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Efficiency of the Combined Use of Cow Dung and Tea Waste on Seed Germination and Seedling Growth of Coriander (*Coriandrum sativum* L.) in Sandy Regosol

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Abstract - **This study aimed to evaluate the use of cow dung and tea waste as organic fertilizers for seed germination and seedling growth of coriander. The experiment followed a completely randomized design with four replications and seven treatments (T1-T7), representing different ratios of cow dung to tea waste: 0:0 (T1, control), 5:0 (T2), 4:1 (T3), 3:2 (T4), 2:3 (T5), 1:4 (T6), and 0:5 (T7). The results indicated that the application of cow dung and tea waste significantly affected ($P < 0.05$) seed germination and most seedling growth parameters. However, leaf number and shoot length were not significantly influenced. Furthermore, treatments T2 (5:0), T3 (4:1), and T4 (3:2) showed considerable improvements in certain seedling parameters compared to the control (T1). Notably, the T4 treatment exhibited the highest values for seed germination percentage (75%), leaf area (10.15 cm²), fresh leaf weight (115.95 mg), fresh stem weight (153.25 mg), fresh shoot weight (269.70 mg), dry stem weight (18.60 mg), and dry shoot weight (81.10 mg), surpassing the control. Overall, the combined application of cow dung and tea waste at a 3:2 ratio (T4) enhanced seed germination and seedling growth, making it a viable organic amendment for coriander cultivation in sandy regosol soil conditions.**
Keywords: **Cow Dung, Tea Waste, Seed Germination, Seedling Growth, Sandy Regosol**

I. INTRODUCTION

Vegetables and medicinal plants are essential in human diets as they provide various nutrients. Coriander (Coriandrum sativum) is a medicinal herb [1]. It can grow in a wide range of tropical and subtropical regions; however, full sun and fertile, well-drained soils are required for its cultivation as a cool-season herb [2]. Duwal *et al.,* [3] stated that coriander is grown as an annual crop, depending on climatic conditions. It can tolerate heat and drought, but temperatures of 15-25 ºC are optimal for vegetative growth, while 20-30 ºC with cold and dry weather is favorable for seed formation. When cultivated for leaf harvesting, reliable irrigation systems are necessary, particularly in hot conditions. The optimal pH range for coriander growth is 4.5-8.0, with 6.3 being the most suitable [4]. Coriander is a small, bushy herb with a thin stem and alternate, compound leaves. Fresh coriander leaves consist mostly of water, along with proteins, carbohydrates, calcium, phosphorus, iron, and vitamins. One hundred grams of coriander seeds contain approximately 11 g of starch, 20 g of fat, 11 g of protein, and 30 g of crude fiber [5]. Essential oils and extracts of C. sativum exhibit various pharmacological effects, including carminative, diuretic, stomachic, antibacterial, antifungal, and anticancer properties [6]. Linalool, eugenol, and methyl eugenol, which possess antibacterial activity against certain bacteria and fungi, form the basis of coriander's medicinal applications [7]. Additionally, coriander has been reported to exhibit antidiabetic, antioxidant, diuretic, antimicrobial, and anticonvulsant properties [8]. Coriander seed oil has also been used for treating skin diseases and as an ingredient in herbal sunscreens [9].

Agricultural waste can contribute to environmental pollution and soil degradation if not properly managed [10]. Organic manures include animal waste, green manure, domestic waste, and other organic materials. Compost is produced from agricultural waste such as straw, maize stalks, and decayed organic matter [11]. Animal manure contains high levels of NPK nutrients [12] and micronutrients. Incorporating cow dung into the soil enhances fertility by increasing nutrient availability for plant growth. Studies have shown that cow manure significantly improves plant growth and yield [13]. It is an effective alternative to chemical fertilizers, promoting long-term soil productivity and microbial activity [14].

Used tea leaves, tea waste, and coffee grounds are commonly generated organic wastes in households, restaurants, hotels, and snack stands worldwide [15]. Most tea manufacturers recycle waste tea on plantations. Tea waste increases soil acidity due to its caffeine content; however, when mixed with 5% urea and cow dung, it transforms into a beneficial bionutrient and biofertilizer [16]. Ensiling and composting are two biological processes used to maximize the utility of tea waste in the tea industry [17]. Proper nutrient management is essential for achieving optimal crop yields, and organic manures supply both macro- and micronutrients [18]-[20]. In Sri Lanka, cow dung and tea waste are widely available in households and can be utilized to enhance coriander leaf production. This study examines the effects of cow dung and tea waste on seed germination and seedling growth in coriander.

II. MATERIALS AND METHODS

A. Location

This study was conducted from January 2023 to April 2023 to evaluate the effects of cow dung and tea waste application on the germination and seedling growth of coriander. The experiment was carried out at the experimental area of Eastern University, Sri Lanka, located at a latitude of 79° 47'40.2" and a longitude of 81° 34'40.07". The temperature at the experimental site ranges from 24° C to 31° C, with an average annual precipitation of 1687.4 mm. The soil in the study area is classified as sandy regosol.

B. Experiment 1

This study aimed to evaluate the effect of seed soaking time on the percentage of seed germination in coriander (Coriandrum sativum L.). The experiment followed a completely randomized design with five replications and four treatments, corresponding to different soaking durations (0, 12, 24, and 48 hours). Coriander seeds of a local variety, purchased from the Seed Certification Center, Department of Agriculture, Polonnaruwa, Sri Lanka, were used in the study. The seeds were placed in clean cups containing fresh water and soaked for 0, 12, 24, and 48 hours according to the designated pre-soaking times.

Polybags measuring 30 cm in length and 30 cm in width were used for the experiment, and all were filled with sandy regosol soil. The bags were labeled and placed in the experimental area. Ten coriander seeds were sown at a depth of 1-2 cm in each polybag according to the treatments. The number of germinated seeds was recorded daily after sowing, and germination percentages were calculated based on the treatments.

C. Experiment 2

This experiment was conducted to evaluate the effect of cow dung and tea waste on seed germination and seedling growth of coriander. The study followed a completely randomized design with seven treatments (Table I) and five replications.

Cow dung was collected from a cattle farm in Polonnaruwa, and tea waste was collected from households. Both cow dung and tea waste were dried under sunlight and then sieved. Each polybag (25 cm in length and 15 cm in width) was filled with sandy regosol soil, and all polybags were labeled. The seed spacing was maintained at 10 cm × 5 cm for leaf harvesting. Organic fertilizers, including cow dung and tea waste, were applied at a rate of 10 t/ha. Accordingly, each plant received 5 g of cow dung, with or without tea waste fertilizer (Table I). The organic fertilizers were added to each polybag based on the treatments and were thoroughly mixed with the soil. All polybags were prepared and kept for two weeks before seed sowing.

TABLE I TREATMENT USED IN THIS EXPERIMENT

Treatment Code	**Treatments**		**Cowdung and Tea Waste Ratio**
	Cowdung (g/plant)	**Tea Waste (g/plant)**	
T1	0	0	0:0
T2	5	0	5:0
T3	4	1	4:1
T4	3	2	3:2
T5	2	3	2:3
T6	1	4	1:4
T7	0	5	0:5

Seeds of a local coriander variety were collected, and a seed spacing of 5 cm was maintained. Three seeds were sown at a depth of 1-2 cm in each polybag. Irrigation was carried out once a day in the evening from seeding to seedling development. Weeding was performed manually. The number of germinated seeds was recorded daily for 20 days to calculate the germination percentage (%). Germination percentage was determined using the formula: Germination percentage is calculated by dividing the number of germinated seeds by the total number of seeds planted and then multiplying the result by 100.Seedling performance parameters were recorded in the fifth week after seeding. The number of fresh leaves per plant was counted, and shoot length was measured using a ruler from the tip of the terminal bud to the base of the plant. Coriander plants have long taproots, and root length was measured from the top root to the main root tip using a ruler. Leaf area was determined using a leaf area meter. Fresh leaves, stems, and roots were separated, and their fresh weights were measured individually. After recording the fresh weights, the samples were dried in an oven at 105°C for one hour, and the dried weights of leaves, shoots, and roots were measured using an analytical balance.

D. Statistical Analysis

The data were analyzed using SAS statistical software (version 9.1), and treatment mean values were compared using Tukey's test at a significance level of $P = 0.05$.

III. RESULTS AND DISCUSSION

A. Experiment 1

Fig. 1 illustrates the seed germination percentage (%) of coriander seeds after presoaking in water. A significant variation ($P = 0.0006$) was observed among the treatments. The lowest germination percentage was recorded in the 48-hour soaking treatment (S4), followed by the 24-hour soaking treatment (S3), while the highest germination percentage was observed in the 12-hour soaking treatment (S2), followed by the no-soaking treatment (S1) after 14 days of seeding. There was no significant difference between treatments S1 and S2 in terms of coriander seed germination. According to Rhoades [21], seeds may die if they remain in water for too long, and most seeds should be soaked for only 12 to 24 hours, but not longer than 48 hours.

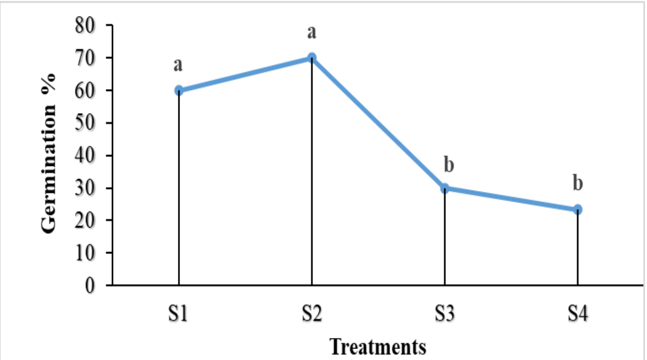

Fig. 1 Response of Presoaking in Water on Seed Germination Percentage of Coriander After 14 Days of Seeding

Means followed by different letters in a row are significantly different based on Tukey's test at P = 0.05.

B. Experiment 2

1. Seed Germination Percentage

The percentages of coriander seed germination across various treatments are shown in Fig. 2. A significant influence (P = 0.0101) was observed on the seed germination percentage. The control treatment (T1) differed significantly (P < 0.05) in seed germination compared to T2 (cow dung alone) and T4 (cow dung and tea waste) treatments. Easha *et al.,* [22] reported that the maximum germination index was found in cow dung vermicompost and matured composts. Seedling development begins with germination.

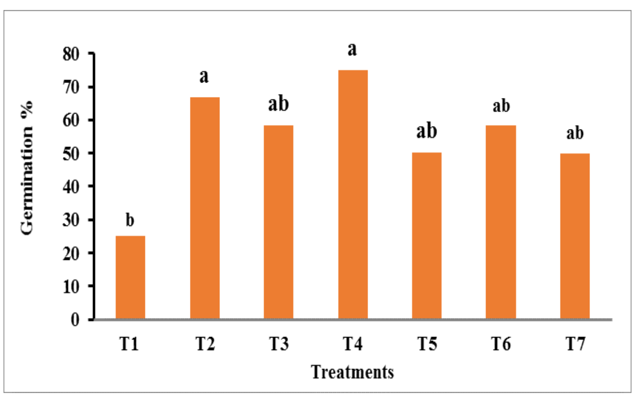

Fig. 2 Response of cow dung and tea waste on seed germination

Azmat *et al.,* [23] stated that seedlings grown in soil containing tea waste, as well as soil mixed with tea waste, exhibited a significant impact on both growth and physiological markers. Strachel *et al.,* [24] reported that compost has a long-term positive effect on the microbiological, biochemical, and physicochemical properties of the soil. In cattle manure-treated soil, increased microbial and enzyme activity indicates enhanced fertility. Therefore, organic manure can be utilized to both increase crop yield and reduce environmental pollution. Enzymes play a key role in various biochemical reactions [25].

Means with different letters in each bar are significantly different based on Tukey's test at P = 0.05.

2. Numbers of Leaves

The number of leaves per plant in each treatment is presented in Table II. No significant variation (P = 0.338) in leaf number per plant was observed in the 5th week after seeding. The highest leaf number was recorded in T4 and T2 (4.3), followed by T3 (4.0), while the lowest leaf number was noted in T5 and T6 (3.5). Tea waste is rich in nutrients and minerals, which enhances yield and quality [26].

3. Leaf Area

Leaf area (cm²) per plant under different treatments is presented in Table II. There was a significant variation (P = 0.0004) in leaf area among treatments. The highest leaf area was recorded in T4 (10.15 cm²), while the lowest was observed in T7 (7.30 cm²). The T4 treatment showed a significant difference compared to other treatments, except for T2. A similar result was reported by Zaman *et al.,* [13], where a consistent improvement in stevia leaf area was observed with higher cattle manure doses. According to Khan *et al.,* [27], a green tea waste-rice bran compost plot produced the largest leaf area, whereas the control plot had the smallest.

TABLE II RESPONSE OF COW DUNG AND TEA WASTE ON LEAF NUMBER PER PLANT AND LEAF AREA IN CORIANDER

Treatments	Number of Leaves	Leaf Area (cm^2)
T1	3.8± 0.3	7.77±0.65c
T2	4.3± 0.3	9.54±0.27ab
T3	4.0± 0.0	8.30±0.35bc
T4	4.3± 0.3	10.15±0.50a
T5	3.5± 0.3	7.54±0.14c
T6	3.5± 0.1	8.26±0.21bc
T7	3.8± 0.5	7.30±0.12c
P value	P=0.338	P=0.0004

Means with different letters in each column are significantly different based on Tukey's test at P = 0.05.

4. Shoot Length

Table III presents the effect of cow dung and tea waste on shoot length (cm) after the 5th week of seeding. The different ratios of cow dung and tea waste did not have a significant effect on shoot length (P = 0.0505). The highest shoot length was recorded in T4 and T7 (3.83 cm), while the lowest was observed in T2 (2.63 cm). Blouin *et al.,* [28] reported the significant effects of vermicompost on plant biomass production in herbs and legumes. Tea waste contains consistent amounts of nitrogen, phosphorus, and potassium, which contribute to the enhancement of vegetative growth and crop yield [29].

5. Root Length

A significant variation (P = 0.0004) in root length was observed at the 5th week after planting (Table III). No significant difference was found between T2 and T7; however, the T1 treatment was significantly different from T2 and T7. The maximum root length was recorded in T7 (6.15 cm), while the minimum was observed in the control treatment (T1) (3.50 cm). Baloch *et al.,* [29] reported that the increase in taproot dimension is due to the positive response of radish to nitrogen. In the study by Wazir *et al.,* [30], used tea waste had a favorable impact on pea plant growth. Tea leaves contain essential elements such as potassium, phosphorus, nitrogen, and tannic acid, which are vital for plant growth. After incorporating tea waste, these elements break down and release nutrients into the soil, enhancing root development.

TABLE III EFFECT OF COWDUNG AND TEA WASTE IN SHOOT AND ROOT LENGTHS OF PLANT

Treatments	Shoot length (cm)	Root length (cm)
T1	3.10±0.24	3.50±0.49b
T2	2.63±0.24	5.88±0.52a
T3	3.13±0.27	5.30±0.45ab
T4	3.83±0.42	3.88±0.55ab
T5	2.75±0.21	4.35±0.62ab
T6	3.35±0.12	4.50±0.17ab
T7	3.83±0.35	6.15±0.50a
P value	P=0.0505	P=0.0004

Means having similar letters/ letters in each column are not significantly varied based on Tukey's test at P=0.05.

6. Leaf Weight

A remarkable influence (P=0.0001) was observed on fresh leaf weight of coriander with various ratios of cowdung and tea waste media (Table IV). Fresh leaf weight was high in T2 (133.15 mg) followed by T3 (124.13 mg). Lowest fresh weight of leaves was noted in T5 (67.23 mg). Significant variation was not observed in leaf weight between T2, T3 and T4 treatments and also T1, T5, T6, T7 treatments. Similar findings were found by Zaman *et al.,* [13], mentioned that fresh weight of leaves was increased gradually with higher cattle manure levels.

Leaf dry weight (g) varied significantly (P = 0.0009) with different ratios of cow dung and tea waste media (Table IV). The highest dry leaf weight was recorded in T2 (19.65 mg), while the lowest was observed in T7 (11.25 mg). The T2 treatment showed a highly significant variation in dry leaf weight (19.65 mg) compared to the control treatment T1 (13.33 mg). A similar result was reported by Sithamparam and Seran [31], where maximum leaf weight was observed at all growth phases when various amounts of phosphate were applied in combination with cattle manure.

TABLE IV RESPONSE OF COWDUNG AND TEA WASTE IN FRESH AND DRY LEAF WEIGHTS

Treatments	Fresh leaf weight (mg)	Dry leaf weight (mg)
T1	71.85±4.82b	13.33±0.76bc
T2	133.15±8.56a	19.65±0.23a
T3	124.13±1.89a	17.20±1.82ab
T4	115.95±5.69a	17.50±1.48ab
T5	67.23±6.87b	11.95±1.81bc
T6	86.85±3.01b	15.43±0.49abc
T7	70.40±1.50b	11.25±0.14c
P value	P=0.0001	P=0.0009

Means having dissimilar letter/ letters in each column are considerably varied based on Tukey's test at P=0.05.

7. Stem Weight

Leaf dry weight (g) varied significantly (P = 0.0009) with different ratios of cow dung and tea waste media (Table IV). The highest dry leaf weight was recorded in T2 (19.65 mg), while the lowest was observed in T7 (11.25 mg). The T2 treatment exhibited a highly significant increase in dry leaf weight compared to the control (T1, 13.33 mg). A similar trend was reported by Sithamparam and Seran [31], where maximum leaf weight was observed at all growth stages when phosphate application was combined with cattle manure.

TABLE V RESPONSE OF THE VARIOUS RATIOS OF COWDUNG AND TEA WASTE ON FRESH AND DRY WEIGHTS OF STEM

Treatments	Fresh stem weight (mg)	Dry stem weight (mg)
T1	108.30±6.95bc	8.50±0.5b
T2	119.55±7.03ab	9.65±0.68ab
T3	119.05±14.07ab	7.98±1.42b
T4	153.75±3.46a	13.60±1.1a
T5	76.88±10.97c	6.88±0.78b
T6	95.18±1.5bc	7.23±0.21b
T7	87.00±3.63bc	6.65±0.70b
P value	P=0.0001	P=0.0003

Means having similar letter/ letters in each column are not considerably varied based on Tukey's test at P=0.05.

Lakmali and Seran [33] stated that the application of cow dung and poultry manure had a significant impact on the fresh stem weight of okra. Different ratios of cow dung and tea waste media significantly influenced dry stem weight (P = 0.0003) (Table V). According to Amanullah *et al.,* [34], at the time of maize silking, fields treated with cattle dung (5 t ha^{-1}) had the highest dry stem weight per plant compared to fields without cattle dung (0 t ha^{-1}). The highest dry stem weight was recorded in T4 (13.60 mg), while the lowest was observed in T7 (6.65 mg). No significant differences were found among T3, T5, T6, and T7 treatments. Furthermore, Halder [35] reported that tea waste was effectively utilized as compost tea and as a growing substrate for mushrooms.

8. Shoot Weight

The cow dung and tea waste media were effective in influencing the fresh shoot weight of coriander (Table VI). A significant variation (P = 0.0001) in fresh shoot weight was observed among different ratios of cow dung and tea waste. The highest fresh shoot weight was recorded in T4 (269.70 mg), followed by T3 (243.18 mg), while the lowest was observed in T5 (144.10 mg). No significant differences were noted among T1, T5, T6, and T7 treatments.

TABLE VI RESPONSE OF COW DUNG AND TEA WASTE ON FRESH AND DRY SHOOT WEIGHTS

Treatments	Fresh shoot weight (mg)	Dry shoot weight (mg)
T1	180.15±11.05b	21.83±1.15bc
T2	252.70±8.25a	29.30±0.85ab
T3	243.18±12.93a	25.18±2.79abc
T4	269.70±5.57a	31.10±2.10a
T5	144.10±16.53b	18.83± 2.46c
T6	182.03±4.23b	22.65±0.65abc
T7	157.40±2.97b	17.90±0.83c
P value	P=0.0001	P=0.0004

Means with dissimilar letters in each column differ significantly based on Tukey's test at P = 0.05.

Table VI presents the dry shoot weight (mg) of coriander under different ratios of cow dung and tea waste. A significant variation (P = 0.0004) was observed in dry shoot weight. The highest dry shoot weight was recorded in T4 (31.10 mg), followed by T2 (29.30 mg), while the lowest was recorded in T7 (17.90 mg). A similar result was reported by Nadarajah and Seran [36], where an increasing trend in dry shoot weight was observed with higher cow manure application. The addition of cow manure may enhance soil health, leading to improved nutrient uptake and better plant performance. Water stress at various developmental stages reduces the biological yield of crops [37]. More than half of the water entering the soil returns to the atmosphere through evapotranspiration [38].

9. Root Weight

Table VII presents the fresh root weight of coriander under different ratios of cow dung and tea waste media. A significant variation (P = 0.0002) was observed in fresh root weight with varying ratios of cow dung and tea waste media. The highest fresh root weight was recorded in T3 (25.5 mg), while the lowest was observed in T4 (9.75 mg). A significant difference was noted between T2 and T4, as a higher amount of cow dung had a greater impact on root growth in T2 than in T4. According to Chen *et al.,* [39], phosphorus-laden engineered biochar derived from cow dung can be reused as a soil amendment to serve as a slow-release phosphorus fertilizer.

Table VII also shows a significant variation (P = 0.0003) in dry root weight with the combined use of cow dung and tea waste. The highest dry root weight was recorded in T2 (3.20 mg), while the lowest dry root weight was observed in T7 (1.20 mg). No significant variation was found among T1, T2, T4, and T6 treatments. A similar result was reported by Esmaielpour *et al.,* [40], who found that the highest root dry weight, based on mean comparison, was obtained from plants grown in a culture medium containing 20% cow manure compost. This was not significantly different from plants grown in a cultivation medium containing 10% compost.

TABLE VII RESPONSE OF COW DUNG AND TEA WASTE ON FRESH AND DRY ROOT WEIGHTS

Treatments	Fresh root weight (mg)	Dry root weight (mg)
T1	13.23±2.15bc	3.00±0.41a
T2	31.83±3.41a	3.20±0.23a
T3	25.55±4.69ab	2.28±0.13ab
T4	9.75±1.27c	2.50±0.29a
T5	16.15±1.70bc	2.28±0.21ab
T6	23.95±1.08ab	2.43±0.07a
T7	18.43± 0.97bc	1.20±0.07b
P value	P=0.0002	P=0.0003

Means having dissimilar letter(s) in each column are significantly different based on Tukey's test at P = 0.05.

IV. CONCLUSION

The combined use of cow dung and tea waste showed a significant effect on some tested parameters of coriander. Experiment 1 indicated that the highest seed germination percentage was recorded in the 12-hour soaking treatment, while the lowest germination percentage was observed in the 24-hour and 48-hour soaking treatments. No significant difference was found between the no-soaking and 12-hour soaking treatments in coriander seed germination. The results of Experiment 2 confirmed that the combined use of cow dung and tea waste had a remarkable effect on seed germination percentage, leaf area, and fresh and dry weights of plant parts. However, the combined use of cow dung and tea waste did not significantly affect (P = 0.0505) shoot length. The 5:0 cow dung to tea waste ratio exhibited a substantial difference from the control treatment (0:0 ratio) in fresh root weight and dry leaf weight, while the 3:2 ratio resulted in relatively higher values for seed germination percentage, leaf area, fresh stem weight, dry stem weight, and dry shoot weight compared to the control treatment. Therefore, a 3:2 ratio of cow dung and tea waste can be recommended for enhancing seed germination and seedling growth of coriander in sandy regosol.

Declaration of Conflicting
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Use of Artificial Intelligence (AI) - Assisted Technology for Manuscript Preparation
The authors confirm that no AI-assisted technologies were used in the preparation or writing of the manuscript, and no images were altered using AI.

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