Eco. Env. & Cons. 28 (January Suppl. Issue) : 2022; pp. (S420-S428)
Copyright@ EM International
ISSN 0971–765X

http://doi.org/10.53550/EEC.2022.v28i01s.059

Effect of Vermiwash on the growth of *Capsicum annuum*

Kulkarni Rajender Rao, Juliana Silveira, Naik Anjali, Naik Sneha, Raikar Sutisha and Rekdo Savita

Department of Zoology, Government College of Arts. Science and Commerce, Quepem, Goa, India

(Received 19 August, 2021; Accepted 21 September, 2021)

ABSTRACT

Earthworms have a critical influence on the soil structure, forming aggregates and improving the physical conditions for the plant growth and nutrition uptake. Earthworms consume large quantities of organic matter such as agro waste, kitchen waste, nitrogen rich materials like cattle dung and excrete casts which have several growth promoters,enzymes which enrich the soil with bacteria and vesicular arbuscular mycorrhizae (VAM) beneficial for the plant growth.Vermiwash is a liquid manure collected from the compost unit after the passage of water through a column of worm action and is useful both as foliar spray or for soil application. In the present investigation an attempt was made to study the effect of vermiwash on the growth parameters of chilli plant *Capsicum annuum.* In plot 4 with vermiwash and drip irrigation technique maximum increase in growth parameters such as root length 11.0 cm, stem length 70.0 cm, number of leaves 120.0, side root length 05.0 cm leaf length 06.5 cm, leaf width 03.2 cm, number of flowers 46.0, number of chillies 43.0 were observed and established with nearly perfect correlation coefficient of 0.992. between root length and stem length.

Key words : *Earthworms, Growth promoters, Liquid manure, Vesicular, Arbuscular mycorrhizae.*

Introduction

The earthworms play important role in breaking down the organic waste substrates, stimulate microbial activity greatly and increase rates of mineralization (Atiye *et al*., 2000). Earthworms are long tubular organisms; eat about 2 times of their body weight daily. The burrowing and casting activities of earthworms can affect the porosity, aeration, water dynamics, structural stability and formation of soil profile (Gebeyehu and Bayissa, 2020). They play vital role in mixing the soil and organic matter. Utilization of earthworms and its natural activity minimize the nutritional problems of crops and plants to a great extent, thus helps in improving soil fertlity (Justin and Leelamathi, 2008). Vermitechnology is an essential part of organic farming; Organic cultivation ensures that the farms remain fertile for years. Organic manures are easily biodegradable and do not cause environmental pollution (Verma *et al*., 2017).

Capsicum annuum is the domesticated species native to Southern North America and Northern South America. India is a major producer, exporter and consumer of the chilli. It is grown in almost all the states. It prefers a warm humid climate during early stages and a dry weather towards the maturity of the pods. As a rain fed crop, it is grown in areas receiving an annual rainfall of 75 to 100 cm. Excessive rain fall causes defoliation and rotting. June- October is the most suitable period for growing chilli in India. Maximum temperature required for *Capsicum annuum* is ranging between 20 ^{o}C to 30 ^{o}C and a minimum temperature not below 10 degree centigrade. During summer, high temperatures causes flower and fruit drop resulting poor fruit set. Chilli

is grown in many types of soil, sandy to heavy clay.The light soils produce better quality than heavy soils. Chilly crop prefers the soil pH 6 to 7. However it is grown on soil of pH 5 in coastal areas to pH 9 in vertisols in India.

Vermiwash is a collection of excretory products and mucous secretion of earthworms along with micronutrients from the soil organic molecules. These are transported to the leaf, shoot and other parts of the plant in the natural ecosystems. Major portion of earthworm's body is filled up with the coelomic fluid, which helps in respiration. Coelomocytes, granulocytes, lymphocytes present in the coelomic fluid, helps in healing of wounds and gives imitation power. No pathogens can survive in this fluid, thereby protecting earthworms from the diseases caused by pathogens. Sayyad (2017); Vermiwash is rich in soluble nutrients; nitrogen, phosphorous and potash are the main nutrients. Hormones such as cytokines, auxins, enzymes, vitamins and amino acids that stimulate the growth and yield of crops are present in the vermiwash.

Vermiwash is a bio fertiliser and act as growth promoter in a wide variety of plants. Mujeera Fathima and Malathy Sekar (2014) studied the growth promoting effects of vermiwash in seed germination and seedling. There are various organic manures such as vermicompost, farmyard manure, coir pith compost used to increase in yield and quality of crops. Use of liquid fertilizers has gained importance recently. For its unique capacity to provide nutrients effectively and quickly vermiwash is used in organic farming, Vermiwash collected by the passage of water through a column of worm activation is generally used as a foliar spray or directly poured at the plants roots in the soil. Drip irrigation is used to save water by providing water directly at the roots to prevent evaporational loss (Suryavanshi *et al*., 2015). Few reports on the use of Vermiwash and its growth promoting effects are available in the literature. (Suresh and Anandan, 2011) (Sundararasu *et al.,* 2014);

Present investigation is carried out to analyse the impact of vermisaline on the various growth parameters of *Capsicum annuum*. Though the responses are positive there is variation in response to different concentrations of vermiwash in *Capsicum annuum*, hence it is important to standardize the concentration of vermiwash based on the crop to which it is to be used.

Methodology

From agricultural Department healthy chilli *capsicum annuum* seeds were procured. The seeds were sown in troughs with very little quantity of water added only once in the morning till the germination of the seeds. After germination of the seeds in about 10 days the quantity of the water was increased. Plants were grown in the trough for another 10 days with full care and protection from pests, All of them attained same root, shoot length and almost same number of leaves (8-9) were selected for transplantation.

A plot of 600 cm x150 cm was prepared for transplantation. As per the protocol the area of cultivation is divided into 4 sub plots with 20 plants in each sub plot. A distance of 30 cm is maintained between two plants. The plots were treated as mentioned below.

PLOT.I – Normal irrigation. Vermiwash was not used. 20 litres of water was released in channels by normal irrigation technique.

PLOT.II – Drip method. Plants are irrigated directly at the roots by drip method.

PLOT. III – Normal irrigation + Vermiwash-20 litres of water was released in channels by normal irrigation technique. 50 ml of 20% Vermiwash was poured to each plant.

PLOT IV- Drip method + Vermiwash. Plants are irrigated with Vermiwash directly at the roots by drip technique.

After every two weeks two plants from each plot were removed. Average root length, stem length, number of leaves, leaf length, leaf width, number of flowers, number of chillies were recorded. Results were analysed for comparative growth analysis. Karl Pearson coefficient of correlation between root length and stem length was calculated to establish effectiveness of vermiwash and drip method in *Capsicum annuum.*

Standard deviation of root length (x) = $\sqrt{\frac{\Sigma X^2}{n} - \left(\frac{\Sigma X}{n}\right)^2}$

Standard deviation of stem length (y) = $\sqrt{\frac{\Sigma y^2}{n} - \left(\frac{\Sigma y}{n}\right)^2}$

Covariance of (X,Y) = $\frac{\Sigma XY}{n} - \left(\frac{\Sigma X}{n}\right)\left(\frac{\Sigma Y}{n}\right)$

Karl Pearson's coefficient of correlation (r) = $\frac{cov(x,y)}{\sigma x\ \sigma y}$

Results

In the present investigation with the *Capsicum annum* (chillies) plant, the root length, stem length, number of leaves, leaf length, leaf width, side root length, number of flowers, and fruits were measured at an interval of two weeks.

Plot 1. Normal irrigation method: In normal irrigation method on day 1 of transplantation the root length was 2 cm,stem length was 8 cm, number of leaves were 8, side root length was 0.8 cm,leaf length with 1.8 cm, leaf width was 0.6 cm, number of flowers were 0 and number of chillies were 0.

On day 14, of transplantation the root length was 2.2 cm, stem length was 14cm, number of leaves were 18, side root length was 1 cm, leaf length was 2 cm, leaf width was 0.8 cm, number of flowers was 0 and number of chillies was 0.

On day 28, of transplantation the root length was 2.3 cm, stem length was 16 cm, number of leaves were 25, side root length was 1 cm, leaf length was 2.5 cm, leaf width was 1 cm, number of flowers was 0 and number of chillies was 0.

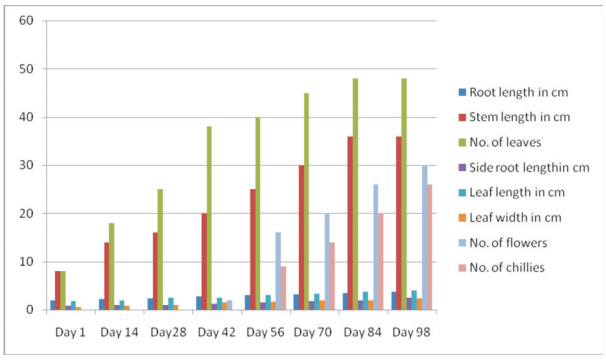
On day 42, of transplantation the root length was 2.8 cm, stem length was 20 cm, number of leaves was 38, side root length was 1.2 cm, leaf length with 3 cm, leaf width was 1.5 cm, number of flowers was 2 and number of chillies was 0.

On day 56, of transplantation the root length was 3 cm, stem length was 25 cm, number of leaves were 40, side root length was 1.5 cm, leaf length was 3 cm, leaf width was 1.6 cm, number of flowers were 16 and number of chillies were 9.

On day 70, of transplantation the root length was 3.2 cm, stem length was 30 cm, number of leaves were 45, side root length was 1.8 cm, leaf length was 3.3 cm, leaf width was 1.9 cm, number of flowers were 20 and number of chillies were 14.

On day 84, of transplantation the root length was 3.5 cm, stem length was 36 cm, number of leaves were 48, side root length was 2 cm, leaf length was 3.8 cm, leaf width was 2 cm, number of flowers was 26 and number of chillies were 20.

On day 98, of transplantation the root length was 3.8 cm, stem length was 36 cm, number of leaves was 48, side root length was 2.5 cm, leaf length was 4 cm, leaf width was 2.3 cm, number of flowers were 30 and number of chillies were 26.(Table.1) (Graph 1)



Graph 1. Growth parameters of plot I.

Plot 2. Drip irrigation method: In Drip irrigation method on day 1 of transplantation the root length was 2 cm, stem length was 8 cm, number of leaves were 9, side root length was 0.8 cm, leaf length was 1.8 cm, leaf width was 0.6 cm, number of flowers were 0 and number of chillies were 0.

On day 14, of transplantation the root length was 2.5 cm, stem length was 16 cm, number of leaves weer 22, side root length was 1.2 cm, leaf length was 2 cm, leaf width was 0.8 cm, number of flowers were

Table 1. Growth Parameters of Plot. I

S. No.	Observation day	Root length in cm	Stem length in cm	No. of leaves	Side root lengthin cm	Leaf length in cm	Leaf width in cm	No. of flowers	No. of chillies
1	Day 1	02.0	08.0	08.0	00.8	01.8	00.6	00.0	00.0
2	Day 14	02.2	14.0	18.0	01.0	02.0	00.8	00.0	00.0
3	Day28	02.3	16.0	25.0	01.0	02.5	01.0	00.0	00.0
4	Day 42	02.8	20.0	38.0	01.2	02.5	01.5	02.0	00.0
5	Day 56	03.0	25.0	40.0	01.5	03.0	01.6	16.0	09.0
6	Day 70	03.2	30.0	45.0	01.8	03.3	01.9	20.0	14.0
7	Day 84	03.5	36.0	48.0	02.0	03.8	02.0	26.0	20.0
8	Day 98	03.8	36.0	48.0	02.5	04.0	02.3	30.0	26.0

0 and number of chillies were 0.

On day 28, of transplantation the root length was 2.9 cm, stem length was 24cm, number of leaves was 34, side root length was 1.8 cm, leaf length with 2.5 cm, leaf width was 1 cm, number of flowers was 2 and number of chillies was 0.

On day 42, of transplantation the root length was 3.2 cm, stem length was 29 cm, number of leaves was 46, side root length was 2 cm, leaf length with 2.5 cm, leaf width was 1.6 cm, number of flowers was 9 and number of chillies was 5.

On day 56, of transplantation the root length was 4 cm, stem length was 30 cm, number of leaves was 50, side root length was 2.3 cm, leaf length with 3 cm, leaf width was 1.8 cm, number of flowers was 15 and number of chillies was 12.

On day 70, of transplantation the root length was 5 cm, stem length was 34 cm, number of leaves was 58, side root length was 2.5 cm, leaf length with 3.5 cm, leaf width was 2 cm, number of flowers was 28 and number of chillies was 20.

On day 84, of transplantation the root length was 5.5 cm, stem length was 40 cm, number of leaves was 60, side root length was 3 cm, leaf length with 4 cm, leaf width was 2.2 cm, number of flowers was 30 and number of chillies was 28.

On day 98, of transplantation the root length was 06 cm, stem length was 45 cm, number of leaves was 69, side root length was 3.2 cm, leaf length with 4.2 cm, leaf width was 2.5 cm, number of flowers was 35 and number of chillies was 28.

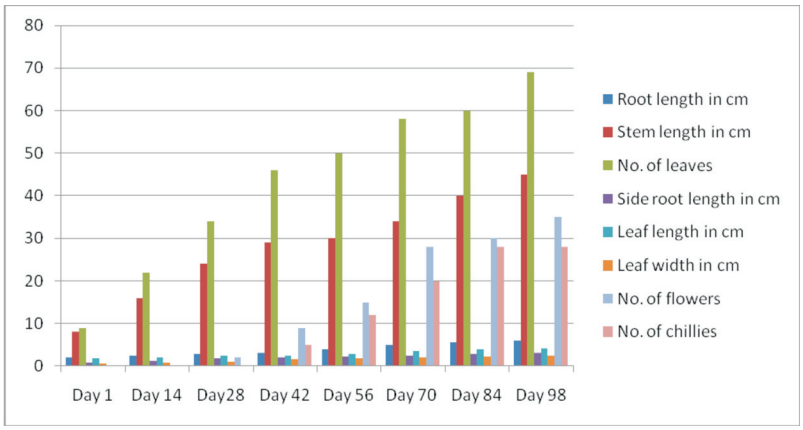
Day 1 02.0 08.0 10.0 00.8 01.8 00.6 00.0 00.0

Plot 3.Normal irrigation + Vermiwash method.

In this method on day 1 of transplantation the root length was 2 cm, stem length was 8 cm, number of leaves was 10, side root length was 0.8cm,leaf length with 1.8 cm, leaf width was 0.6 cm, number of flowers was 0 and number of chillies was 0.

On day 14, of transplantation the root length was 2.9 cm, stem length was 15 cm, number of leaves was 25, side root length was 1.5 cm, leaf length with 2.5 cm, leaf width was 0.8 cm, number of flowers was 0 and number of chillies was 0.

On day 28, of transplantation the root length was 3.4 cm, stem length was 28cm, number of leaves was



Graph 2. Growth parameters of plot II.

Table 2. Growth parameters of plot II.

S. No.	Observation day	Root length in cm	Stem length in cm	No. of leaves	Side root length	Leaf length in cm	Leaf width in cm	No. of flowers	No. of chillies
1	Day 1	02.0	08.0	09.0	00.8	01.8	00.6	00.0	00.0
2	Day 14	02.5	16.0	22.0	01.2	02.0	00.8	00.0	00.0
3	Day28	02.9	24.0	34.0	01.8	02.5	01.0	02.0	00.0
4	Day 42	03.2	29.0	46.0	02.0	02.5	01.6	09.0	05.0
5	Day 56	04.0	30.0	50.0	02.3	03.0	01.8	15.0	12.0
6	Day 70	05.0	34.0	58.0	02.5	03.5	02.0	28.0	20.0
7	Day 84	05.5	40.0	60.0	03.0	04.0	02.2	30.0	28.0
8	Day 98	06.0	45.0	69.0	03.2	04.2	02.5	35.0	28.0

33, side root length was 1.8 cm, leaf length with 2.9 cm, leaf width was 1 cm, number of flowers were 4 and number of chillies were 1.

On day 42, of transplantation the root length was 4.1cm, stem length was 36 cm, number of leaves was 45, side root length was 2.5 cm, leaf length with 3.2 cm, leaf width was 1.8 cm, number of flowers were 12 and number of chillies were 10.

On day 56, of transplantation the root length was 4.8 cm, stem length was 42 cm, number of leaves was 59, side root length was 3 cm, leaf length with 3.4 cm, leaf width was 2.2 cm, number of flowers were 20 and number of chillies were 16.

On day 70, of transplantation the root length was 5.4 cm, stem length was 58 cm, number of leaves was 62, side root length was 3.6 cm, leaf length with 3.7 cm, leaf width was 2.5 cm, number of flowers were 26 and number of chillies were 22.

On day 84, of transplantation the root length was 6.1 cm, stem length was 60 cm, number of leaves was 69, side root length was 4 cm, leaf length with 4.3 cm, leaf width was 2.7 cm, number of flowers were 36 and number of chillies were 30.

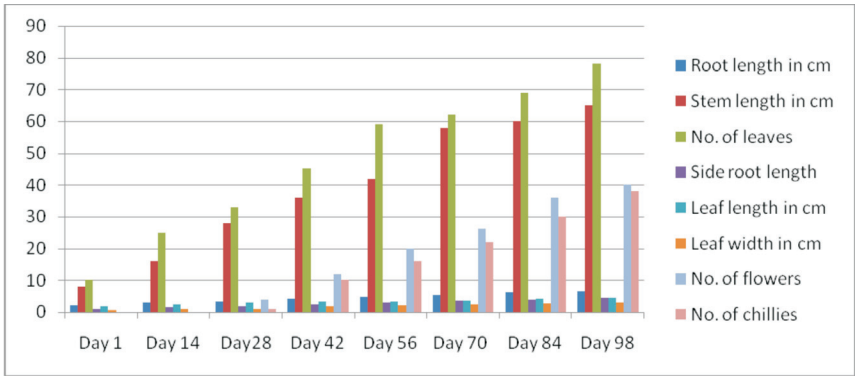
On day 98, of transplantation the root length was 6.5 cm, stem length was 65 cm, number of leaves was 78, side root length was 4.5 cm, leaf length with 4.5 cm, leaf width was 3 cm, number of flowers was 40 and number of chillies was 38.

In this method on day 1 of transplantation the root length was 2 cm, stem length was 8 cm, number of leaves was 10, side root length was 0.8cm,leaf length with 1.8 cm, leaf width was 0.6 cm, number of flowers was 0 and number of chillies was 0.

On day 14, of transplantation the root length was 3.5 cm, stem length was 18 cm, number of leaves was 25, side root length was 1 cm, leaf length with 2.5 cm, leaf width was 0.9 cm, number of flowers were 0 and number of chillies were 0.

On day 28, of transplantation the root length was 4,2 cm, stem length was 28 cm, number of leaves was 38, side root length was 2.1 cm, leaf length with 3 cm, leaf width was 1.1 cm, number of flowers were 6 and number of chillies were 2.

On day 42, of transplantation the root length was 5.7 cm, stem length was 36 cm, number of leaves was 51, side root length was 3.2 cm, leaf length with 3.7 cm, leaf width was 1.8 cm, number of flowers were 15 and number of chillies were 12.



Plot 4. Vermiwash + drip technique method.

Table 3. Growthparameters of plot III.

S. No.	Observation day	Root length in cm	Stem length in cm	No. of leaves	Side root length	Leaf length in cm	Leaf width in cm	No. of flowers	No. of chillies
1	Day 1	02.0	08.0	10.0	00.8	01.8	00.6	00.0	00.0
2	Day 14	02.9	15.0	25.0	01.5	02.5	00.8	00.0	00.0
3	Day28	03.4	28.0	33.0	01.8	02.9	01.0	04.0	01.0
4	Day 42	04.1	36.0	45.0	02.5	03.2	01.8	12.0	10.0
5	Day 56	04.8	42.0	59.0	03.0	03.4	02.2	20.0	16.0
6	Day 70	05.4	58.0	62.0	03.6	03.7	02.5	26.0	22.0
7	Day 84	06.1	60.0	69.0	04.0	04.3	02.7	36.0	30.0
8	Day 98	06.5	65.0	78.0	04.5	04.5	03.0	40.0	38.0

On day 56, of transplantation the root length were 6.6 cm, stem length was 42 cm, number of leaves was 62, side root length was 3.6 cm, leaf length with 4.5 cm, leaf width was 2.6 cm, number of flowers were 24 and number of chillies were 23.

On day 70, of transplantation the root length was 7.8 cm, stem length was 55 cm, number of leaves was 76, side root length was 3.8 cm, leaf length with 5.2 cm, leaf width was 2.9 cm, number of flowers were 32 and number of chillies were 28.

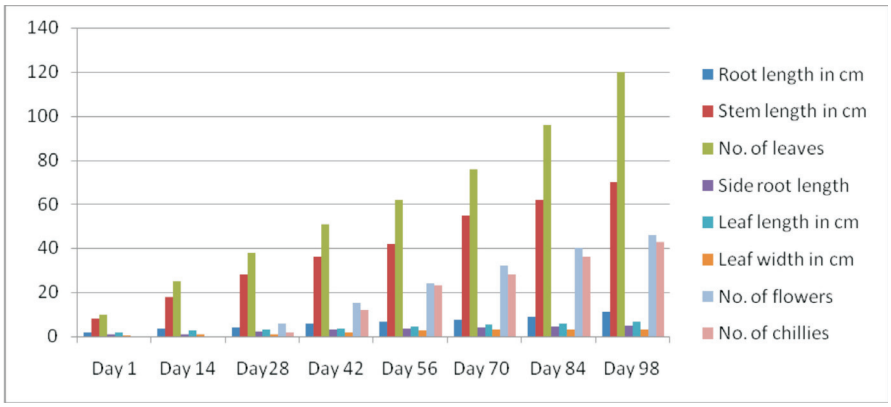
On day 84, of transplantation the root length was 9 cm, stem length was 62 cm, number of leaves was 96, side root length was 4.5 cm, leaf length with 5.8 cm, leaf width was 3 cm, number of flowers were 40 and number of chillies were 36.

On day 98, of transplantation the root length was 11 cm, stem length was 70 cm, number of leaves was 120, side root length was 5 cm, leaf length with 6.5 cm, leaf width was 3.2 cm, number of flowers was 46 and number of chillies was 43. The results were further evidenced by calculating correlation coefficient between root length (s) and Shoot length (y) for different plots shows that maximum correlation coefficient for plot 4 of drip technique and vermiwash, minimum for plot 1 of normal irrigation. Plot 2 is moderate and plot 3 is having better growth than plot 1 and plot 2.

Discussion

Green-revolution aimed at providing food necessary for ever growing human population significantly increased, agricultural production, yield per hectare, by improving soil fertility through additional application of fertilizers and pesticides.

Chemical fertilizers are relatively inexpensive, and are rapidly taken up by plants Chen (2006). Larcheveque *et al.* (2011) concluded that artificial chemical fertilizers yield higher growth and root development compared to organic manure in a poplar plantation in clay soil. The effects of chemical fertilizer and organic manure treatments on the growth of yellow poplar seedlings and soil characteristics was investigated by Si Ho Han *et al.* (2016). Chemical fertilizers decreased all the vital nutrients needed for plant growth in the long run. Excess use of fertil-



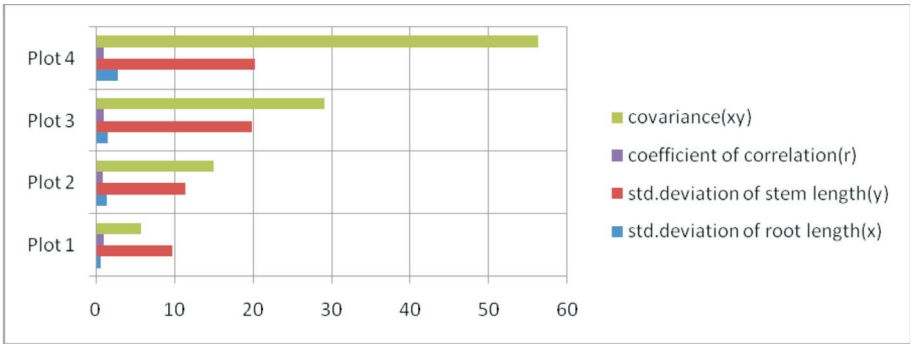
Graph 4. Growth parameters of plot IV

Table 4. Growth parameters of plot IV.

S. No.	Observation day	Root length in cm	Stem length in cm	No. of leaves	Side root length	Leaf length in cm	Leaf width in cm	No. of flowers	No. of chillies
1	Day 1	02.0	08.0	10.0	00.8	01.8	00.6	00.0	00.0
2	Day 14	03.5	18.0	25.0	01.0	02.5	00.9	00.0	00.0
3	Day28	04.2	28.0	38.0	02.1	03.0	01.1	06.0	02.0
4	Day 42	05.7	36.0	51.0	03.2	03.7	01.8	15.0	12.0
5	Day 56	06.6	42.0	62.0	03.6	04.5	02.6	24.0	23.0
6	Day 70	07.8	55.0	76.0	03.8	05.2	02.9	32.0	28.0
7	Day 84	09.0	62.0	96.0	04.5	05.8	03.0	40.0	36.0
8	Day 98	11.0	70.0	120.0	05.0	06.5	03.2	46.0	43.0

Table 5. Statistical analysis between root length (s) and Stem length (y) for different plots.

Caculations	PLOT.I	PLOT.II	PLOT.III	PLOT.IV
Root length Ó.X	00022.800	00031.100	00035.200	00049.800
Stem lengthÓ.Y	00185.000	00226.000	00312.000	00319.000
Ó.XY	00573.400	00998.400	01605.600	02436.000
$Ó.X^2$	00067.900	00136.150	00172.440	00372.780
$Ó.Y^2$	05033.000	07418.000	15322.000	16001,000
Std.deviation of Root length(x)	00000.604	00001.380	00001.481	00002.801
Std.deviation of stem length(y)	00009.713	00011.366	00019.855	00020.251
Covariance (x,y)	00005.768	00014.978	00029.100	00056.278
Karl Pearson's Coefficient of correlation (r)	00000.983	00000.954	00000.989	00000.992



Graph 5. Statistical analysis between root length (s) and Stem length (y) for different plots.

izers resulted in surface and ground water pollution, killing of useful microbes, acidification of the soil (Zainal *et al.*, 2021). In contrast, organic manure significantly increased the soil characters such as pH, nitrogen, available phosphorus, exchangeable potassium, calcium, and magnesium (Anggita *et al.*, 2018). Green Revolution resulted in great economic prosperity during its early years supporting overall economy of the nations. Unscrupulous use of fertilizers and pesticides resulted in Air, water and soil pollution, killed beneficial insects and wildlife. Uncontrolled wides pread irrigation practices depleted the soil nutrients thus decreased soil fertility. Sustainable agriculture aims at improvement of both soil and plant health, productivity of the crops, leading to the enrichment of the surrounding ecology (Gabriel *et al.*, 2013).

Earthworms are crucial in regulating the biogeochemical cycles by making nutrients such as nitrogen, phosphorous, and potassium easily available to plants and water cycle by making drilospheres that allow water to flow more rapidly down through the soil profile and also increasing water holding capacity and porosity of the soil.

Organic farming has become one of the popular methods of farming. Organic farming is a far deeper concept than mere non-chemicalization, though organic food is grown without the use of synthetic chemicals, such as fertilizers and pesticides. Mishra *et al.* (2015); Demand for organic foods is increasing day by day as the large segment of population showing inclination towards organic foods considering them as healthier and safer. Worm worked soils have burrows or drilosheres richly inhabited with useful bacteria. Water passing through these passages washes the nutrients from these drilospheres to the roots to get absorbed by the plants (Boyhan and Stone, 2016).

Surface irrigation is the traditional form of irrigation in the agriculture. Evaporation, percolation before reaching roots results in huge loss of water in this type of irrigation. Drip technique is an advanced system of the micro irrigation, which provides effective irrigation method as water supplied directly around the roots of plant and reduces the loss of water by evaporation (Kaarthikeyan, Suresh, 2019). It plays a major role in water conservation, increased crop production and utilize each and every drop of water supplied.

These studies have confirmed that both manure

compost and vermicompost usually has compelling beneficial effects on plant growth. However, there have been very few experimental investigations exploring effects of vermiwash applications on plant growth. Palanichamy *et al.,* 2011) Spinach and Onion growth on administration of vermiwash, was found to be significantly higher when compared to control group. No significant effect was observed on the plants of potato (Ansari, 2008). The effect of vermiwash was observed on okra by Ansari and Kumar (2010).

Our main objective was to investigate the effects of vermiwash applications on growth, yield and fruit quantity of *Capsicum annuum*. Present investigation shows that in plot I with normal irrigation technique plant growth was slow as compared to the other three plots due to lack of vermiwash. In plot II the growth was good as compared to the first plot due to the continuous supply of water at the roots of the plants directly by Drip irrigation technique. Plot III better growth was recorded, however excellent growth parameters were recorded in plot IV with vermiwash and drip irrigation. These results are in perfect accordance with the earlier investigations by Hemant *et al.* (2013) and (Wang *et al.,* 2017). They have reported that vermiwash sprayed on the tomato plants, showed a significant growth of plants, such as, shoot length, number of leaves. Studies on growth promoting effects of vermiwash on the germination of vegetable crops reported similar results by Mujeera Fathima and Malathy Sekar (2016). Nearly perfect correlation was obtained between Growth of roots and stem, in the present study of effect of vermiwash on *Capsicum annuum* indicating supply of essential micro and macro nutrients from vermiwash.

Conclusion

Organic farming aims at not only reducing the cost of production but also provides us with chemicals free healthy foods, which are in great demand in today's market. Organic manure helps in increasing soil pH, the concentrations of nitrogen, phosphorus, and major cations, thus overall soil fertility. In the present investigation, in experimental plots vermiwash response to the plant growth was highly significant; this may be due to increased availability of more exchangeable nutrients in the soil by the application of vermiwash.

Acknowledgements

Authors are grateful to Dr. Joydeep Bhattacharjee, Principal for his constant motivation. Shri.B.S. Prabhu, from Krishi Vignyan Kendra, South Goa. Directorate of Agriculture, Government of Goa, Shri. Ehrlich Barretto, Associate Professor in Mathematics, Shri. Rahul Kulkarni for their help during the study period.

References

Anggita, T., Muktamar, Z. and Fahrurrozi, F. 2018. Improvement of selected soil chemical properties and potassium uptake by mung beans after application of liquid organic fertilizer in Ultisol." TERRA/ : J Land Restoration 1: 1–7.

Ansari, A.A. 2008. Effect ofVermicompost and Vermiwash on the Productivity of Spinach (Spinaciaoleracea), Onion (*Allium cepa*) and Potato (*Solanum tuberosum*. *World Journal of Agricultural Sciences.* 4 (5): 554-557

Ansari, A.A. and Kumar Sukhraj, 2010. Effect of vermiwash andvermicompost on soil parameters and productivity of okra (*Abelmoschuses culentus*) in Guyana. *African Journal of Agricultural Research.* 5(14) : 1794-1798.

Atiyeh, R. M. S., Subler, C. A., Edwards, G. Bachman, Metzger, J. D. and Shuster, W. 2000. Effects of vermicomposts and composts on plant growth in horticultural container media and soil. *Pedobiologia.* 44 : 579–590.

Boyhan, G.B. and Stone, S.P. Breeding for organic and sustainable production. In: Nandwani D, editor. Organic farming for sustainable agriculture. *Sustainable Development and Biodiversity.* 9 Cham, Switzerland: Springer; 2016. p. 123–136

Chen, J.H. 2006. The combined use of chemical and organic fertilizers and/or biofertilizer for crop growth and soil fertility. In International Workshop on Sustained Management of the soil-rhizosphere system for efficient crop production and fertilizer use; 2006.

Gabriel, D.G., Sait, S.M. and Kunin, W.E. 2013. Food production vs. biodiversity: comparing organic and conventional agriculture. *J Appl Ecol.* 50:355–364.

Gebeyehu, H.R. and Bayissa, L.D. 2020. Levels of heavy metals in soil and vegetables and associated health risks in Mojo Area, Ethiopia. *Plos One.* 15 : 1-22.

Hemant Samadhiya, Puneeta Dandotiya, Jaya chaturvedi and Agrawal, O.P. 2013. Effect of vermiwash on the growth and development of leaves and Stem of tomato plants. *International Journal of Current Research.* 5 (10) : 3020-3023.

Jayabhaye, M.M. and Bhalerao, S.A. 2015. Influence of Vermiwash on Germination and Growth Param-

eters of Seedlings of Green gram (*Vigna radiata* L.) and Black gram (*Vigna mungo* L.). International *Journal of Current Microbiology and Applied Sciences.* 4(9): 635-643.

Justin, C.G.L. and Leelamathi, M. 2008. Role of earthworm in sustainable Agriculture. *Agrobios Newesletter.* VII(2): 33-34.

Kaarthikeyan, G. M. and Suresh, A. 2019. A Study on Understanding the Adoption of Water Saving Technology: A Case Study of Drip Irrigation. *International Journal of Recent Technology and Engineering (IJRTE).* 7(6) : 1123-1130.

Larcheveque Marie and Annie Desrochers and Guy, R. Larocque, 2011. Comparison of manure compost and mineral fertilizer for hybrid poplar plantation establishment on boreal heavy clay soils. *Annals of Forest Science.* 68 : 849–860.

Mishra, K., Singh, K. and Tripathi, C.P.M. 2015. Organic farming of rice crop and management of infestation of Leptocorisavaricornis through combined effect of vermiwash with biopesticides. *Research Journal of Science and Technology.* 7(4) : 205-211.

Mujeera Fathima and Malathy Sekar, 2016. Studies on Growth Promoting effects of Vermiwash on the Germination of Vegetable Crops Int. *J. Curr. Microbiol. App. Sci.* 3(6) : 564-570.

Palanichamy, V., Mitra, B., Reddy, N., Katiyar, M., Rajkumari, R.B. and Ramalingam C. 2011. Utilizing Food Waste by Vermicomposting, Extracting Vermiwash, Castings and Increasing Relative Growth of Plants. *International Journal of Chemical and Analytical Science.* 2(11) : 1241-1246

Sayyad, N.R. 2017. Utilization of vermiwashpotential against insect pests of tomato. *International Research Journal of Biological Sciences.* 6(1) : 44-46.

Si Ho Han, Ji Young An, Jaehong Hwang, Se Bin Kim and Byung Bae Park 2016. The effects of organic manure and chemical fertilizer on the growth and nutrient concentrations of yellow poplar (*Liriodendron tulipifera* Lin.) in a nursery system. *Forest Science and Technology.* 12(3) : 137-143.

Sundararasu, K., Jeyasankar, A., Tharmaraj, K., Ganesh, P., Kolanjinathan, K. 2014. Effect of vermiwash on growth and yield of brinjal, *Solanum melongena*. *Asian Journal of Science and Technology.* 5 (3) : 171-173.

Suresh, K.R. and Anandan, A. 2011. Influence of vermicompost and vermiwash on physico chemical properties of rice cultivated soil. *Current Botany.* 2(3): 18-21.

Suryavanshi, P., Buttar, G. S. and Brar, A. S. 2015. Micro irrigation for sustainable agriculture: a brief review. *Indian Journal of Economics and Development.* 11(1) : 147-155.

Verma, S., Singh, A., Pradhan, S.S., Singh, R.K. and Singh, J.P. 2017. Bioefficacy of Organic Formulations on Crop Production- A Review. *International Journal of Current Microbiology and Applied Sciences.* 6(5) : 648-665.

Wang X.X., Zhao, F., Zhang, G., Zhang, Y. and Yang, L. 2017. Vermicompost Improves Tomato Yield and Quality and the Biochemical Properties of Soils with Different Tomato Planting History in a Greenhouse Study. *Front. Plant Sci.* 8 : 1978.

Zainal Muktamar, Bandi Hermawan, Wulandari, Priyono Prawito, Sigit Sudjatmiko, Nanik Setyowati, Fahrurrozi Fahrurrozi and Mochammad Chozin, 2021. Vermicompost Buffering Capacity to Reduce Acidification of Pb and Cd Contaminated Inceptisols and Entisols. *J Trop Soils.* 26(1): 1-9.