Evaluation of The Possibility of Establishing Certain Organic Cultivation Packages as Nutrient Sources for Chamomile (*Matricaria chamomilla* L.) Cultivation at Temperate Region of Uttarakhand, India

ABSTRACT

An utmost attempt was made to investigate the response of Chamomile (*Matricaria chamomilla* L.) to certain types and doses of organic manures at under open condition at temperate regions of Uttarakhand during the year 2019-2020. The study comprised of varying levels of three different organic manure sources namely, FYM, compost and vermicompost, along with a check treatment replicating thrice having plot having dimensions 1 m× 1 m with a spacing of 20 cm × 20 cm. The experiment was laid out in a randomized complete block design (RCBD). Forty-five (45) days old chamomile seedlings (attained about 10-15 cm in height) were transplanted during October, 2019 under open field condition. The soils of the experimental site were tested favourable with respect to some of the basic physical and chemical properties. The results revealed that maximum plant height (48.26 cm), number of branches per plant (35.40) and plant spread (33.09 cm) were significantly higher under T_4 (FYM @ 25 t/ha) application at 180 days after transplanting. Application of T_{10} (VC @ 4 t/ha) produced early flowering (119.73 days). At bud initiation stage the highest total fresh (33.12 q/ha) and dry (7.59 q/ha) biomass yield were found in T_4 (FYM @ 25 t/ha). At flowering stage maximum value of total fresh (60.02 q/ha) and dry (12.70 q/ha) biomass yield were found in T_{10} (VC @ 4 t/ha). The results, further revealed that T_{10} provided the fastest crop growth rate (0.86 g/m^2/day). The highest number of flowers per plant (139.73), fresh flower yield (67.35 q/ha), dry flower yield (13.95 q/ha) and maximum cost : benefit (1:3.56) were obtained in plots which received FYM @ 25 t/ha. All the organic input treatments performed better over control and the treatment FYM @ 25 t/ha shall be recommended for profitable organic cultivation of chamomile.

Keywords: Chamomile (*Matricaria chamomilla* L.), FYM, compost, vermicompost, crop growth rate, flower yield, chlorophyll, cost : benefit

Introduction

Chamomile (*Matricaria chamomilla* L.) is annual, aromatic, herbal plant known as true chamomile or German chamomile which belongs to the Asteraceae family having chromosome number 2n=18 (Farooqi *et al.*, 2001). It is native to southern and eastern Europe. Chamomile widely distributed in Europe, Asia, Africa and America, and it has both autumn and spring varieties. Chamomile has medicinal properties, anticonvulsant, anti-inflammatory, antispasmodic, relaxing, antirheumatic, carminative, antiseptic bandages, antibacterial, treatment of acne, insomnia, gastric ulcer prevention and treatment (Kawthar *et al.*, 2017). In addition to pharmaceutical uses, the oil is extensively used in perfumery, cosmetics, aromatherapy and in food industry. studied that the essential oil present in the flower heads contains chamazulene and is used in perfumery, cosmetic creams, hair preparations, skin lotions, tooth pastes, and also in fine liquors (Gowda *et al*., 1991). The dry flowers of chamomile are also in great demand for use in herbal tea, baby massage oil, for promoting the gastric flow of secretion, and for the treatment of cough and cold. Chamomile as medical plant is allegedly compatible with a wide range of climates and soils (Das *et al.,* 1998). The use of organic fertilizer for growing medicinal plants is widespread due its beneficial effects in the soil, providing organic matter, improving physical structure and directly influencing its water holding capacity and water availability for plants. Moreover, organic fertilizers contribute to greater stability of nutrients through mineralization process, are an energy source for soil microorganisms and provide macro and especially micronutrients for plants (Frederickson *et al.,* 1997). Madadi *et al.* (2022) reported that chamomile, by increasing the level of oxidants and osmolytes and reducing cell division and viability extracts, could disrupt and decrease the growth of flixweed suggesting natural herbicidal effects to suppress flixweed. Further, they also claimed that chamomile could be planted as a preceding crop in rotation with wheat to reduce flixweed competition with wheat. Wang *et al.* (2023) through a preliminary study reported that an organic compound derived from chamomile (*Chamomila recutita* L.) which is called 2-Cyclopenten-1-one (CCO), can inhibit the soil urease activity and nitrification as well and thereby has the latent to serve as a dual-function inhibitor for decreasing fertilizer-induced N losses and increasing N use efficiency, simultaneously. Their study further elaborated that, the ability of CCO to reduce N losses and improve maize yield was potentially superior to DCD (dicyandiamide), NBPT (thiophosphoric triamide), or the combination of DCD and NBPT. Compared with the urea treatment, the addition of CCO significantly reduced urease activity and nitrification, which subsequently increased the content of NH_4^+-N and decreased the content of NO_3^--N in the soil during the maize growth period. Moreover, the cumulative NH_3 and N_2O emissions, global warming potential (GWP) and greenhouse gas intensity (GHGI) of the maize field were lowest from the CCO applied plots during the growth season, decreasing by 32.5 %, 21.94 %, 7.69 % and 20.92 %, respectively, compared to urea treatment. Notably, CCO application significantly reduced the abundance of ammonia-oxidizing archaea and bacteria in soil.

Organic fertilizers are naturally available mineral sources that contain moderate amount of essential plant nutrients. Organic fertilizers can be natural (manure and slurry) or processed, such as compost, blood meal and humic acid, natural enzyme-digested proteins, fish meal, and feather meal etc. (Shaji et al., 2021). Organic fertilizers act as slow-release fertilizers, in a sense, they provide nutrients in lower amount over an extensive time period and have the advantages for improving soil (microbiological, physicochemical, and biochemical) properties and thus influence soil quality; helping in replenishing the loss in organic matter in short- and long-term periods and thus maintain soil fertility; enhancing the existing soil nutrients, and thereby healthy growth is achieved with minimum nutrient densities; and minimizing environmental degradation without reducing crop yields and achieve sustainable levels of agriculture production (Shaji et al., 2021). Favourable effects of arbuscular mycorrhizal fungi (AM fungi) as an organic nutrient source have been reported by some researchers. Katarzyna *et. al.* (2019), reported higher aboveground and underground mass including mass of raw material in chamomile (*Matricaria recutita* L.). Further, Eulenstein *et al.* (2017) quoted the enhancement in growth and dry matter production after application of AM fungi. Also, AM fungi is reported to accelerate decomposition and acquisition of nitrogen directly from organic material (Hodge et al., 2001), increase plant growth (Urcoviche et al., 2015), and protect plants against salinity by alleviating salt-induced oxidative stress (Abdel Latef and Chaoxing, 2011).

Considering the negative impact on soil and climate due to inorganic farming and to maintain a sustainable soil and chamomile production we hypothecated those organic manures *viz.*, FYM, compost and vermicompost would play a vital role in sustaining soil quality during cultivation of chamomile organically. And hence, different graded doses of these three manures were examined in response to chamomile in our experiment.

Materials and Methods

The experiment comprised of ten treatments with three replications. The experiment was laid out in a Randomize Complete Block Design in triplicates having plot size of (1m × 1m) and consisted of ten treatments, *i.e.*, T_1 (control), T_2 (FYM @ 15 t/ha), T_3 (FYM @ 20 t/ha), T_4 (FYM @ 25 t/ha), T_5 (compost @ 10 t/ha), T_6 (compost @ 15 t/ha), T_7 (compost @ 20 t/ha), T_8 (vermicompost @ 2 t/ha), T_9 (vermicompost @ 3 t/ha) and T_{10} (vermicompost @ 4 t/ha). Chamomile seeds were sown in the first week of September, 2019 in the nursery beds. 45 days old seedlings (10-15 cm in length) of chamomile are transplanted with the spacing of 20 cm × 20 cm during October, 2019 under open field condition. Cultural operations like gap filling, irrigation, hoeing and weeding were done at regular intervals. Five plants were selected randomly from each plot to record the observations at respective stages.

Planting material

The experimental material used for the present investigation comprised of Chamomile (*Matricaria chamomilla* L.). Seeds of chamomile were purchased from the Herbal Research and Development Institute (HRDI), Mandal-Gopeshwar, Chamoli, Uttarakhand.

Soil parameters

Bulk density (g/cc)

Bulk density refers as weight of dry soil per unit of volume typically expressed as in g/cc. Soil bulk density was determined by core method (as described in Black, 1965). Firstly, the stainless-steel core sampler was pushed vertically with help of hammer and wooden plank at the mid-point of 0-5 cm soil layer without disturbing the soil within the core. The core containing soil sample was removed by excavating soil by using spade. The protruding soil was trimmed with the knife from both ends of the core. The soil within the core was transferred to the pre-weighted moisture box. The moisture box with soil sample was then weighted and oven dried at 105ºC for 24 hours. Oven dry weight of the sample was taken and the dimensions of the core and its volume were measured.

$$Bulk\ density\ (g/cc) = \frac{Oven\ dry\ weight\ of\ the\ soil\ core}{Volume\ of\ the\ soil\ core}$$

Soil porosity (%)

Assuming particle density of soil of 2.65 g cm^{-3}, the porosity of all soils was calculated using the below equation (as described in Black, 1965) as :

$$Porosity\ (\%) = 1 - \frac{Bulk\ density}{Particle\ density} \times 100$$

Soil moisture content (%)

Weight of the oven dry soil was taken and moisture content was calculated from each sample as (as described in Black, 1965):

$$Moisture\ content\ (\%) = \frac{Soil\ moist\ weight - Soil\ dry\ weight}{Soil\ dry\ weight} \times 100$$

Water holding capacity (%)

Maximum water holding capacity was determined by Keen Rackzowski box technique (as described in Black, 1965). For determination of water holding capacity, a filter paper was placed at the bottom of the Keen Raczkowski box. The soil was packed by taping the box 20 time on a wooden bench. Small portion of the soil was further added to the box and tapped as before. Finally, the top of the box was leveled by striking off the surplus soil with the straight edge of spatula. The box was taken placed in a petridish containing water and was left for overnight. The box containing the saturated soil was removed from the petridish, weight was taken, finally dried in an oven at 105ºC and weight was recorded.

$$Maximum\ water\ holding\ capacity\ (\%) = \frac{Moisture\ held\ by\ the\ soil}{weight\ of\ dry\ soil} \times 100$$

Plant growth parameters

Plant height (cm)

Plant height was recorded with the help of scale and expressed in centimeters from ground level up to the tip of stem. Five plants were randomly selected from each plot and expressed as average height per plant.

Number of branches per plant

Numbers of branches per plant were counted on the basis of five randomly selected plants for each replication of all the treatments. The mean of three replications was considered as final value in all the treatments.

Plant spread (cm)

The plant spread was recorded for each treatment. Five plant per replication from all the treatments were randomly selected for plant spread. Plant spread was recorded in centimeters in both the directions *i.e.,* East - West (E - W) and North - South (N - S) and mean value were taken as the actual plant spread.

Number of days taken to appearance of first flower

Numbers of days required for flower initiation were counted from transplanting up to the stage when flower bud on the plant was fully open.

Total biomass: fresh and dry (q/ha)

Total plant biomass observation was recorded at bud formation and flowering stages with respect to different treatments. Five plants were randomly selected from each plot in each replication for biomass measurement and the mean of three replications were computed in g/plant**.** For fresh biomass randomly selected plant samples were collected by uprooting whole plant by soil excavation. After excavation, the samples were slaked by dipping it into water and washed by gently flowing water. For dry biomass analysis the collected plant samples were oven dried at 60ºC for more than 48 h till constant weight of the samples were observed.

Total fresh and dry biomass were also recorded in q/ha by using the formula given below.

$$Total\ fresh\ biomass\ (q/ha) = \frac{Total\ fresh\ biomass\ (g)/plot\ (sqm) \times 10000}{1000 \times 100}$$

$$Total\ dry\ biomass\ (q/ha) = \frac{Total\ dry\ biomass\ (g)/plot\ (sqm) \times 10000}{1000 \times 100}$$

Crop growth rate (g/m^2/day) during flowering to maturity stage

Crop growth rate (CGR) is the rate of dry matter production per unit ground area per unit time which was calculated by using the following formula and expressed as g/m^2/day (Watson, 1952).

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

where, W_1 = dry weight of the plant (g/m^2) at time t_1

W_2 = dry weight of the plant (g/m^2) at time t_2

$(t_1 - t_2)$ = time interval in days

A = unit land area (m^2)

Crop growth rate was studied between two growth stages: (i) Bud initiation stage (ii) Flowering stage.

Plant pigment parameters

Total chlorophyll content (mg/g fresh leaf weight)

Hiscox and Israelstam (1979) method was used to find the chlorophyll content of leaf samples using Dimethyl sulphoxide (DMSO).

Determination of total chlorophyll content (Arnon, 1949)

The absorbance (optical density) of green colour was measured on UV-VIS spectrophotometer at 645 and 663 nm. From the absorbance values, the concentration of total chlorophyll (mg/g) were calculated by using following equations.

$$Total\ chlorophyll\ (mg/g) = [20.21\ (A_{645}) + 8.02\ (A_{663})] \times \frac{V}{1000\ \times W}$$

Where,

A_{663} = Absorbance (optical density) at 663 nm

A_{645} = Absorbance (optical density) at 645 nm

V = Total volume of the extract (mL)

W = Weight of the sample (g)

Results and Discussion

Physico-chemical properties of soil

Some of the basic physicochemical properties of the soils of the experimental site were studied and the mean value of results are presented on Table 1. The results clearly indicates that initially, the soils of experimental site were tested optimum with respect to physical and chemical properties *viz.*, bulk density (1.19-1.27 g/cc), porosity (55.83-60.37 %), water holding capacity (52.45-61.76 %), moisture content (23.03-34.91 %), pH (5.55-6.52), EC (0.08-0.14 dS/m) and oxidizable organic carbon (0.59-1.02 %). Changes in all the soil properties were noticed when soil analysis were done after harvesting with varying degree of changes. Among the soil physical properties, slight increase in bulk density (BD) values were seen suggesting there has been increment in compaction from sowing time to harvesting of crop. Likewise, fall in the porousness of soils in all the treatments were witnessed which is directly related with increase in BD in respective treatments. Water holding capacity (WHC) was also seen to increase in all the treatments with varying degree of increments. There were minute changes in soil pH. EC values were hike a little but still are in completely safe range for crop production satisfactorily. Negligible changes in organic carbon (OC) content were also seen in all the treatments. Few of the treatments resulted in fall in OC content suggesting the utilization of appreciable amount OC during the active crop growth period. Increase in OC were seen treatments where plants performed weaker suggesting less accumulation OC by the plants and in addition carbon content by the crop residues in those treatments. Summarily, the soil of the experimental site has abundant nutrient status and with organic manures it could raise chamomile satisfactorily.

Table 1: Physico-chemical soil properties of experimental site

Treatment details	pH		EC (dS/m)		Bulk Density (g/cc)		Porosity (%)		Soil moisture content (%) at sowing	Water holding capacity (%)		Organic Carbon (%)	
	Before	After	Before	After	Before	After	Before	After		Before	After	Before	After
T_1 (Control)	6.01	6.05	0.08	0.11	1.28	1.36	59.18	52.11	28.12	58.21	60.18	1.02	1.00
T_2 (Farmyard Manure @ 15 t/ha)	6.15	6.01	0.14	0.18	1.19	1.29	58.90	53.16	26.86	53.55	55.58	1.00	0.93
T_3 (Farmyard Manure @ 20 t/ha)	6.00	6.06	0.10	0.18	1.21	1.27	58.26	53.22	27.24	56.48	59.35	0.88	0.92
T_4 (Farmyard Manure @ 25 t/ha)	5.89	6.06	0.10	0.16	1.25	1.30	60.37	53.59	26.98	56.66	60.79	0.95	0.92
T_5 (Compost @ 10 t/ha)	5.68	5.88	0.08	0.13	1.23	1.29	57.21	51.43	23.03	58.88	62.48	0.59	0.61
T_6 (Compost @ 15 t/ha)	6.16	6.22	0.09	0.14	1.21	1.27	58.18	53.66	24.20	57.12	62.10	0.66	0.67
T_7 (Compost @ 20 t/ha)	5.55	5.89	0.08	0.21	1.25	1.29	56.76	52.87	26.10	52.45	59.06	0.61	0.69
T_8 (Vermicompost @ 2 t/ha)	6.05	6.00	0.12	0.18	1.26	1.36	60.06	56.33	34.91	61.76	65.52	0.71	0.77
T_9 (Vermicompost @ 3 t/ha)	6.52	6.36	0.09	0.18	1.27	1.34	55.83	53.65	29.10	57.89	63.01	0.67	0.55
T_{10} (Vermicompost @ 4 t/ha)	6.13	6.02	0.09	0.16	1.22	1.27	57.86	53.16	24.62	53.12	60.23	0.97	0.91

Plant growth parameters

The data presented in Table 2 revealed the highest plant height (48.26 cm), number of branches per plant (35.53) and plant spread (33.09 cm) at 180 DAT were found in T_4. However, Kwiatkowski *et al.* (2022) reported chamomile plant height ranging from 56.63 – 59.92 cm in response to different foliar biological preparations sprays (growth stimulant Bio-algeen, fertilizer Herbagreen Basic, and Effective Microorganisms applied as EM Farming spray). Our results further showed that growth of plant increased with increasing amount of applied organic manure levels and showed a progressive effect on plant height, number of branches per plant and plant spread with respect to number of days after transplanting. It might possibly be due to the fact that organic manures support in the plant metabolic activity by the supply ample amount of such important macronutrient and micronutrient in the early vigorous growth and development of plant (Anburani and Manivannan, 2002). Kumar *et al.* (2016) reported that growth of chamomile growth was found to be superior with the application of FYM. Yadav and Singh (1997) also reported that the application of FYM in marigold significantly improved the number of branches per plant with the increasing level of FYM.

Table 2: Effect of different types and doses of organic manures on plant height (cm), number of branches per plant, plant spread (cm) at 180 DAT in Chamomile (*Matricaria chamomilla* L.)

Treatment details	Plant height (cm) ± S.E(m)	Number of branches per plant ± S.E(m)	Plant spread (cm) ± S.E(m)
T_1 (Control)	41.87±0.24	29.46±0.43	27.26±0.67
T_2 (Farmyard Manure @ 15 t/ha)	45.84*±0.11	32.73*±1.33	29.50±0.84
T_3 (Farmyard Manure @ 20 t/ha)	45.96*±0.99	33.13*±0.57	30.23*±0.57
T_4 (Farmyard Manure @ 25 t/ha)	48.26*±0.26	35.40*±0.72	33.09*±0.53
T_5 (Compost @ 10 t/ha)	44.44*±0.79	31.40±0.20	28.93±1.71
T_6 (Compost @ 15 t/ha)	45.93*±0.39	32.26*±0.81	29.71*±0.90
T_7 (Compost @ 20 t/ha)	46.89*±0.57	33.53*±0.24	31.20*±0.17
T_8 (Vermicompost @ 2 t/ha)	45.54*±0.70	32.06*±0.63	29.33±0.58
T_9 (Vermicompost @ 3 t/ha)	46.46*±0.93	34.26*±1.38	31.57*±1.16
T_{10} (Vermicompost @ 4 t/ha)	48.08*±0.68	35.06*±0.52	32.80*±0.37
S.E(d)	0.92	1.05	1.09
C.D. $_{(0.05)}$	1.96	2.23	2.32

**Significant at 5% level of significance as compared with control*

The data presented in Table 3 showed that the first flower appearance (119.73 days) was noted significantly the earliest under the treatment T_{10}. This might be because of presence of gibberellins and other useful hormones in vermicompost which is associated with regulation of flowering (Palei *et al.*, 2016). The present findings are in harmony with the finding of Azizi *et al*. (2008) in chamomile. The results also revealed that T_{10} treatment provided the fastest crop growth rate (0.86 g/m^2/day) from the stage of bud formation to flowering and produced early flowering (119.73 days) in Chamomile (*Matricaria chamomilla*). The favourable effect of vermicompost caused the faster crop growth rate might be due to the fast take-up of macro and micronutrients like Fe, Zn, enzymes, growth hormones and also by enhancing soil fertility and moisture retention capacity of the soil. Jagadeesh *et al.* (2018) observed highest crop growth rate by the application of vermicompost.

Table 3: Effect of different types and doses of organic manures on number of days taken to appearance of first flower, crop growth rate (g/m^2/day) and total chlorophyll content (mg/g fresh leaf weight) in Chamomile (*Matricaria chamomilla* L.)

Treatment details	Number of days taken to appearance of first flower ± S.E(m)	Crop growth rate (g/m^2/day) ± S.E(m) [during bud formation to flowering stage]	Total chlorophyll content (mg/g fresh leaf) ± S.E(m)
T_1 (Control)	127.46±2.39	0.59±0.04	0.527±0.016
T_2 (Farmyard Manure @ 15 t/ha)	126.53±1.04	0.75*±0.04	0.603*±0.007
T_3 (Farmyard Manure @ 20 t/ha)	122.80*±1.04	0.77*±0.07	0.610*±0.009
T_4 (Farmyard Manure @ 25 t/ha)	121.13*±1.96	0.84*±0.05	0.639*±0.009
T_5 (Compost @ 10 t/ha)	125.46±1.67	0.71±0.02	0.566*±0.007
T_6 (Compost @ 15 t/ha)	124.33±0.26	0.78*±0.08	0.583*±0.004
T_7 (Compost @ 20 t/ha)	123.60±0.52	0.84*±0.00	0.578*±0.021
T_8 (Vermicompost @ 2 t/ha)	125.20±1.17	0.77*±0.02	0.577*±0.020
T_9 (Vermicompost @ 3 t/ha)	121.66*±1.96	0.79*±0.00	0.593*±0.005
T_{10} (Vermicompost @ 4 t/ha)	119.73*±1.09	0.86*±0.06	0.619*±0.004
S.E(d)	1.98	0.06	0.017
C.D. $_{(0.05)}$	4.19	0.14	0.036

**Significant at 5% level of significance as compared with control*

Data obtained on total chlorophyll content (mg/g) at mid stage of growth in chamomile (*Matricaria chamomilla* L.) indicated that the highest total chlorophyll (a+b) content (0.639 mg/g) was observed under T_4 (Table 4). The present findings are in conformity with the finding of Ngetich *et al.* (2012) in spider plant (*Cleome gynandra* L.) and reported that increase in FYM rate led to subsequent increase in leaf chlorophyll content of spider plant. However, Kwiatkowski *et al.* (2022) reported a lower total chlorophyll content ranging from 0.126 – 0.319 mg/g owing to different foliar biological preparations sprays (growth stimulant Bio-algeen, fertilizer Herbagreen Basic, and Effective Microorganisms applied as EM Farming spray).

Data presented in Table 4 indicated that total fresh and dry biomass yield (q/ha) of chamomile were significantly affected by various treatments in bud initiation as well as flowering stage. The highest value of total fresh biomass yield (35.25 q/ha) and total dry biomass yield (7.59 q/ha) were found in T_4. Rao *et al.* (1998) also reported that application of FYM increase the biomass yield of Davana (*Artemisia pollens*) as compared to control. Ngetich *et al.* (2012) also reported that fresh and dry biomass yield of spider plant increases with increasing rate of FYM and this is because farmyard manure being an excellent source of macro- and micro-nutrients, could have contributed to enhanced biomass production. At flowering stage, maximum value of total fresh biomass yield (60.02 q/ha) and total dry biomass yield (12.70 q/ha) were appeared from T_{10}. Perhaps this is due to the application of vermicompost, which supplies macronutrients, enzymes, and growth hormones and provides micronutrients such as Zn, Fe, Cu, Mn in an optimum level. Blouin *at al.* (2019) found significant effects of vermicompost on plant biomass production and reported that largest biomass increments in the presence of vermicompost.

Table 4: Effect of different types and doses of organic manures on total fresh and dry biomass yield (q/ha) at bud initiation and flowering stage in Chamomile (*Matricaria chamomilla* L.)

Treatment details	Total biomass yield (q/ha) ± S.E(m)			
	Bud initiation stage		Flowering stage	
	Fresh	Dry	Fresh	Dry
T_1 (Control)	25.50±0.36	4.52±0.08	48.63±1.84	8.10±0.28
T_2 (Farmyard Manure @ 15 t/ha)	30.02*±1.45	5.85*±0.06	56.60*±1.73	10.38*±0.22
T_3 (Farmyard Manure @ 20 t/ha)	33.76*±0.66	7.21*±0.31	58.51*±1.51	11.88*±0.49
T_4 (Farmyard Manure @ 25 t/ha)	35.25*±0.94	7.59*±0.31	59.32*±1.13	12.67*±0.19
T_5 (Compost @ 10 t/ha)	28.99*±1.30	5.17±0.07	54.08*±2.00	9.42*±0.18
T_6 (Compost @ 15 t/ha)	32.44*±1.19	5.22*±0.18	57.77*±1.40	9.93*±0.39
T_7 (Compost @ 20 t/ha)	33.12*±0.53	7.13*±0.18	58.97*±1.33	12.20*±0.15
T_8 (Vermicompost @ 2 t/ha)	30.47*±1.66	6.05*±0.05	55.75*±1.59	10.67*±0.19
T_9 (Vermicompost @ 3 t/ha)	31.08*±0.36	6.19*±0.08	58.79*±1.06	10.95*±0.10
T_{10} (Vermicompost @ 4 t/ha)	33.97*±0.79	7.50*±0.41	60.02*±0.42	12.70*±0.08
S.E(d)	1.51	0.31	2.09	0.36
C.D. $_{(0.05)}$	3.20	0.66	4.43	0.78

**Significant at 5% level of significance as compared with control*

Yield characters

Data recorded on fresh and dry flower yield (q/ha) of Chamomile (*Matricaria chamomilla*) have been portrayed in Table 5. The highest fresh flower yield (67.35 q/ha) and dry flower yield (13.95 q/ha) were obtained with the application of T_4. Kwiatkowski *et al.* (2022) also reported total dry yield of chamomile ranging from 8.20 – 9.20 q/ha owing to different foliar biological preparations sprays (growth stimulant Bio-algeen, fertilizer Herbagreen Basic, and

Effective Microorganisms applied as EM Farming spray). The lower yield under their experiment as compared to our experiment could possibly be due to the lower chlorophyll content resulting in lesser photosynthetic activities in the plants in their research. They further noticed that chamomile responded significantly on those different biological formulations when applied once or twice which clearly indicated that chamomile preferably performed well in organic inputs. The favourable effect of FYM on flower yield (@ 1 kg/m^2 FYM) was reported by Chandra *et al*. (2018). The better performance in flower yield of chamomile under T_4 could be attributed to higher dose of FYM (25 t/ha FYM) and FYM is a store house of several plant nutrients and provided adequate condition of soil and increased population of microorganisms and their activities, which gave synchronized effect and enhanced yield of flower than other organic manure. Enhanced flower yield of marigold over control owing to the successive addition of FYM was observed by Yadav and Singh (1997). Similar results were reported with Kumar *et al*. (2007), Kumar (2002), Bhat *et al*. (2010) and Shadanpour *et al*. (2011) in marigold as well.

The rest of the treatments were also witnessed providing higher yield over control, however, it is worth to note the treatment T_4 provided 64.16% higher yield over control which could be due to better plant physiological activities in the treatment which might in turn be due to better soil chemical, physical and biological properties derived from higher rate of FYM @25 t/ha followed by T_{10} (vermicompost @ 4 t/ha).

Table 5: Effect of different types and doses of organic manures on fresh and dry flower yield (q/ha) and economics of chamomile (*Matricaria chamomilla* L.) cultivation

Treatment details	Flower yield (q/ha) ± S.E(m)		Per cent increase in dry flower yield over control	C:B ratio
	Fresh	Dry		
T_1 (Control)	31.85±3.67	5.00±0.56	-	1: 1.38
T_2 (Farmyard Manure @ 15 t/ha)	47.56*±1.84	8.22*±0.88	39.17	1: 2.02
T_3 (Farmyard Manure @ 20 t/ha)	59.05*±1.37	12.01*±0.73	58.37	1: 3.16
T_4 (Farmyard Manure @ 25 t/ha)	67.35*±1.57	13.95*±0.51	64.16	1: 3.56
T_5 (Compost @ 10 t/ha)	42.00*±2.80	6.46±0.78	22.60	1: 1.53
T_6 (Compost @ 15 t/ha)	45.85*±1.47	8.02*±0.74	37.66	1: 1.95
T_7 (Compost @ 20 t/ha)	57.65*±3.35	10.60*±0.67	52.83	1: 2.67
T_8 (Vermicompost @ 2 t/ha)	44.04*±2.17	6.73±0.21	25.71	1: 1.63
T_9 (Vermicompost @ 3 t/ha)	56.76*±5.32	9.83*±0.74	49.14	1: 2.61
T_{10} (Vermicompost @ 4 t/ha)	61.53*±3.84	12.75*±0.84	60.78	1: 3.41
S.E(d)	4.19	1.01	-	
C.D. $_{(0.05)}$	8.87	2.15	-	

**Significant at 5% level of significance as compared with control*

Correlation Between Certain Crop Growth Parameters

Correlations between chlorophyll content (mg/g) and fresh flower yield (q/ha)

Statistically significant positive correlation, which is depicted by the R^2 value of 0.7912 as per Pearson's correlation chart, between chlorophyll content (mg/g) and fresh flower yield (q/ha) was being established (Figure 1). The relation clearly indicated that with the increase in chlorophyll content there resulted a statically significant ($p <= 0.01$; $R^2 = 0.7912$) increase in fresh flower yield which is expressed as the following equation:

$$Fresh\ flower\ yield = 324.73\ (chlorophyll\ content) - 139.77$$
$$R^2 = 0.7912, n = 10, p < 0.01$$

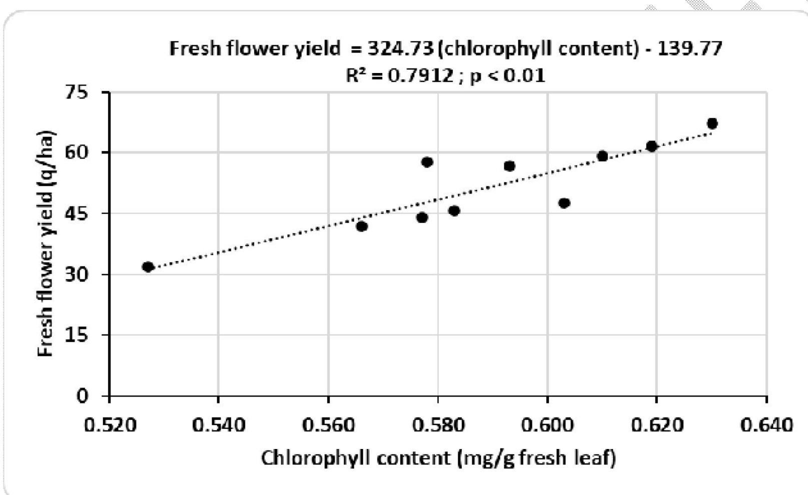

Fig. 1. Correlations between chlorophyll content (mg/g) and fresh flower yield (q/ha)

Correlations between plant spread (cm) and chlorophyll content (mg/g)

Statistically significant positive correlation, which is depicted by the R^2 value of 0.712 as per Pearson's correlation chart, between plant spread (cm) and chlorophyll content (mg/g) was also being established (Figure 2). The relation clearly indicated that the chlorophyll content significantly increased with increase in plant spread ($p <= 0.05$; $R^2 = 0.712$). The established relation is expressed as the following equation:

$$Chlorophyll\ content = 0.0138\ (Plant\ spread) + 0.169$$
$$R^2 = 0.712, n = 10, p < 0.05$$

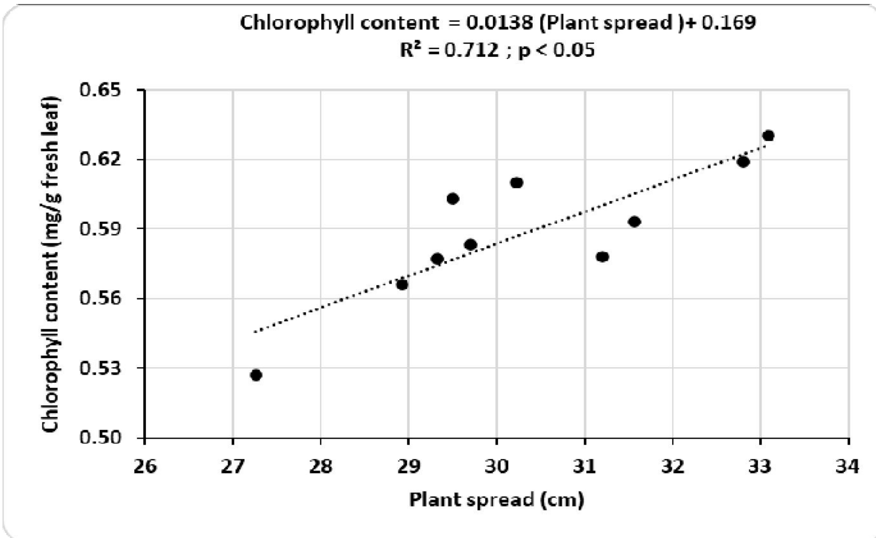

Fig. 2. Correlations between plant spread (cm) and chlorophyll content (mg/g)

Correlations between number of days taken to first flowering and flower yield (q/ha)

Statistically significant negative, which is depicted by the R^2 value of 0.7959 as per Pearson's correlation chart, correlation between number of days taken to first flowering and flower yield (q/ha) was being established (Figure 3) as per our observed data. The correlation clearly indicated that the fresh flower yield is subjected to decrease significantly as long as the beginning of flowering delays ($p <= 0.01$; $R^2 = 0.7959$). The established relation is expressed as the following equation:

$$Fresh\ flower\ yield = -3.8995\ (Days\ taken\ to\ first\ flowering) + 534.08$$

$$R^2 = 0.7959, n = 10, p < 0.01$$

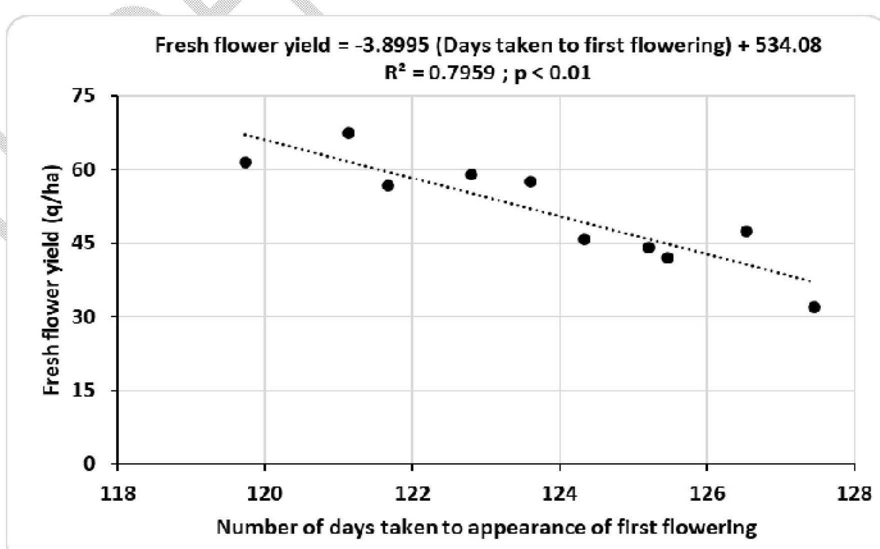

Fig. 3. Correlations between number of days taken to first flowering and flower yield (q/ha)

Economic Studies

The data related to economics of different treatments have been presented in Table 5. The highest net income (Rs 653,566.25) per hectare was projected in T_4 (FYM @ 25 t/ha). The maximum benefit derived per unit cost invested i.e., C:B (1: 3.56) was seen in T_4. Similar result also reported by Kisic *et al*. (2018) in chamomile.

Table 6: Effect of different types and doses of organic manures on the economics of Chamomile (*Matricaria chamomilla* L.) production

Treatments details	Estimated dry flower yield (kg/ha)	Selling rate (Rs/kg)	Total cost (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	C:B ratio
T_1 (Control)	500.00	600	125,933.75	300,000	174,066.25	1: 1.38
T_2 (Farmyard Manure @ 15 t/ha)	822.50	600	163,433.75	493,500	330,066.25	1: 2.02
T_3 (Farmyard Manure @ 20 t/ha)	1201.67	600	173,433.75	721,000	547,566.25	1: 3.16
T_4 (Farmyard Manure @ 25 t/ha)	1395.00	600	183,433.75	837,000	653,566.25	1: 3.56
T_5 (Compost @ 10 t/ha)	646.67	600	153,433.75	388,000	234,566.25	1: 1.53
T_6 (Compost @ 15 t/ha)	802.50	600	163,433.75	481,500	318,066.25	1: 1.95
T_7 (Compost @ 20 t/ha)	1060.83	600	173,433.75	636,500	463,066.25	1: 2.67
T_8 (Vermicompost @ 2 t/ha)	677.33	600	153,433.75	404,000	250,566.25	1: 1.63
T_9 (Vermicompost @ 3 t/ha)	983.33	600	163,433.75	590,000	426,566.25	1: 2.61
T_{10} (Vermicompost @ 4 t/ha)	1275.00	600	173,433.75	765,000	591,566.25	1: 3.41

Conclusion

The experiment was conducted to evaluate the possibility for establishing the certain organic cultivation packages of Chamomile (*Matricaria chamomilla* L.) On the basis of observations recorded during the experiment, it can be concluded that the application of T_4 (FYM @ 25 t/ha) was found to be more effective and better performing among all other treatments with respect to physiological growth parameters as well as yield attributes. The maximum net return and benefit: cost ratio was also obtained under treatment T_4 (FYM @ 25 t/ha). Therefore, treatment T_4 (FYM @ 25 t/ha) after testing under open field cultivation of Chamomile (*Matricaria chamomilla* L.) can be recommended for commercial cultivation. Following the results obtained in the present investigation it was clearly seen that increasing doses of all the type of organic manures provided better results in all the traits under this investigation. The results implies that further increase in the dose of FYM (25 t/ha) which was in T_4 could result in even better performance and production of chamomile. Therefore, there is seen a good scope for future research with the higher doses of FYM *i.e.*, higher than

25 t/ha. However, there is still necessity to evaluate the economics of the marginal dose of FYM added additionally.

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