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EFFECT OF ECO-ENZYME ON GROWTH, YIELD AND QUALITY CHARACTERS OF DIFFERENT CULTIVARS OF RADISH (*RAPHANUS SATIVUS* L.)

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Abstract– The current investigation was done to evaluate the results of applying " Eco-enzyme" on growth, yield and quality of Asiatic and European cultivars of radish in comparison with control. Eco-enzyme, a liquid organic fertilizer was prepared by fermenting certain ingredients such as Jaggery, kitchen waste (fruit peel) and water, which were mixed together in a ratio of 1 : 3 : 10. Experiment was conducted on the agriculture field, LPU, Phagwara in summer, 2023. Radish varieties Pusa Chetki and Scarlet Globe were used as V_1 and V_2 respectively. Experiment was based on FRBD with six treatments which were T0: control (RDF), T_1: 100% Eco-enzyme @ 20 ml/l, T_2: 25% RDF + Eco-enzyme@ 20 ml/l, T_3: 50%RDF + Eco-enzyme@ 20 ml/l, T_4: 75% RDF + Eco-enzyme@ 20 ml/l, T_5: RDF + Eco-enzyme@ 20ml/l and three replications. Eco-enzyme was applied through fertigation at the time of irrigation. In this experiment T_3 recorded highest emergence percentage (80.91%) and fastest days to emergence (8.23) in both the varieties. T_5 recorded highest plant height of 18.84 cm at 30 DAS and highest number of leaves (14.18). T_0 recorded maximum leaf area (107.92 cm^2), root length (20.07 cm), diameter of roots (2.01 cm), fresh root weight (120.42 g), dry root weight (13.38 g) and a total yield of 4.01 ton/ha. T_5 recorded highest ascorbic acid content (16.75mg/100g), T.S.S. (5.16 °Brix), firmness (7.35 kg/cm^2). Best net return (102800/ha) and B : C ratio (2.58 : 1) were observed under the same.

INTRODUCTION

Radish (*Raphanus sativus* L.) is a root vegetable classified under the Brassicaceae family, which includes other vegetables like turnip, cauliflower, mustard greens, broccoli, cabbage, etc. It originated from Europe and some parts of western Asia. The edible part of radish is referred to as fusiform roots. This particular vegetable is consumed worldwide for its crispy, slightly pungent roots and delicate greens. The color of the fusiform roots are generally white but some varieties can be red, pink, purple, white, and even black. They are commonly eaten raw in salads, sliced for sandwiches, pickled, or used as a garnish. From a nutritional perspective, radishes are low in calories but high in fiber, vitamin C, potassium, antioxidants, and dietary fiber, making them beneficial for health. These compounds have the potential to reduce the risk of chronic diseases. The antioxidants present in radish are associated with a wide range of health benefits such as improved digestion, detoxification, and immune support. Apart from these, radish also bears potential medicinal effects.

Radish production in India is significantly grown in various parts of the country. Major growing regions include states like Uttar Pradesh, Bihar, Rajasthan, Maharashtra, Punjab, Haryana, Karnataka, and Tamil Nadu. According to the National Horticulture Database, the total area under radish cultivation in India was 0.212 million hectares during the year 2019-20, with a total production of 2,843 metric tons (National Horticulture Board, 2019). Punjab shares around 11.51% of the total production with 385.15 metric tons.

Radish is a cool-season crop and it matures relatively quickly, usually within 20 to 60 days, depending upon the variety. It requires well-drained soil with moderate moisture and requires full sun or partial shade. They can be sown directly into the soil, and their rapid growth allows for a relatively quick harvest. Several radish varieties are cultivated in India to cater to different preferences and market demands. Radish is cultivated mainly during the winter season in India, from October to March, as it prefers cooler temperatures; however there are some varieties that can be grown during the summer season as well. It is typically grown as an intercrop with other vegetables or as a standalone crop in small-scale farms and home gardens. Common varieties include Pusa Desi, Pusa Himani, Punjab Safed, Pusa Reshmi, Pusa Chetki, and Japanese White. Radish cultivation face challenges such as pest and disease infestations, particularly from flea beetles, root maggots, and fungal diseases like damping-off and downy mildew. Pest incidence mostly occurs during late winter season and during summers. Proper pest and disease management strategies, including crop rotation, use of pesticides, and good agricultural practices, are essential to mitigate these challenges.

Organic radish cultivation involves growing radishes without the use of synthetic pesticides, herbicides or fertilizers. It focuses on maintaining soil health, biodiversity, and ecological balance while producing healthy and nutritious radishes. One of the organic inputs that is having the potential to be utilized for cultivation of radish can be Eco-enzyme also known as Bio-enzyme or Garbage enzyme. Fruits and vegetable wastes are produced in large quantities in market and releases foul odour and release methane gas which causes problems due to improper waste management in municipal landfills (Virtrurtia *et al.* 1989). Eco-enzyme is a multipurpose formulation produced from the fermentation of organic wastes. The main ingredients are fruit or vegetable peel, jaggery and water. In 2006, a researcher from Thailand named Dr. Rosukon Poompanvong developed a solution using organic solid waste especially fruit and vegetable peels and named it Eco-enzyme (Chelliah and Palani, 2015). This enzyme is a composite organic substance made up of organic acids, proteins, and minerals produced by fermentation of waste peels of vegetables, fruits, sugars, and water. Some research states that the eco-enzyme also contains various secondary metabolites such as flavonoid, quinone, saponin, alkaloid, and cardio-glycoside (Cherekar, 2020).

Citrus enzymes that are prepared through proper fermentation of citrus fruits is used as a natural household cleaner, insecticides, organic fertilizer, fruit or vegetable cleaner, etc. It is capable of removing odour and dissolves toxic pollutants released from various forms of air pollution. This formulation is also capable of cleaning ground water and can also retain soil fertility. The production of this enzyme yields significant global environmental benefits. Throughout the enzyme fermentation process, it generates O3 gas, commonly known as ozone, which is a positive contribution to the environment (Rubin, 2001). It is a natural antiseptic and prevents sludge formation (Pinang, 2012). One vital ingredient in eco-enzyme is acetic acid (CH_3COOH), which has anti-microbial properties. The eco-enzyme is acidic and comprises of bio-catalytic enzymes such as lipase, trypsin, amylase, which can kill or prevent pathogenic bacteria (Vika *et al*. 2020).

From an economic point of view, the manufacture of eco-enzymes can reduce dependence on synthetic chemicals used to manufacture cleaning solutions, pesticides, liquid organic fertilizer (Eviati and Solomon, 2009). The application of eco-enzymes as an organic fertilizer treatment for the soil can lead to an augmentation of organic carbon content in the soil. This, in turn, results in an elevation of the Cation Exchange Capacity and pH levels of the soil, thus positively influencing its chemical properties (Sihombing *et al.* 2019). Carbon trioxide or CO_3 present in the eco-enzyme is the prime source of organic carbon capable of increasing soil fertility and stabilizing the soil (Rasit *et al*. 2019). It also contains NO_3^- (Nitrate) which are needed by the soil as nutrients (Vika *et al*. 2020).

Eco-enzymes contain various bioactive compounds, including enzymes, vitamins, and growth regulators, which can stimulate plant growth. It enhances root development, resulting in a stronger root system (Lumbanraja, 2021), leading to increased nutrient uptake and better overall plant vigor (Sultan *et al*., 2022). This can potentially result in taller and healthier plants. It may also improve the productivity of crops by positively influencing flowering, fruit set, and fruit development (Lubabah *et al*., 2022). They can enhance the efficiency of nutrient utilization, leading to increased biomass production and higher crop yields. As a result, the crops grown with eco-enzymes have higher levels of these nutrients, potentially leading to improved nutritional value. It can improve seed germination rates by becoming a protective layer against soil borne and seed borne pathogens (Rochyani *et al.* 2020). This can lead to more uniform and vigorous plant establishment. Besides enhancing various growth parameters, it promotes plant growth by accelerating various physiological processes such as nutrient assimilation, photosynthesis, and hormone synthesis, leading to increased biomass accumulation and faster growth rates (Hasanah *et al*. 2022).

The simplest Eco-enzyme that is usually made easily at home and can be utilized for applying it to garden plants is done by fermenting kitchen waste specifically citrus peels. Jaggery is used as an additive that acts as a catalyst for the fermentation reaction. Jaggery, Kitchen waste (fruit peels) and water are mixed in a container in the ratio of 1:3:10. During the first month, gas is released as the fermentation process proceeds. The pressure built into the container due to accumulation of gases is released daily to avoid breaking of the container. The container needs to be flipped once in a while in order to mix the sediments properly. The containers should be placed in a cool, dry, and well-ventilated place away from sunlight. This fermentation process takes around three months to produce the enzyme. In addition, the application of yeast can fasten the process of fermentation (Thirumurugan, 2016). When the fermentation is done, the end product is detected by its brownish colour. The solution is then filtered after three months to obtain enzyme solutions which can be stored in plastic bottles. A white mold formation can be observed on the top surface of the solution which may be yeast. Eco-enzyme never expires. The longer we keep it, the stronger it will become. The eco-enzyme strength will increase when water is added to make a dilute solution.

MATERIALS AND METHODS

The experiment was carried out at research farm of School of Agriculture, Lovely Professional University, Phagwara (Punjab) during the summer season of 2023. The experiment site is located between 31.224020°N latitude and 75.770798°E longitude at an altitude of 225 meters from mean sea level. The experiment was carried out with 6 treatments and two varieties: V_1: Pusa Chetki, V_2: Scarlet Globe were used. The total number of ridges were 36, length of each ridge was 3 meters.

Field preparation

To attain fine tilth, the field had been ploughed with primary tillage viz. tractor, cultivator and rotavator followed by secondary tillage. The experimental plot was made weed free. After proper levelling, experimental layout was marked and prepared. The Recommended dose of fertilizer was used NPK (50:100:50) kg/hectare.

Soil condition

Most of the soil in the experimental field is composed of sandy loam. To prepare for sowing, soil samples were randomly gathered from the field using a soil auger, reaching a depth of 15 cm. These samples were later combined to form a composite sample, the results are displayed in Table 1.

Table 1. Chemical properties of the soil in the experimental site

S. No.	Composition: Chemical properties	Composition: Content	Method employed
1.	Soil pH	8.03	Glass electrodep Hmeter (Piper, 1966)
2.	Electrical conductivity (dSm^{-1})	0.206	Electrical conductivity meter
3.	Available nitrogen (kg/ha)	252.5 kg/ha	Alkaline permanganate method (Subbaiah and Asija, 1976)
4.	Available phosphorus (kg/ha)	18.5 kg/ha	Olson’s extraction method (Jackson, 1958)
5.	Available potassium (kg/ha)	192.8 kg/ha	Flame photo meter method (Black, 1959)

S.No.	Treatment	Details	Variety 1	Variety 2
1	T_0	Control (100% RDF)	V_1T_0	V_2T_0
2	T_1	20 ml/l Eco-enzyme	V_1T_1	V_2T_1
3	T_2	25% RDF + 20 ml/l Eco-enzyme	V_1T_2	V_2T_2
4	T_3	50% RDF + 20 ml/l Eco-enzyme	V_1T_3	V_2T_3
5	T_4	75% RDF + 20 ml/l Eco-enzyme	V_1T_4	V_2T_4
6	T_5	100% RDF + 20 ml/l Eco-enzyme	V_1T_5	V_2T_5

Treatment details

Treatment application

Urea, single super phosphate and muriate of potash were applied as per treatment at the time of sowing. Eco-enzyme was applied through fertigation once every week all through the duration of the crop. 20 ml of eco-enzyme per litre of water as an optimum dosage was taken into consideration.

RESULTS AND DISCUSSION

The study investigates that the various combination of eco-enzyme and recommended dose of fertilizers on radish cv. Pusa Chetki and Scarlet Globe showed significant results in growth, yield, and quality attributes.

As per the data presented in Table 2, T_5 (100% RDF + 20 ml/l Eco-enzyme) recorded significantly maximum readings in various growth, yield and quality attributes named plant height (18.84 cm), number of leaves (14.18), Chlorophyll content (39.69 SPAD reading), Firmness (7.35 kg/cm^2), T.S.S (5.16) and ascorbic acid (16.75 mg/100g). T_0 (Control) recorded significantly maximum reading in leaf area (107.9 cm^2), fresh root weight (120.42 g), dry root weight (13.38 g), length of roots (20.07 cm), diameter of roots (2.01 cm), root yield per plot (6.72 kg) and total yield (22.41 t/ha). The lowest was recorded in T1 (100% Eco-enzyme) in terms of plant height (12.63 cm), fresh root weight (91.54 g), dry root weight (10.17 g), length of roots (15.26 cm), diameter of roots (1.53 cm), root yield per plot (5.11 kg) and total yield (17.04 t/ha).

This could be because the nitrate contained in eco enzyme is a prime source of nitrogen that is required by the plants during the plants' growth and vegetative phase (Vika *et al*., 2020). The available Nitrogen present in liquid organic fertilizer regulates increasing plant growth, favours leaf growth (Praman *et al*., 2020). The application of eco-enzyme as liquid fertilizer marked significant changes in plant's height, stem diameter, broader leaves as compared to plants under control (Liu *et al*. 2020). Lambanraja *et al*., 2021, found increased pant height in mustard plants when eco-enzyme was applied as a liquid fertilizer in an experiment. He also recorded significant results in other growth parameters such as number of leaves, plant diameter, etc. Sultan *et al*. (2022) found significant results in plant height as well as other growth parameters of shallots due to the effect of eco-

Table 2. Effect of various treatment combinations on growth, yield, and quality attributes of radish (*Raphanus sativus* L.)

Treatment	Plant height (cm)	Number of leaves	Leaf area (cm^2)	Fresh root weight(g)	Dry root weight (g)	Length of roots (cm)	Diameter of roots (cm)	Root yield/ plot(kg)	Total yield (t/ha)	Chloro-phyll content	Firm-ness (kg/cm^2)	T.S.S	Ascorbic acid(mg/ 100g)
T0 (Control:100% RDF)	16.98	13.81	107.9	120.42	13.38	20.07	2.01	6.72	22.41	38.65	7.16	5.02	16.32
T1 (20 ml/l Eco-enzyme)	12.63	13.69	88.08	91.54	10.17	15.26	1.53	5.11	17.04	38.33	7.10	4.98	16.18
T2 (25 % RDF+ 20 ml/l Eco-enzyme)	14.20	13.94	89.76	102.84	11.43	17.14	1.71	5.74	19.14	39.04	7.23	5.07	16.48
T3 (50 % RDF+20 ml/l Eco-enzyme)	15.84	13.58	90.17	108.46	12.05	18.08	1.81	6.06	20.19	38.03	7.04	4.94	16.05
T4 (75%RDF+20 ml/l Eco-enzyme)	16.81	13.70	97.45	113.85	12.65	18.97	1.90	6.36	21.19	38.35	7.10	4.98	16.19
T5 (100%RDF+20 ml/l Eco-enzyme)	18.84	14.18	105.8	118.65	13.18	19.77	1.98	6.62	22.08	39.69	7.35	5.16	16.75
C.D. at 5% (Factor A×B)	2.047	N/A	3.814	7.560	0.839	1.261	0.128	0.710	0.250	N/A	N/A	N/A	N/A
S.E.(d) (Factor A×B)	0.981	1.O22	1.827	3.622	0.402	0.604	0.061	0.037	0.120	2.863	0.531	1.208	0.493
S.E.(m) ± (Factor A×B)	0.694	0.723	1.292	2.561	0.284	0.427	0.043	0.026	0.085	2.025	0.375	0.854	0.349

(RDF: Recommended dose of fertilizers, T.S.S.: Total soluble solids).

enzyme at an optimal dose of 1.75 ml/l. Rana *et al*. (2023) also found significant results in number of leaves in field mustard (*Brassica rapa* L.), when an optimal dose of 10ml/l of eco-enzyme was used as treatment. Eco-enzyme when applied only through foliar application to the leaves damages plant tissues due to less pH, sometimes disrupts the waxy layer over the leaves and nutrient absorption slows down gradually. When fertigation is done, the essential nutrients are carried to the leaves through the roots in certain processed forms, that boosts the absorption process and favours the plant to attain essential quality attributes (Hasanah *et al.,* 2022). Treatments comprising only eco-enzyme or its higher concentration such as T_1 (20 ml/l eco-enzyme) and T_2 (25% RDF + 20ml/l eco-enzyme) recorded less yield because eco-enzymes contain very less amount of available nitrogen as compared to chemical fertilizers, but they possess some capability of supplying some essential nutrients and enzymes that helps in activating some phytohormones that boosts their metabolism, that favours better crop stand (Thanya *et al*., 2023).

The presence of acetic acid in eco-enzymes inhibits the growth of pathogens, maintains the pH of the soil and favours the growth and development of plants and results in increased plant height and number of leaves (Sultan *et al*. 2022). Rahanama *et al*. (2017) found increased chlorophyll index when eco-enzyme was applied through fertigation. Eco-enzyme treated plants showed proper growth and development, having broader stems, increased plant height, more number of leaves that were greener as compared to the plants treated according to control. Hence, it's very obvious to assume the presence of increased chlorophyll content by the influence of eco-enzyme. According to Firmansyah *et al*. (2017), the available nitrogen for plants is responsible for bringing direct effect on protein formation and as a part of chlorophyll formation to the leaves. Nasution's (2020) stated that organic acid can stimulate and increase the growth of roots and increase plant membrane permeability. Additionally, organic acid also helps microorganism activity above the soil, producing growth hormones.

In interaction between the varieties, V_2 (Scarlet Globe) responded better with eco-enzyme than V_1 (Pusa Chetki) in terms of growth, yield and quality parameters. This could be because varieties of plants play an important role and are very susceptible to the environment and also vary in its characteristics due to certain genetic factors. Differences in plant growth can be caused due to the inherited characters of each parent. Moreover, coupled with adaptation to the environment will produce different phenotypes (Devy *et al*. 2021).

CONCLUSION

Based on the findings of current study, it was determined that the application of T_5 consisting of 100% RDF + 100% Eco-enzyme showed the superior results in various growth attributes like days to emergence, emergence percentage, plant height, number of leaves and in quality attributes like firmness, total soluble solids, ascorbic acid. T_0 (Control) showed maximum reading in leaf area, fresh root weight, dry root weight, length of roots, diameter of roots and yield parameters such as root yield per plot and total yield. In term of interactions with both varieties V_1, V_2 the application of T_5 (100% RDF + 20ml/l Eco-enzyme), reported the superior performance. After evaluating all the parameters and treatments, it was determined that V_2T_5 showed best performance.

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