort of 30 plants was maintained per treatment, facilitating an in-depth analysis of the experimental treatments' impact on strawberry economical traits. Dosage of nitrogen was varied among the treatments and for foliar application, nano urea was used in two different concentrations (N_1: 300 ppm Nano Urea and N_2: 400 ppm Nano Urea). All the plants received standard cultural practices as per the recommendations. For estimation of the benefit cost ratio, standard market variables were used to arrive at the cost input for different aspects of cultivation. Benefit: Cost ratio was ascertained using the formula (Saleem et al., 2020)

$$\text{Benefit: cost ratio} = \frac{\text{Net return (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

Treatment details

T_1: RDF (PAU recommendation), **T_2:** 25% RDF + N_1, **T_3:** 25% RDF + N_2, **T_4:** 50% RDF +N_1, **T_5:** 50% RDF + N_2, **T_6:** 75% RDF + N_1, **T_7:** 75% RDF + N_2, **T_8:** 25% RDF + N_1+ *Azotobacter*, **T_9:** 25% RDF + N_2+ *Azotobacter*, **T_{10}:** 50% RDF + N_1+ *Azotobacter*, **T_{11}:** 50% RDF + N_2+ *Azotobacter*, **T_{12}:** 75% RDF + N_1+ *Azotobacter*, **T_{13}:** 75% RDF + N_2+ *Azotobacter*, **T_{14}:** 25% RDF + *Azotobacter*, **T_{15}:** 50% RDF + *Azotobacter*, **T_{16}:** 75% RDF + *Azotobacter*.

Result and discussion

Cost of cultivation

All treatments were evaluated for the economics aspects of cultivation, shown in Table 1 and figure 1. Prevailing market prices served as the basis for determining the conclusive benefit-cost ratios. The interpretation of results employed common cost concepts rooted in agricultural economics. The effect of various treatments had significant results on strawberry cv. Winter Dawn. Maximum cost of cultivation in the first year (987985.43 ₹rupees) was noticed under the treatment T_{13} and T_{11} having cost 987835.43 rupees₹ and 986178.22 rupees, respectively. The control (T_1) was recorded with 970322.65 rupees₹for cost of cultivation while the minimum (965351.01 rupees)₹was noticed under the treatmentT_2 (25% RDF + N_1). In the second-year experiment (2023-24), the maximum cost of cultivation (1005485.43 rupees) was n₹oticed under the treatment T_{13} followed by T_{12} and T_{11} having cost 1005335.43 and 1003678.22₹, respectively (Tabl₹e 2 and figure 2). The control (T_1) was recorded with 987822.65 rupees for cost of cul₹tivation while the minimum (982851.01 rupees) was noticed und₹er the treatment T_2.

Gross income

Maximum gross income (₹4587079.66 rupees) during first year of experiment was noticed under the treatment T_9 followed by T_{11} and T_{10} having gross income 31₹05929.57 and 3005046.02, respectively. The control (T_1) was recorded with 1403₹430.72 rupees of gross income while the minimum (307100₹ rupees) was noticed under the treatment T_{14} (25% RDF + *Azotobacter*). In the second-year experiment (2023-24), the maximum gross income (3865885.8₹ rupees) was noticed under the treatment T_9 followed by T_{11} and T_{10} having gross income 3255537.50 a₹nd 3163282.93, res₹pectively. The control (T_1) was recorded with 1338600.8 of gr₹oss income while the minimum (335042.4) was no₹ticed under the treatment T_{14}.

Net returns

Net returns were maximum (360₹2708.65) was noticed under the treatment T_9 followed by T_3 and T_{11} having gross income 2639166.467₹ and 2209751.35, res₹pectively. The control (T_1) was recorded with 433108.07 rupees₹of net returns while theloss of 676671.01 rupees wa₹s noticed under the treatment T_{14}. In the second-year experiment (2023-24), the maximum net returns (₹ 2864014.79) was noticed under the treatment T_9 followed by T_{11} and T_8 having gross income ₹ 2251859.28 and ₹ 2161561.923, respectively. The control (T_1) was recorded with ₹ 350778.15 of net returns while the loss of ₹ 666228.61 was noticed under the treatment T_{14}.

B: C ratio

Analysis of the input and output factors revealed that during first year of experiment, maximum benefit cost ratio (3.66) was noticed under the treatment T_9 followed by T_3 and T_{11} having benefit cost ratio 2.73 and 2.24, respectively. The control (T_1) was recorded with 0.45 rupees of net returns while the negative B:C ratio -0.69 was noticed under the treatment T_{14} (25% RDF + *Azotobacter*). In the second- year experiment (2023-24), the maximum benefit cost ratio (2.86) was noticed under the treatment T_9 followed by T_{11} and T_8 having B:C ratio 2.24 and 2.16, respectively. The control (T_1) was recorded with 0.36 of benefit cost ratio while the negative B:C ratio -0.67 was noticed under the treatment T_{14}.

The overall results indicate that replacing 75% of conventional urea with 400 ppm nano urea along with *Azotobacter* application was instrumental in achieving maximum B:C ration in strawberry cultivation. In the realm of strawberry cultivation, the integration of nanourea in conjunction with *Azotobacter* presents a multifaceted boon to economic sustainability (Pirzadah et al., 2019; Thirugnanasambandan, 2018), underpinned by its profound implications for yield enhancement and resource efficiency alongside *Azotobacter* in strawberry cultivation represents a ground-breaking frontier in agricultural science, promising multifaceted economic advantages (Viscardi et al., 2016). Nano urea, distinguished by its nano-scale dimensions and heightened solubility (Lakshman et al., 2016), stands poised to revolutionize nutrient management strategies in strawberry farming (Shaifali et al., 2023). Its nanostructure facilitates efficient nutrient delivery (Guo et al., 2018), ensuring enhanced uptake by strawberry plants and minimizing nutrient losses through leaching and volatilization (Rana et al., 2021). Concomitantly, the introduction of *Azotobacter* into the agricultural milieu augments the nitrogen supply through biological nitrogen fixation, circumventing the need for additional nitrogen fertilizers (Mukherjee, 2017). By reducing dependency on synthetic fertilizers, farmers stand to gain substantial economic savings while mitigating environmental repercussions stemming from chemical fertilizer usage.

Table 1 Effect of nano urea in combination with *Azotobacter* on economics of cultivation in strawberry cv. Winter Dawn

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**	**T13**	**T14**	**T15**	**T16**
Fixed cost																
Ploughing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Cloud crushing	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Bed preparation	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Rent of land	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
Interest @ 12%	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
Labour charges	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800
Variable cost																
Drip Irrigation	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
Planting material	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000
Manures and fertilizers	62522.65	57551.01	57701.01	59358.22	59508.22	61165.43	61315.43	76421.01	76571.01	78228.22	78378.22	80035.43	80185.43	75971.01	77778.22	79585.43
Mulcing	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000	50000
Cost of Cultivation	970322.7	965351	965501	967158.2	967308.2	968965.4	969115.4	984221	984371	986028.2	986178.2	987835.4	987985.4	983771	985578.2	987385.4
Returns																
Yield per plant (kg)	0.316	0.458	0.609	0.444	0.458	0.417	0.413	0.465	0.689	0.541	0.576	0.447	0.486	0.138	0.152	0.170
Yield $hectare^{-1}$	23390.51	33896.44	45058.34	32859.11	33910.1	30867.29	30557.98	34431.62	50967.55	40067.28	42612.39	33073.31	35995.63	10236.67	11241.99	12607.89
Sale price	60	80	80	70	70	65	65	85	90	75	75	70	65	30	35	35
Gross Income	1403431	2711715	3604667	2300138	2373707	2006374	1986269	2926688	4587080	3005046	3195930	2315131	2339716	307100	393469.5	441276
Net Income	433108.1	1746364	2639166	1332980	1406399	1037409	1017154	1942467	3602709	2019018	2209751	1327296	1351730	-676671	-592109	-546109
B:C	0.45	1.81	2.73	1.38	1.45	1.07	1.05	1.97	3.66	2.05	2.24	1.34	1.37	-0.69	-0.60	-0.55

Figure 1: Effect of nano urea in combination with *Azotobacter* on economics of cultivation in strawberry cv. Winter Dawn

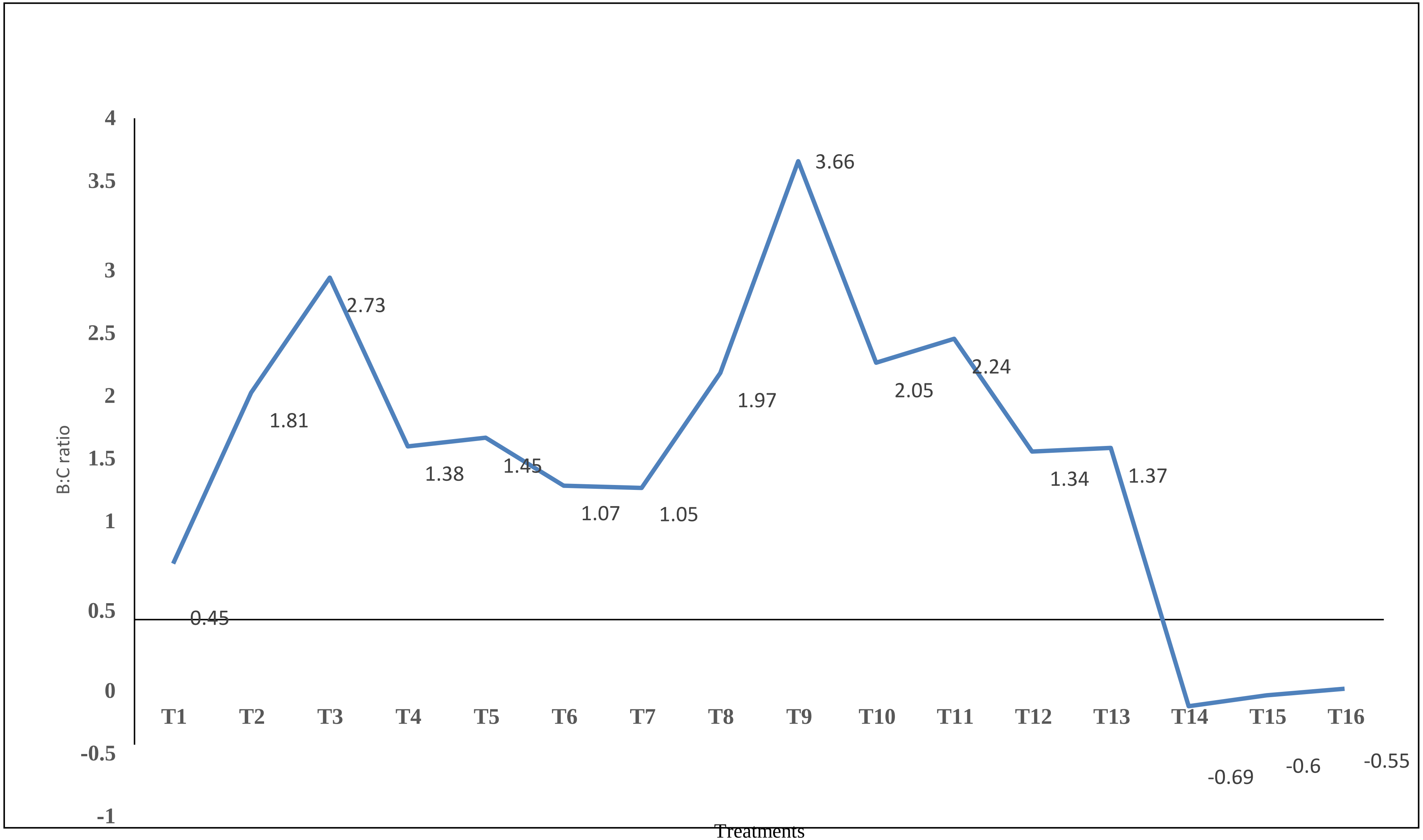

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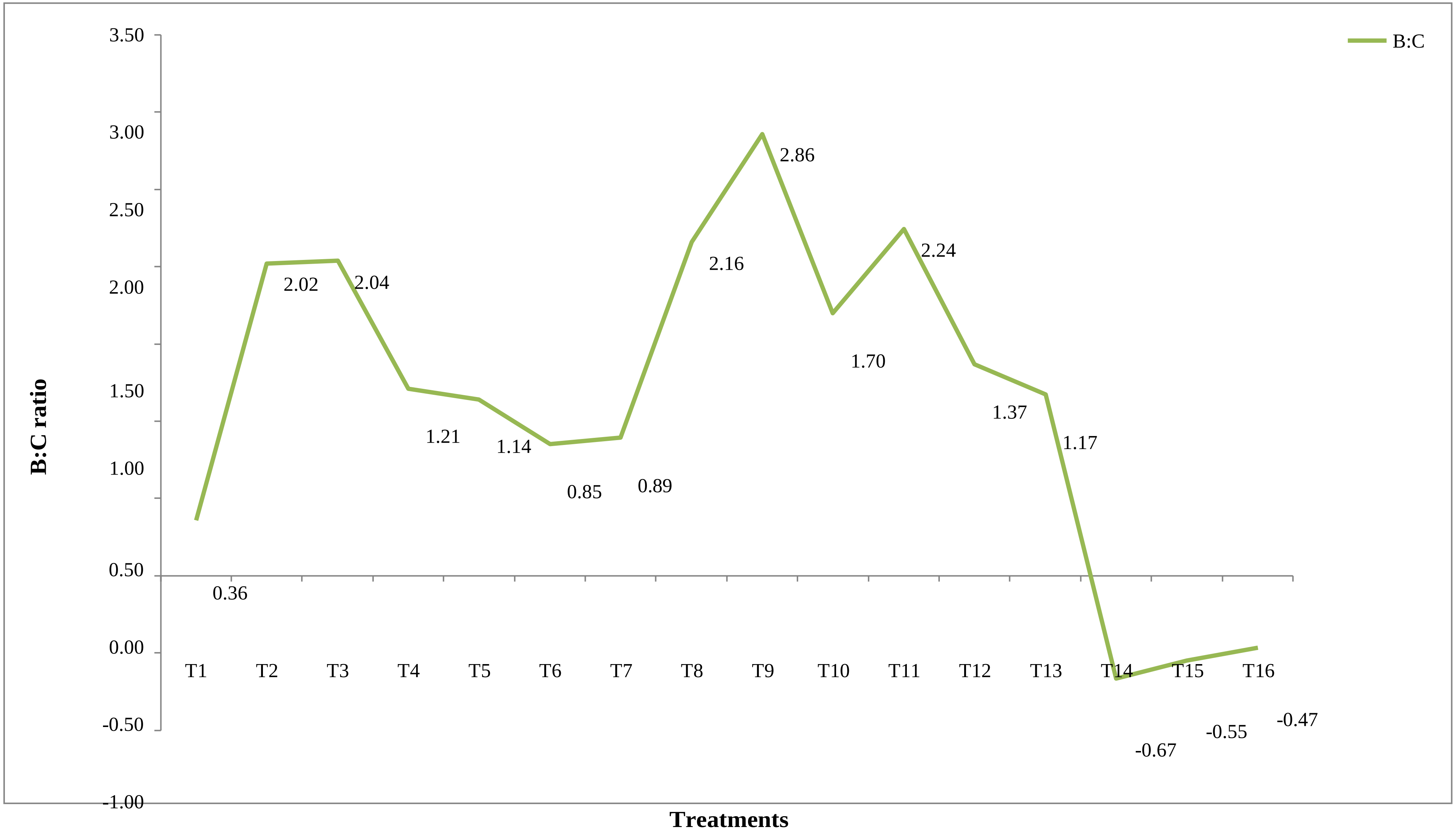
Table. 2 Effect of nano urea in combination with *Azotobacter* on economics of cultivation in strawberry cv. Winter Dawn

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**	**T8**	**T9**	**T10**	**T11**	**T12**	**T13**	**T14**	**T15**	**T16**
Fixed cost																
Ploughing	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Cloud crushing	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Bed preparation	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500	7500
Rent of land	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
Interest @ 12%	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
Labour charges	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800	155800
Variable cost																
Drip Irrigation	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500	87500
Planting material	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000	518000
Manures and fertilizers	62522.65	57551.01	57701.01	59358.22	59508.22	61165.43	61315.43	76421.01	76571.01	78228.22	78378.22	80035.43	80185.43	75971.01	77778.22	79585.43
Mulcing	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000	55000
Cost of Cultivation	987822.7	982851	983001	984658.2	984808.2	986465.4	986615.4	1001721	1001871	1003528	1003678	1005335	1005485	1001271	1003078	1004885
Returns																
Yield per plant (kg)	0.301	0.501	0.504	0.420	0.407	0.379	0.388	0.503	0.580	0.488	0.587	0.460	0.454	0.151	0.175	0.207
Yield hectare^{-1}	22310.01	37067.59	37314.01	31107.63	30090.62	28055.13	28712.49	37215.09	42954.29	36101.89	43407.17	34003.74	33574.29	11168.08	12942.85	15352.04
Sale price	60	80	80	70	70	65	65	85	90	75	75	70	65	30	35	35
Gross Income	1338601	2965407	2985121	2177534	2106343	1823583	1866312	3163283	3865886	2707642	3255538	2380262	2182329	335042.4	452999.6	537321.4
Net Income	350778.2	1982556	2002120	1192876	1121535	837117.8	879696.6	2161562	2864015	1704113	2251859	1374926	1176844	-666229	-550079	-467564
B:C	0.36	2.02	2.04	1.21	1.14	0.85	0.89	2.16	2.86	1.70	2.24	1.37	1.17	-0.67	-0.55	-0.47

Figure. 2 Effect of nano urea in combination with *Azotobacter* on economics of cultivation in strawberry cv. Winter Dawn



Conclusion

Beyond immediate economic gains, the adoption of nano urea and *Azotobacter* holds promise for long-term sustainability in strawberry cultivation. By fostering soil health, minimizing environmental impacts, and enhancing resource use efficiency, this innovative approach aligns with the principles of agro ecological resilience, ensuring the continued viability of strawberry farming amidst evolving climatic and economic challenges. Consequently, the economic benefits derived from nano urea and *Azotobacter* both transcends mere cost savings, heralding a transformative trajectory towards sustainable and profitable strawberry production systems.

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