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Response of coriander (*Coriandrum sativum* L.) variety- Jawahar Dhaniya 1 to foliar application of fertilizers and nano-fertilizers

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Abstract

The study was carried through the *Rabi* season of the year 2021-2022 to observe the response of coriander (*Coriandrum sativum* L.) var. - Jawahar Dhaniya 1, to foliar application of fertilizers and nano-fertilizers on the various growth parameters, yield parameters, quality parameters, nutrient use efficiency and economics of treatments. The study was laid out in randomized block design (RBD) with 13 treatments and 3 replications. The first spraying was done before flowering (50 DAS) and the second spraying was done at the seed formation stage (70 DAS). From the experiment it was observed that treatment T₄ (Foliar spray of 0.25% Nano Urea) produced the maximum plant height (104.06 cm) followed by T₁₂ (100.31 cm) and treatment T₁₂ produced the maximum number of branches per plant (7.33) followed by treatment having foliar spray of 0.25% nano urea (7.00) at physiological maturity. Treatment T₄ also produced the highest number of umbels per plant (33.57), maximum number of umbellets per umbel (6.47), maximum seed yield per plant (5.21g) and maximum seed yield (q/ha) (14.34 q/h). The maximum number of seeds per umbel (41.27) and highest test weight (11.75g) were observed in the treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium). Maximum essential oil content (0.55%) was obtained from control and the highest nutrient use efficiency (42.67%) was observed in treatment T₂ (Foliar spray of 2.0% Urea). The treatment T₄ (Foliar spray of 0.25% Nano Urea) gave the maximum gross monetary return (Rs. 243780/ha) with maximum net monetary return (Rs.68095/ha) and maximum benefit-cost ratio (2.66).

Keywords: Coriander, nano-fertilizers, growth parameters, seed yield, nutrient use efficiency

Introduction

Coriander (*Coriandrum sativum* L.) is one of the first seed spices to be utilized by humans. It is a very old flavouring substance and it is used for its leaves, fruits/seeds and stems. Coriander is an annual herb with chromosome number $2n = 22$ and it belongs to the family Umbelliferae (Apiaceae) which mostly consists of aromatic flowering plants ^[1, 2]. Chinese parsley, cilantro, Arab parsley, Mexican parsley, Yuen sai dhanian and kothmir are some of the other names for coriander ^[3]. There are two morphological types: erect and tall with a relatively stronger main shoot and shorter branches, and bushy with long spreading branches and relatively weaker main shoot ^[4]. Coriander is tropical crop and require cool weather for high and good quality seed yield ^[5]. Coriander has been known to be native of Mediterranean area, but currently it has been cultivated all over the world, particularly in the regions of Central and Eastern Europe, South Asian countries etc. Coriander plant is used in cookery with all its parts. Preparation of dips, sauces and chutneys as well as spice ingredient used in the manufacturing of bakery products, marinating meat or chicken, dressing or garnishing salads, flavouring soda and syrup, preparation of dessert or chocolates and liquors are some of the ways the young plants are used. The coriander seeds are also sources of essential oil (between 0.03 and 2.6%) that is employed as a significant component in perfumery industries.

Coriander oleoresin (1.5%) which is obtained by solvent extraction of coriander is a natural food additive. Vitamins A and C are also found in coriander leaves. Coriander is also used as a flatus-relieving agent and in the manufacturing of various medicines. The fruit is antispasmodial, diuretic, aphrodisiac, refrigerant and stimulant. In India, coriander is a crop

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that is cultivated in all the states of the country but it is the most popular in Madhya Pradesh, Rajasthan, Gujarat, Odisha, Assam, Uttar Pradesh, Chhattisgarh, Bihar, Haryana, West Bengal and Andhra Pradesh [6]. It was found that the area and production of coriander in India in the year 2020-2021 was 6.61 lakh ha and 8.31 lakh tonnes [7]. Coriander seeds were the highest grown in Madhya Pradesh in the fiscal year 2021 with the area and production of 2.96 lakh ha and 4.01 lakh tonnes [7]. From India, coriander seeds, powder, as well as volatile oil are exported to Malaysia, Singapore, Sri Lanka, the United States and the Gulf countries.

Agriculture has been using fertilizers to ensure the health of crops, the issue with the traditional fertilizers is that they take a long time to degrade or deplete in soil which make soil barren. As a result, plants are deprived of crucial nutrients. In addition, nutrient application as directly in soil can also face constraints like leaching and surface runoff [8, 9]. The most promising solution to this dilemma is the nano fertilizers since it is delivered on command; it is site specific, efficient and easily soluble. Nano-fertilizers are nano-materials, which are substances in the nanometer scale consisting of nanoparticles, containing macro and Micronutrients are being used in agriculture to enhance crop production in a controlled manner [10, 11]. Nano fertilisers are also becoming popular in agriculture as a means of enhancing crop production, efficiency of nutrient utilisation and reduction of chemical fertiliser use. Use of nano-fertilizers instead of traditional ones is good since when applied, it supply nutrients into the soil gradually and in a controlled manner thereby avoiding water pollution [12]. Nano-fertilizers stabilize the release of nitrogen, phosphorus and other macro nutrient fertilizers to the plant. It also prevents losses of nutrients and undesired reactions of nutrients with water, air and microorganisms in particular [13]. It has been indicated that, with the use of nano-fertilizers, crop production can increase up to 30%, as compared to using the conventional chemical fertilizers [14]. The foliar application Iron, Zinc and NPK nano-fertilizer on seed yield and morphological characteristics of chickpeas in rainfed conditions revealed that plant heights were elevated by the foliar application of nanofertilizers and had same effect [15] on the number of primary and secondary branches. Moreover, 34 and 12% enhanced the seed yield and the seed weight respectively by foliar application of Fe+Zn nano-fertilizers. The foliar application of NPK and Fe +Zn nano-fertilizers increased plant biomass by 14% and foliar application of Fe nano-fertilizer increased harvest index by 47.12%.

Therefore, the current research was done to evaluate the difference in various growth parameters, yield parameters, quality parameters, nutrient use efficiency and economics of treatments of coriander under application of various fertilizers and nano-fertilizer at various concentrations.

Material and Method

The current study titled “Response of Coriander (*Coriandrum sativum* L.) var. - Jawahar Dhaniya 1 to Foliar Application of Fertilizers and Nano-fertilizers” was conducted in the Rabi season, 2021-2022 in the Vegetable Research Centre, Maharajpur, Department of Horticulture, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.). The study was conducted on randomized block design that consisted of 3 replications and

13 treatments. The details of the treatment are given in table 1.

The field was prepared by two ploughings, followed by the application of 15 t/ha of well-decomposed farmyard manure, which was uniformly incorporated into the soil. The recommended dose of phosphorus and potassium (40:20 kg/ha) was applied at sowing as a basal dose through diammonium phosphate (DAP) and muriate of potash (MOP) respectively. Nitrogen was supplied through urea. In all treatments and replications, top dressing of nitrogen was applied except in treatments T₁, T₂, T₃, and T₄, where only the basal dose of urea was applied at sowing and the remaining nitrogen requirement was fulfilled through foliar application of urea and nano urea. A seed rate of 15 kg/ha was used. Prior to sowing, the seeds were split into two halves by gentle rubbing and treated with *Trichoderma viride* @ 4g per kg seed. Sowing was carried out manually in lines, maintaining a spacing of 30 cm between rows and 10 cm between plants. A light irrigation was given immediately after sowing to ensure proper germination, followed by irrigations at 20-day intervals up to the flowering stage.

Table 1: Treatment Details

Notations	Treatments
T ₁	Foliar spray of 1.5% Urea
T ₂	Foliar spray of 2.0% Urea
T ₃	Foliar spray of 0.20% Nano Urea
T ₄	Foliar spray of 0.25% Nano Urea
T ₅	Foliar spray of 0.20% Zinc
T ₆	Foliar spray of 0.40% Zinc
T ₇	Foliar spray of 0.02% Nano Zinc
T ₈	Foliar spray of 0.04% Nano Zinc
T ₉	Foliar spray of 0.40% Magnesium
T ₁₀	Foliar spray of 0.60% Magnesium
T ₁₁	Foliar spray of 0.04% Nano Magnesium
T ₁₂	Foliar spray of 0.06% Nano Magnesium
T ₁₃	Control

Foliar applications included conventional fertilizers (urea, zinc, and magnesium) as well as nano-fertilizers (nano urea, nano zinc, and nano magnesium). Two sprays were administered: the first at 50 days after sowing (pre-flowering stage) and the second at 70 days after sowing (seed formation stage). Urea was applied at 1.5% and 2.0%, zinc at 0.20% and 0.40%, and magnesium at 0.40% and 0.60%. Nano urea was applied at 0.20% and 0.25%, nano zinc at 0.02% and 0.04%, and nano magnesium at 0.04% and 0.06%.

For recording observations, five plants were randomly selected from each treatment in all three replications. Data were collected in both the field and laboratory as per the experimental requirements. Plant height at harvest was measured in centimeters from the base to the apical growing point at physiological maturity using a meter scale, and the number of branches per plant was counted from the same five tagged plants. The number of umbels was counted at the time of harvest of 5 randomly selected plants from each treatment of each replication and the average value was considered as the number of umbels per plant. At the time of harvesting, umbellets were counted in five randomly selected umbels per plant and the mean value was considered as the number of umbellets per plant. Five umbels were chosen randomly from each selected plant and the seeds were counted. The mean value was considered as

the number of seeds per umbel. After the final winnowing and cleaning of the produce of each plot, from the produce one thousand seeds were counted and these seeds were then weighed on electronic balance and the weight was recorded as the test weight of the plot/ treatment. This process is done for all the treatments of all three replications. The total seed weight of five randomly selected plants was recorded with the help of an electronic weighing machine. The mean values were computed as seed yield per plant and are expressed in grams. Clean seeds are obtained from individual plots after harvesting and winnowing and then the seeds are weighed and the weight is noted in grams per plot. The noted weight is then converted into quintal per hectare for further calculations.

Oil was extracted using the Soxhlet apparatus. First, seeds were taken after harvesting from each treatment. The seeds were air dried in order to obtain 5 g of each sample and placed inside a thimble. 80 ml of petroleum ether was added to the flask. Allow the petroleum ether to boil by placing the entire set on a heating mantle. The extraction procedure is completed in 2 hours. Let the samples cool. The samples subsequently be placed in the oven and then desiccators. At last, weigh the samples and note the weight. The essential oil content is calculated in percentage with the help of the following formula:

$$\text{Fat \%} = \frac{W_2 - W_1}{W} \times 100$$

Where, W1= Weight of the empty collection vessel

W2= Final weight of collection vessel

W= Sample's weight

The nutrient use efficiency was calculated after harvesting with the help of the yield of coriander. At first, the total uptake was calculated for all the treatments of all the replications. Then with the help of total uptake, the NUE was calculated. The following formulas were used for calculating the total uptake and NUE:

$$\text{Total Uptake (kg/ha)} = \frac{\% \text{ Nutrient Content in plant} \times \text{Yield (kg/ha)}}{100}$$

$$\text{NUE (\%)} = \frac{\text{Total Uptake by treated plot} - \text{Total Uptake by control plot}}{\text{Fertilizer Applied in treated plot (kg/ha)}}$$

The total cost of cultivation of coriander was determined by taking into account various field operating expenses including labour, fertilizers, nano-fertilizers, irrigation, machinery etc.

The gross monetary returns were computed by multiplying the current market price (kg^{-1}) of coriander seeds by the total coriander seed yield. Using the coriander market price as of right now, the treatment-by-treatment gross monetary returns are determined.

By subtracting the cultivation costs from the gross return determined by the economic yield for each treatment, the net monetary return was assessed.

The B: C ratio for each treatment was determined by dividing the gross monetary returns by the treatment's cultivation costs.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross monetary returns}}{\text{Cost of cultivation}}$$

Results and Discussion

Tables 2, 3 and figure 1, 2, 3 present the growth, yield, quality, nutrient use efficiency and economic parameters of the evaluated coriander treatments. Data demonstrated that foliar application of nano urea has remarkably influenced the height of the plants. Treatment T₄ (Foliar spray of 0.25% Nano Urea), recorded the maximum plant height of 104.06 cm, followed by treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium) with the plant height of 100.31 cm. Treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium), observed the maximum number of branches per plant (7.33), followed by treatment T₄ (Foliar spray of 0.25% Nano Urea) with 7.00 number of branches per plant.

Nitrogen is important macronutrient in the crop development; nitrogen has a positive impact on the plant height. Under nitrogen, this increment may be due to increase in cell growth. Some of the studies suggested that the exogenous usage of selected nanoparticles might have a considerable positive effect on plant growth [16, 17]. Further, the height of the plant in rice was improved with the incorporation of nano fertilizer with conventional ones even at a reduced rate of application [18, 19]. Like findings provided by [20] who obtained enhanced plant height using 75% NPK and combined nano nutrients of N, P, K, Zn in wheat under experimental conditions. Likewise, Mehta [21] has also recorded the increase in the height of the plant in wheat with NPK application with nano-nutrient (NPK). A test conducted by [22] showed that the maximum height of the plant was recorded in the rice plants treated with 100% Nano-N fertilizer and the lowest was in the no fertilizer group. It was found that the nano urea was superior, since its application showed the highest plant height; of 73.67 cm at 45 DAT, 91.50 cm at 60 DAT, 95.33 cm at 75 DAT and 103.10 cm at 90 DAT, in spring rice [23]. Limited depletion of nitrogen in the soil due to reduced leaching and volatilization in nano urea formulations also help in enhancing plant height [24]. In an experiment conducted on *Vigna sinensis* L., Khalai *et al.* [25] found that the iron composition of 0.25 g/l and nano magnesium possessed the maximum number of lateral branches on a plant. Maximum number of branches can also be significantly influenced by the judicious application of specific nano-fertilizers, leading to enhanced vegetative growth and overall plant architecture [26].

The maximum number of umbels per plant (33.57) was observed in the treatment with foliar spray of 0.25% Nano Urea (T₄), followed by T₁₃ (Control) (32.67). Treatment T₄ (Foliar spray of 0.25% Nano Urea) recorded the highest number of umbellets per umbel (6.47), followed by treatment T₁₃ (Control) to be the second highest (6.37). Maximum number of seeds per umbel (41.27) was observed in the treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium), followed by treatment T₄ (Foliar spray of 0.25% Nano Urea) with the second highest number of seeds per umbel (40.53). The treatment with the foliar application of 0.25% Nano Urea (T₄) recorded maximum seed yield per plant (5.21), followed by treatment T₁₃ (Control) (5.05). The data recorded for seed yield (q/ha) shows the maximum (14.34) seed yield (q/ha) in the treatment T₄ (Foliar spray of 0.25% Nano Urea), followed by (14.13 q/ha) the treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium). The test weight of coriander was recorded maximum (11.75) in the treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium),

followed by (11.70 g) treatment T₄ (Foliar spray of 0.25% Nano Urea).

The same results found in previous studies by [27] also revealed that the 40kg N/ha + 2 sprays of nano urea at 4ml/L applied at the tillering and pre-flowering stage was found to be best in regards to growth, yield parameters and yield of finger millet. Like the current study, [28] found that the combination of 50% RDN by urea and 50 percent N by nano urea favoured the highest grain and straw yield in rice (*Oryza sativa* L.). Nano urea had always shown the highest number of tillers per square meter at 60 DAT (509.13), 75 DAT (379.50) and 90 DAT (287.00) exceeding other treatments in spring rice [23]. The enhanced efficacy of nano-urea can be attributed to its controlled nutrient release mechanism, which optimizes nitrogen uptake and utilization by the plant, leading to superior physiological development and yield metrics [23]. Nano urea is more controlled and targeted in terms of release of nitrogen and thus making sure that the plants when needed absorb the nutrient effectively [29]. 30 kg N/ha + Nano urea was more effective than the other treatments, (215.73 filled grain per panicle (FGPP) and 24.12 g (test weight)) which shows an increase in grain filling and maturation [23]. The above improvement in grain filling can be explained by the special characteristics of nano urea. The nano particles promotes the process of translocation of starch from the actively photosynthesizing regions of the leaves and straw to the developing grains in an efficient manner [30]. This enhanced the efficiency of translocation and is linked to the small size of the particle of nano urea, which can be transported more effectively in the vascular system of the plant. Moreover, nano urea application also led to a high and a long-term availability of nitrogen at the crucial stages of growth [31]. This sustained the presence of nitrogen leading to prolonged duration of increased photosynthetic activity. Based on the results of a research conducted by [32], it has also been reported that nano urea offers a sustained and regulated supply of nitrogen to the plants to guarantee a constant supply of nutrient to the plants. Such a long-term supply of nitrogen had a significant role of maximizing the sun interception to carry out photosynthesis, thus enhancing an increase in the overall photosynthetic efficiency. Essentially, the synergistic effects between the enhanced starch translocation and the controlled nitrogen supply due to the application of Nano urea led to the subsequent increase of the number of grains per panicle. This highlights the potential of nano urea not only in the efficient delivery of nutrients but also in having a positive effect on physiological pathways that are vital to the realization of optimum crop yield.

The maximum essential oil content (0.550%) was observed in treatment T₁₃ (Control), followed by (0.510%) treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium). The highest nutrient use efficiency (42.67%) was observed in treatment

T₂ (Foliar spray of 2.0% Urea), followed by (39.30%) treatment T₁ (Foliar spray of 1.5% Urea). Contrary to the current study, in an experiment which was conducted to study the effect of foliar application of Fe, Zn, and Mn on essential oil, growth and yield of onion plants (*Allium cepa* L.) it is discovered that foliar spray of Zn @ 0.3g/L gave the highest essential oil content in comparison to the other concentrations and fertilizers [33]. In a previous study on nutrient use efficiency (NUE) of wheat (*Triticum aestivum* L.) as affected by NPK fertilizers, including N levels (100, 125, 150 kg/ha N), P levels (25, 50, 75 kg/ha P₂O₅) and K levels (25, 50, 75 kg/ha K₂O). It was observed that the maximum NUE and grain yield was found at @125 kg/ha, N followed by 50 kg/ha K₂O [34].

Data pertaining to economics of the parameters are presented in table 3. Foliar spray of 1.5% Urea (T₁) had the lowest cost of cultivation (Rs. 84685) compared to treatment T₁₂ (Foliar spray of 0.06% Nano Magnesium) which had the highest cost of cultivation (Rs. 130461). The treatment T₄ (Foliar spray of 0.25% Nano Urea) recorded maximum gross monetary return (Rs. 243780). Despite the lowest gross monetary return of 177990 persecuted in the treatment T₁₀ (Foliar spray of 0.60% Magnesium). The net monetary return in treatment T₄ (Foliar spray of 0.25% Nano Urea) was the highest (151007) and the lowest net monetary return was recorded in the treatment T₁₀ (Foliar spray of 0.60% Magnesium). The highest value of B: C ratio was (2.66) recorded in the treatment T₄ (Foliar spray 0.25% Nano Urea) and the lowest value of B: C ratio was (1.61) recorded in the treatment T₁₀ (Foliar spray 0.60% Magnesium).

In an experiment on effect of nano fertilizers on growth, yield and economic of tomato discovered that there were five treatments i.e. T₁ [Farmers Practice(FP) (100% NPK+ 100% Zn application), T₂ [FP (50% N + 100% PK + 50% Zn) + two sprays of Nano N], T₃ [FP (100% NPK + 50% Zn) + two sprays of Nano Zinc], T₄ [FP (100% NPK + 100% Zn)+ Two sprays of Nano Cu], T₅ [FP (50% N+ 100% PK+ 50% Zn)+ 1st spray Nano N + 2nd spray Nano Zn + 3rd spray Nano Cu] @ 4ml / lit water each. The combination (50% N + 100% PK + 50% Zn) + 1st spray Nano N + 2nd spray Nano Zn + 3rd spray Nano Cu] was the most optimum treatment with the highest gross income, highest net returns and highest B: C ratio [35]. Particularly, the interventions that included innovative nitrogen application techniques, including LCC and nano urea, emphasized high-quality economic performance over traditional one. The treatment combining LCC had the highest total return (169,668.90 NRs; 1 USD = 132.37 NRs) and net return (70,477.80 NRs) and a favourable BCR of 1.71. In the same manner, the 30 kg N/ha that was fed on Nano urea reflected high economic returns with a BCR of 1.78 [23]. This resembled the current study since we obtained the best economics in the treatment sprayed with Nano Urea.

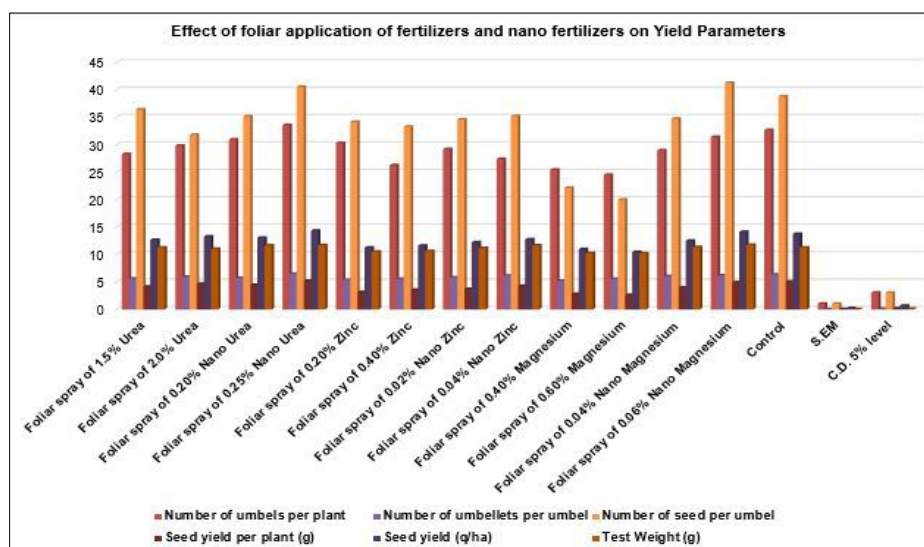
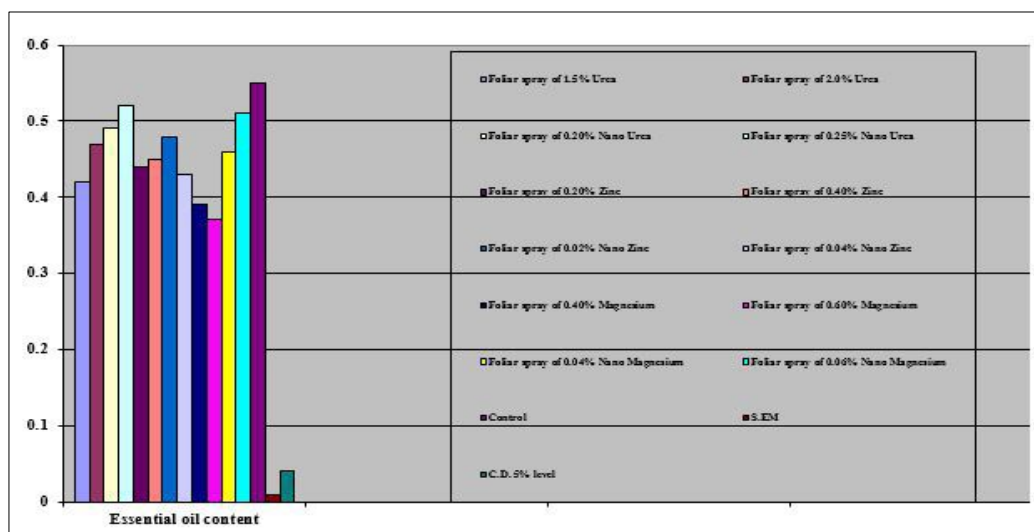
Table 2: Effect of foliar application of Traditional fertilizers and nano-fertilizers on Growth parameters of Coriander

Treatment Details	Plant Height (cm)	Number of Branches (per plant)
Foliar spray of 1.5% Urea	93.38	5.73
Foliar spray of 2.0% Urea	95.53	6.53
Foliar spray of 0.20% Nano Urea	97.74	6.47
Foliar spray of 0.25% Nano Urea	104.06	7.00
Foliar spray of 0.20% Zinc	89.05	5.87
Foliar spray of 0.40% Zinc	91.65	6.40

Foliar spray of 0.02% Nano Zinc	96.54	6.50
Foliar spray of 0.04% Nano Zinc	97.09	6.67
Foliar spray of 0.40% Magnesium	82.23	5.27
Foliar spray of 0.60% Magnesium	90.17	5.13
Foliar spray of 0.04% Nano Magnesium	91.23	6.57
Foliar spray of 0.06% Nano Magnesium	100.31	7.33
Control	98.75	6.87
S.E.M	2.26	0.23
C.D. 5% level	6.58	0.67

Table 3: Effect of foliar application of Traditional and nano-fertilizers on Economic parameters of coriander

Treatment Details	Cost of Cultivation (Rs.)	Gross income (Rs.)	Net Income (Rs.)	B:C Ratio
Foliar spray of 1.5% Urea	84685	218860	130785	2.58
Foliar spray of 2.0% Urea	84766	225760	140994	2.62
Foliar spray of 0.20% Nano Urea	91065	221850	130875	2.43
Foliar spray of 0.25% Nano Urea	92773	243780	151007	2.66
Foliar spray of 0.20% Zinc	101159	191420	90261	1.89
Foliar spray of 0.40% Zinc	117358	197540	80182	1.68
Foliar spray of 0.02% Nano Zinc	100601	208080	107479	2.06
Foliar spray of 0.04% Nano Zinc	116241	217090	100849	1.86
Foliar spray of 0.40% Magnesium	101584	186660	85076	1.83
Foliar spray of 0.60% Magnesium	109895	177990	68095	1.61
Foliar spray of 0.04% Nano Magnesium	115277	212840	97563	1.84
Foliar spray of 0.06% Nano Magnesium	130461	240210	109749	1.84
Control	89961	233920	143959	2.60

**Fig 1:** Effect of foliar application of Traditional fertilizers and nano fertilizers on yield, yield attributing traits and quality parameters in coriander**Fig 2:** Effect of foliar application of traditional and nano-fertilizers on Essential oil in coriander

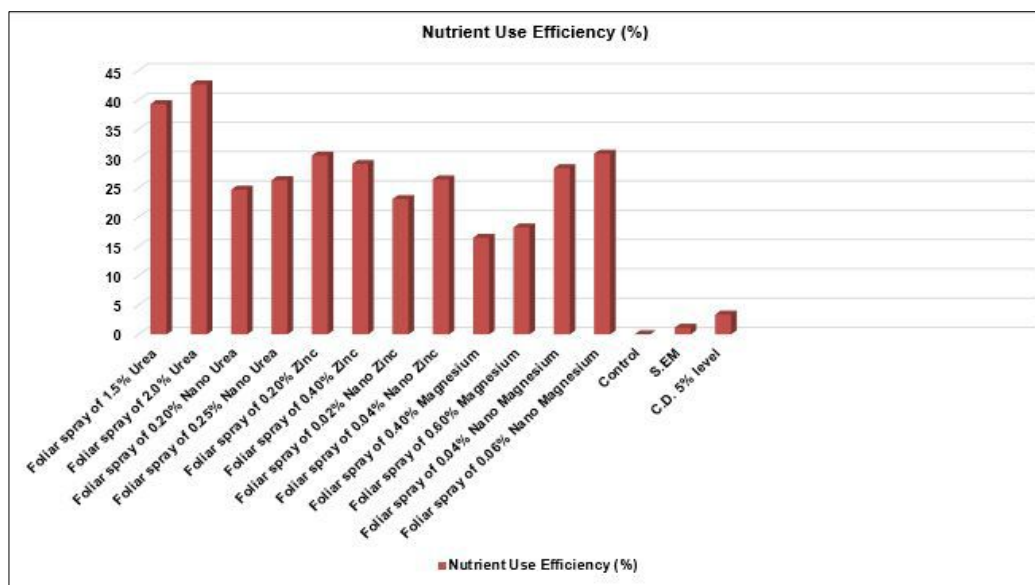


Fig 3: Effect of foliar application of Traditional and nano-fertilizers on Nutrient Use Efficiency in coriander

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