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Effect of herbal Kunapjala (a traditional form of liquid organic manure) on plant growth, oil yield and oil quality of chamomile (*Matricaria chamomilla* L.)

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Kunapjala, a liquid organic manure of antiquity mentioned in Surpala's Vrikshayurveda, acts as an efficient source of plant nutrients. To check the impact of Kunapjala on cultivation of chamomile, an important essential oil- bearing plant, a field experiment was conducted at Medicinal Plant Research and Development Centre, Pantnagar using three different doses (D1-D3) of three types of herbal Kunapjala (K1-K3). The experiment was performed in Randomized Block Design consisting of 10 treatments (T1-T10) with three replications each and results were compared to recommended dose of inorganic fertilizers (RDF). Various treatments of Kunapjala significantly affected different floral parameters. Highest concentration of nettle based Kunapjala (T3) initiated early bud formation along with increased flower size. Similarly, essential oil content (0.27%) and number of bioactive compounds (33) in chamomile oil was also maximum with nettle based Kunapjala (T3). Contrary to floral parameters, vegetative parameters were significantly promoted with RDF. Maximum number of flowers and flower yield was also seen in T10 (RDF). From the results of the current investigation, it can be concluded that nettle based herbal Kunapjala can be used as an effective and viable alternative to the conventional methods for increasing flower size as well as yield and quality of essential oil of chamomile.

Keywords: Chamomile, Essential oil, GC-MS, Kunapjala, Organic farming
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Agriculture is a way of livelihood for millions of people throughout the world. Expanded demands for meals, land shortage and negative farming practices have forced the excessive usage of artificial fertilizers in agriculture. Though, the intensive use of chemical fertilizers can make the country self-sufficient but also causes ecological imbalance and deterioration of natural resources resulting in serious threat to living organisms[1]. Bearing in mind the existing situation, agriculture researchers, everywhere on the globe, have now begun to offer attention to the terrible outcomes of the usage of inorganic fertilizers. More emphasis is now to form a system, which isn't only effective and value-powerful however additionally conserving and sustainable for centuries[2]. Alternative strategy for this could be successful utilization of organic farming practices especially traditional farming practices that depends on ecologically sustainable methods in preference to usage of chemical fertilizers[3].

Use of organic manure for cultivation of plants dates back to 1000 AD in India. Vrikshyayurveda, an ancient literature on traditional and sustainable methods of plant cultivation which forms a part of *Ayurvedic* history of India, mentions many of these organic manures[4]. The organic manures can be used in solid or liquid form. Solid organic fertilizers slowly release their components in the soil. However, liquid organic fertilizers can be mixed in water and being in liquid phase, these can be rapidly taken up by the plants. Many liquid organic fertilizers are formed by the fermentation of organic wastes *viz*., cow dung, cow urine, animal and plant residues as carbon substrates over specific period[5]. Kunapjala, Panchgavya, Beejamrit, Jeevamrit etc. are some commonly used liquid organic fertilizers[6]. Various organic formulation inputs based on cow dung, cow urine and plant wastes showed good microbial count and enzymatic activities resulting in improvement of soil carbon content and soil fertility[7]. In a recent study, Jeevamrit, a traditional fermented bioformulation has been found

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to improve soil nutrient content, soil microbial diversity and herbage yield of *Bacopa monnieri*[8].

Kunapajala, a liquid organic manure cited in *Vrikshyayurveda*, acts as an efficient source of plant nutrients. The elaborated meaning of Kunapa is "emitting a stinking odour like a dead body " which aptly describes the liquid manure as it is composed of animal excreta, bones, flesh, marrow, fish and decomposed plant productsetc[9]. The reason for the potency of Kunapajala is that the components of Kunapajala were fermented, because of which the complex compounds including proteins, fats, carbohydrates and many others are broken into low molecular weight products due to which the nutrients from Kunapajala are offered to the plant at a faster rate than from the historically used bulk organic matter[10]. Kunapajala is applicable on any crop at any growth stage and it works as a standard liquid manure and a herbal growth booster[11]. Kunapjala is also known to effectively control disease incidence in crops[12].

Matricaria chamomilla, generally known as German or Hungarian chamomile is a herb of high medicinal and aromatic value belonging to Asteraceae family. It is one of the most utilized herbal tea and is now cultivated on nearly each continent *e.g*., Europe, Asia, North and South America[13]. The plant is mainly cultivated for its flowers that yield essential oil whose most important constituent is chamazulene that is broadly used in pharmaceutical, food, perfumery and flavoring industry[14]. The worldwide demand for chamomile essential oil is increasing regularly as it contains antibacterial and antifungal properties as well[15]. Chamomile essential oil is extracted via steam distillation of fresh (or moderately dried) flowers[16]. The oil is used in foodstuffs, in the flavouring of alcoholic and non-alcoholic beverages[17].

The present study, to use herbal form of a traditional liquid fertilizer *viz*., Kunapjala, for improving growth, yield and essential oil quality of *M. chamomilla* L., was planned as a sustainable organic practice for chamomile cultivation to meet the increasing demand of high-quality chamomile plants by the concerned industries.

Materials and Methods

The field experiment was carried out from November 2020 to April 2021 at the Medicinal Plants Research and Development Centre, Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, Uttarakhand (29°N latitude, 79.3°E longitude, altitude 243.84 meters above mean sea level). The soil of experimental field was sandy clay loam with pH 6.67, whereas electric conductivity (EC) was in the tune of 0.101 dSm^{-1}. The soil had approximately 0.68% organic carbon, with available nitrogen, phosphorus and potassium levels of 183.57, 20.18 and 188.51 $kgha^{-1}$, respectively. The experiment was designed using a Randomized Block Design (RBD) with ten treatments and three replications.

For preparing herbal Kunapjala, a mixture was prepared in a 200 L capacity plastic drum using cow dung (10 kg), cow urine (10 L), sour butter milk (2 L), jaggery (2 kg), sprouted urd pulse (2 kg), mustard cakes (2 kg), rice bran water (3 L), fresh milk (1 L), dry cow dung (3-4 pieces), 10 kg of nettle grass and/or leaves of other grasses. Volume of the mixture was topped up to 200 L using tap water. The mixture was shaken properly with a wooden stick and lid of the drum was closed. The shaking process was carried out twice daily, in the morning and evening, until bubbles ceased to appear, indicating the completion of the process and readiness of the herbal Kunapajala. The mixture was thoroughly strained using a cloth to prepare it for further use. In the present investigation, three different types of herbal Kunapjala *viz*., K1: Kunapjala prepared using nettle plants, K2: Kunapjala prepared using common weeds, K3: Kunapjala prepared using 50% K1 and 50% K2 at three different doses *viz*., D1: 200 lt/ac, D2: 400 lt/ac and D3: 600 lt/ac were tested and compared to recommended dose of fertilizers (RDF) *i.e*., NPK 40-30-30 $kgha^{-1}$.

Different vegetative and floral parameters were recorded including plant height (cm), number of primary branches per plant, root length (cm), root weight (g/plant), biomass of plant (g), number of days required for the first bud initiation, number of days to 50% flowering, the number of flowers per plant, flower diameter (cm), flower weight per plant (g) and flower yield per hectare ($kgha^{-1}$).

Extraction of essential oil

The essential oil of chamomile was extracted by hydro-distillation of flower head using Clevenger apparatus. Flowers from each plot were plucked, weighed and shade dried. Dried flowers were placed in the flask, which was then filled with water 1/3 times. The flask was connected with a condenser having 100-120 mL water. The material in the flask was heated using a heating mantle. After 45 min. the vapour containing oil was circulated in the inner tube which was condensed to water and oil. The oil being

lighter settled on the top and got separated. Complete process of distillation took 4-6 h. The volume of obtained oil was recorded and multiplied by the factor of specific gravity (0.9) to convert it to w/w basis. The oil content is then computed by the formula:

$$\text{Oil content (\%)} = \frac{\text{weight of oil (g)}}{\text{weight of dry flowers (g)}} \times 100$$

Oil yield was calculated by multiplying the oil content (%) of each plot with the corresponding dry flower weight.

Essential oil analysis

Effect of herbal Kunapjala on essential oil quality was assessed separately using Agilent (model 8890) GC system fitted with single quadrupole Mass Spectrometer (5977B MSD) analyzer. The GC consists of Split / Splitless (SSL) injectors and a HP-5MS capillary column of dimensions 30 m x 250 µm x 0.25µm. The temperature programme of GC started at 50°C for 0.5 min. The column was sequentially heated at a rate of 5°C/min. to 180°C and at 10°C/min. to 300°C for 3-5 min. The ionization voltage was 70eV and mass range was 50-600.

Results and Discussion

Effect of herbal Kunapjala on vegetative parameters

Carefully recorded results of vegetative parameters are presented in Table 1. Maximum values of all vegetative parameters *viz*., plant height (82.36 cm), number of primary branches (15.86), root length (8.33 cm), root fresh weight, dry weight (12.59 g and 5.15 g respectively) and plant biomass both fresh and dry (318.5 g and 120.92 g respectively) was observed in T10 (treatment with NPK fertilizer). Highest doses of herbal Kunapjala showed values closer to the values obtained by NPK. Lower doses, however, showed comparatively lower values of the vegetative parameters. This may be because organic fertilisers take longer time to release the nutrients. Major nutrients supplied by the inorganic fertilizers will be, however, rapidly absorbed by the crop. In a similar study on *Pogostemon patchouli* Pellet., it was found that application of phosphorus and nitrogen fertilisers increased growth and yield characteristics as compared to control and bio-fertilizers[18]. Similarly, with the application of inorganic fertilizer, greater fresh weight and dry weight was observed in saffron[19], safed musli[20] and ashwagandha[21].

Effect of herbal Kunapjala on floral parameters

Results of floral parameters is presented in Table 2. Number of days taken for the appearance of first bud and for the completion of 50% flowering was found to be minimum (8.93 and 20.62, respectively) in T3 *i.e.,* treatment of highest dose of nettle based Kunapjala while maximum was taken in T10 (15.81 and 25.58, respectively). Early flowering can be linked to a high net absorption rate as a result of improved development, which leads to the creation of endogenous metabolites, allowing for early flowering[22]. Flower diameter was found to be maximum (2.23 cm) in T3 while minimum (1.55 cm) in T4. Number of flowers per plant was, however, found maximum (710.03) in T10 while minimum (417.11) in T4. Fresh weight of flowers per plant was maximum in T10 (75.78 g) followed by T9 (67.11 g). Dry weight of flowers per plant was maximum and at par in T10 and T9 (12.86 g and 12.74 g, respectively) while minimum was in T4 (8.88 g). Similarly, the fresh flower yield was maximum in case of T10

Table 1 — Effect of herbal Kunapjala on vegetative characters of chamomile

Treatments	Plant height (cm)	Number of primary branches	Root length (cm)	Root weight (g)		Plant weight (g)	
				Fresh weight	Dry weight	Fresh weight	Dry weight
T1 (K1D1)	68.36	14.59	6.81	7.78	3.16	284.03	106.56
T2 (K1D2)	75.73	15.74	7.05	8.36	3.54	289.54	117.57
T3 (K1D3)	73.82	12.92	6.32	7.51	3.74	267.67	110.64
T4 (K2D1)	57.76	11.88	5.26	6.89	2.68	220.11	76.45
T5(K2D2)	62.75	13.48	6.41	7.43	2.84	232.02	83.16
T6 (K2D3)	65.32	14.88	6.81	7.89	3.39	241.13	88.81
T7 (K3D1)	60.12	12.45	7.25	8.57	3.54	234.15	92.81
T8 (K3D2)	64.36	14.39	7.56	9.25	3.98	254.86	95.88
T9 (K3D3)	66.52	15.81	7.74	10.28	4.26	266.77	102.27
T10 (RDF)	82.36	15.86	8.33	12.59	5.15	318.58	120.92
SEm±	4.829	0.922	0.509	0.708	0.315	19.347	7.822
CD (5%)	14.46	2.76	1.52	2.12	0.94	57.93	23.42

K1: nettle based Kunapjala, K2: Kunapjala prepared by common weeds, K3: 50%K1+50% K2; D1: 200 lt./ac, D2: 400 lt./ac, D3: 600 lt./ac. SEm: Standard error of mean; CD: Critical difference)

Table 2 — Effect of herbal Kunapjala on floral characters

Treatments	Number of days taken for first bud initiation	Number of days taken for 50% flowering	Number of flowers per plant	Flower diameter (cm)	Flower weight per plant (g)		Flower yield per hectare (kg/ha)	
					Fresh weight	Dry weight	Fresh flower yield	Dry flower yield
T1 (K1D1)	12.45	24.14	510.36	1.93	53.44	9.77	5,937.78	1,085.56
T2 (K1D2)	11.96	23.56	587.07	2.21	56.65	11.78	6,294.45	1,308.89
T3 (K1D3)	08.93	20.62	536.74	2.23	55.46	10.39	6,162.22	1,154.44
T4 (K2D1)	14.17	25.13	417.11	1.55	49.53	8.88	5,503.33	986.67
T5 (K2D2)	13.86	25.03	428.52	1.75	50.78	10.48	5,642.22	1,164.44
T6 (K2D3)	13.56	24.99	493.44	1.93	52.88	11.88	5,875.56	1,320.00
T7 (K3D1)	13.41	24.78	542.82	1.84	58.71	10.59	6,523.33	1,176.67
T8 (K3D2)	12.56	23.59	595.74	2.02	65.81	11.92	7,312.22	1,324.44
T9 (K3D3)	12.45	23.48	608.43	2.11	67.11	12.74	7,456.67	1,415.56
T10 (RDF)	15.81	25.58	710.03	1.75	75.78	12.86	8,420.00	1,428.89
SEm±	1.14	0.901	42.371	0.134	4.893	0.819	543.606	91.047
CD (5%)	3.41	2.69	126.86	0.19	14.65	2.45	1,627.65	272.61

K1: nettle based Kunapjala, K2: Kunapjala prepared by common weeds, K3: 50%K1+50% K2; D1: 200 lt./ac, D2: 400 lt./ac, D3: 600 lt./ac. SEm: Standard error of mean; CD: Critical difference)

(8,420 kg/ha) followed by T9 (7,456.67 kg/ha). However, maximum dry flower yield was at par in T10 and T9 (1,428.89 and 1,415.56 kg/ha, respectively) while minimum was in case of T4 (986.67 kg/ha). The conversion of photosynthates into proteins resulted in greater flower primordia and flower bud development, resulting in higher flower yield[23].

Effect of herbal Kunapjala on quantity of essential oil

The oil content was found maximum (0.27%) in T3 while minimum (0.11%) was found in T10 (0.11%) as shown in Table 3. This increase in essential oil content might be due to the increase in number of oil glands and/or stimulation of terpene biosynthesis pathway by the organic treatments. Similar to this, application of bio and organic fertilizers resulted in increase in oil % in medicinal pumpkin[24], *Rosmarinus officinalis* L.[25] and dragonhead[26,27]. Oil yield was recorded maximum in T2 (3.25 kg/ha) and T3 (3.11 kg/ha) followed by T9 (2.71 kg/ha). Oil yield with herbal Kunapjala treatment was, thus, significantly higher (more than double) compared to T10 (1.55 kg/ha) treatment. Increase in oil yield may also be because of larger flower diameter and consequently presence of higher number of oil secreting glands.

Effect of herbal Kunapjala on quality of essential oil

GC MS analysis of oil samples was done to analyse the effect of different types of herbal Kunapjala on oil quality (Fig. 1-Fig. 4). 38 compounds were identified in oil sample 1 (oil obtained by the hydro-distillation of flower heads treated with nettle based Kunapjala (K1). The major compounds included 1,5-Heptadien-4-one, 3,3,6-trimethyl- (1.19%); Camphor (1.02%);

Table 3 — Effect of herbal Kunapjala on chamomile essential oil

Treatments	Oil content (%)	Oil yield (kg/ha)
T1 (K1D1)	0.18	1.97
T2 (K1D2)	0.25	3.25
T3 (K1D3)	0.27	3.11
T4 (K2D1)	0.15	1.48
T5 (K2D2)	0.16	1.91
T6 (K2D3)	0.17	2.21
T7 (K3D1)	0.15	1.74
T8 (K3D2)	0.17	2.25
T9 (K3D3)	0.19	2.71
T10 (RDF)	0.11	1.55
SEm±	0.011	0.223
CD (5%)	0.034	0.668

(K1: nettle based Kunapjala, K2: Kunapjala prepared by common weeds, K3: 50% K1+50% K2; D1: 200 lt./ac, D2: 400 lt./ac, D3: 600 lt./ac., SEm: Standard error of mean; CD: Critical difference)

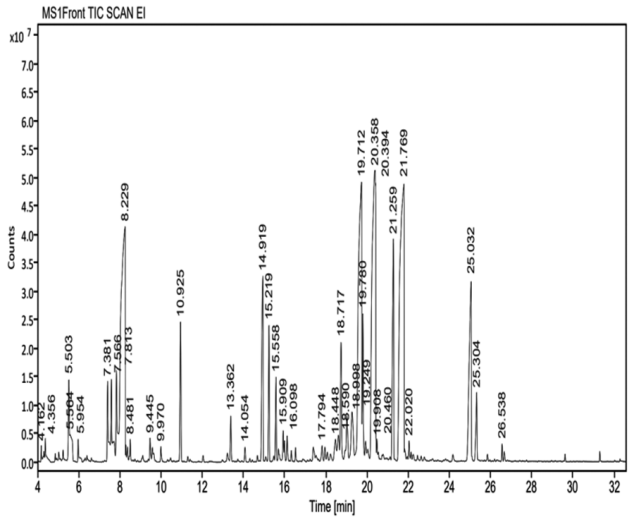

Fig. 1 — GC chromatogram of oil sample 1

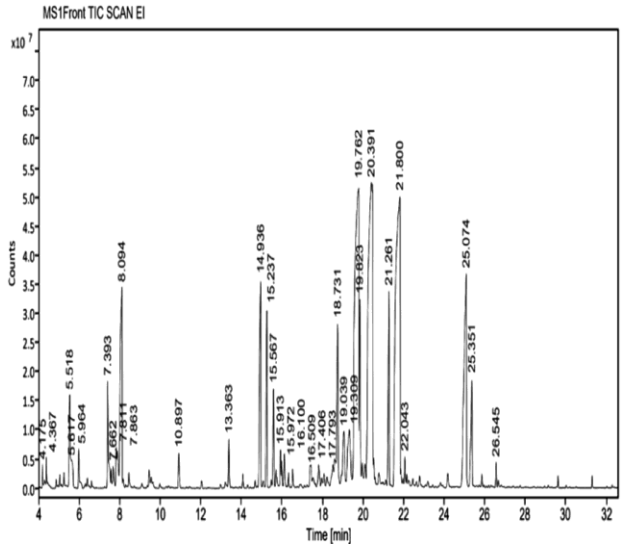

Fig. 2 — GC chromatogram of oil sample 2

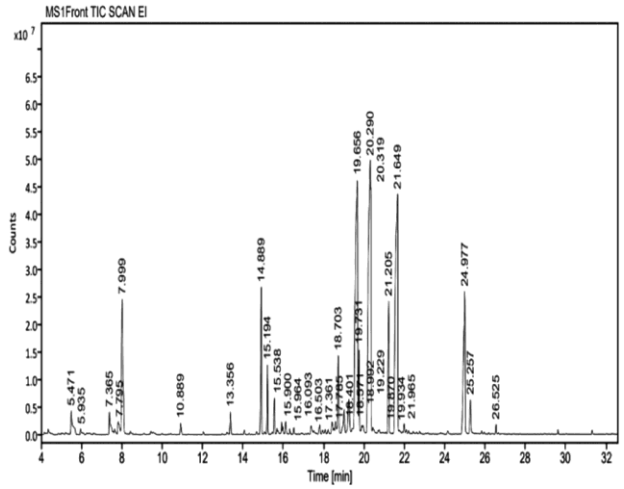

Fig. 3 — GC chromatogram of oil sample 3

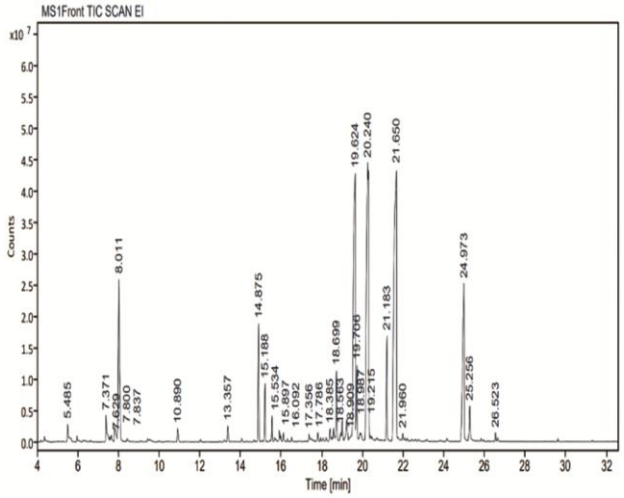

Fig. 4 — GC chromatogram of oil sample

Cyclohexanone, 5- methyl-2-(1-methylethyl)-, cis- (1.05%); Fluopicolide (1.35%); Cyclohexanol, 5-methyl2-(1-methylethyl)-, (1α,2β,5α)-(±)- (14.74%); Cyclohexanol, 5-methyl-2-(1-methylethyl)-, acetate, (1α,2β,5β)- (2.14%); cis-β-Farnesene (3.84%); (1R,3S,4S)-1,3-Dimethyl-3-(4-methylpent-3-en-1-yl)-2-oxabicyclo[2.2.2]oct-5-ene (1.83%); Germacrene D (1.07%); 3-((3R)-2,3- Dimethyltricyclo[2.2.1.02,6] heptan-3-yl)propanal (2.06%); .tau.-Cadinol (1.44%); 2-Furanmethanol, tetrahydro-α,α,5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl)-, [2S-[2α,5β- (13.86%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (1.91%); α-Bisabolol (13.12%); (S)-2,2,6-Trimethyl-6-((S)-4-methylcyclohex-3-en-1-yl)dihydro-2H-pyran-3(4H)-one (1.72%);Chamazulene (4.39%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (18.01%); (Z)-2-(Hexa-2,4-diyn-1- ylidene)-1,6- dioxaspiro[4.4]non-3-ene (6.14%) and (Z)-2-(Hexa-2,4-diyn-1- ylidene)-1,6-dioxaspiro[4.4]non-3-ene (1.32%).

33 compounds were identified in oil sample 2 *i.e.*, the oil obtained by the hydro distillation of flowerheads treated with Kunapjala prepared using common weeds (K2). The major compounds included1,5-Heptadien-4-one, 3,3,6-trimethyl- (1.65%); (+)-2-Bornanone (1.65%); Cyclohexanol, 5-methyl2-(1-methylethyl)-, (1α,2β,5α)-(±)- (5.71%); cis-β-Farnesene (4.54%); (1R,3S,4S)-1,3-Dimethyl-3-(4-methylpent-3-en-1-yl)-2-oxabicyclo[2.2.2]oct-5-ene (2.52%); Germacrene D (1.24%); 3-((3R)-2,3-Dimethyltricyclo[2.2.1.02 ,6]heptan-3-yl)propanal (2.69%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (1.36%); .tau.-Cadinol (1.98%); 2-Furanmethanol, tetrahydro-α,α,5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl)-, [2S-[2α,5β(R- (16.89%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (2.21%); (S)-2,2,6-Trimethyl-6-((S)-4-methylcyclohex-3-en-1-yl)dihydro-2H-pyran-3 (4H)-one (18.21%); Chamazulene (2.95%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (18.87%); (Z)-2-(Hexa-2,4-diyn-1- ylidene)-1,6- dioxaspiro[4.4]non-3-ene (8.08%) and (Z)-2-(Hexa-2,4-diyn-1- ylidene)-1,6- dioxaspiro[4.4]non-3-ene (2.16%).

In oil sample 3 i.e., the oil obtained by the hydro distillation of flower heads treated with Kunapjala prepared by mixing K1 and K2 in 50:50 ratio (K3), 33 compounds were identified.

The major compounds in the oil sample included Cyclohexanol, 5-methyl-2-(1-methylethyl)-, (1α,2β,5α)-(±)- (5.89%); cis-β-Farnesene (4.34%); (1R,3S,4S)-1,3-Dimethyl-3-(4-methylpent-3-en-1-yl)-2-oxabicyclo[2.2.2]oct-5-ene (1.66%); 3-((3R)-2,3-Dimethyltricyclo[2.2.1.02,6]heptan-3-yl)propanal (2.35%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (1.05%); .tau.-Cadinol (1.66%); 2-Furanmethanol, tetrahydro-α,α,5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl)-, [2S-[2α,5β(R (19.21%); 2-Furanmethanol, tetrahydro-α,α,5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl)-, [2S-[2α,5β(R (2.06%); α-Bisabolol (19.24%); (S)-2,2,6-Trimethyl-6-((S)-4-methylcyclohex-3-en-1-yl) dihydro-2H-pyran-3(4H)-one (3.15%); Chamazulene (3.77%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (18.81%); (Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6-dioxaspiro[4.4]non-3-ene (7.42%) and (Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6-dioxaspiro[4.4]non-3-ene (1.15%).

In oil sample 4 *i.e.*, the essential oil obtained by the hydro distillation of flowers of plant treated with NPK fertilizer, only 30 compounds were identified. The major compounds in the oil sample included (+)-2-Bornanone (1.09%); Cyclohexanol, 5-methyl-2-(1-methylethyl)-, (1α,2β,5α)-(±)- (7.36%); cis-β-Farnesene (3.37%); (1R,3S,4S)-1,3-Dimethyl-3-(4-methylpent-3-en-1-yl)-2-oxabicyclo[2.2.2]oct-5-ene (1.49%); 3-((3R)-2,3-Dimethyltricyclo[2.2.1.02,6] heptan-3-yl)propanal (2.07%); .tau.-Cadinol (1.02%); 2-Furanmethanol, tetrahydro-α,α,5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl)-, [2S-[2α,5β(R*) (17.63%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (2.09%); (S)-2,2,6-Trimethyl-6-((S)-4-methylcyclohex-3-en-1-yl) dihydro-2H-pyran-3(4H)-one (20.86%); Chamazulene (2.93%); 2H-Pyran-3-ol, tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*) (23.48%); (Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6-dioxaspiro[4.4] non-3-ene (8.77%) and (Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6-dioxaspiro[4.4]non-3-ene (1.45%).

In the present investigation, essential oil sample1 had maximum (38) number of compounds while sample 2 and 3 had 33 compounds each and sample 4 had minimum (30) compounds only which indicates that the organic fertilizer treatment improved both the quality as well quantity of essential oil. In a similar study, application of aqueous extract of compost and biofertilizer increased the level of major compounds like terpinen-4-ol, γ-, α-terpinene, β-caryophyllene and spathulene etc. in essential oil of marjoram as compared to NPK fertilizer[28]. Similarly, application of compost and liquid compost improved the growth, essential oil content and its composition in sweet basil (*Ocimum basilicum* L.)[29] and coriander (*Coriandrum sativum* L.)[30], respectively.

Among the various constituents of chamomile essential oil, α-Bisabolol, Chamazulene and cis-β-Farnesene are the most significant ones. Essential oil sample 4 had highest α-Bisabolol content (19.24%) followed by sample 1 (13.12%) while sample 2 and 3 lacked α-Bisabolol. Similarly, another very important essential oil component *i.e.*, Chamazulene was found maximum in sample 1 (4.39%) followed by sample 3 (3.77%) (Table 4). Sample 2 and 3 had higher β-Farnesene (4.54 and 4.34 respectively) than sample 1 and 4.

Table 4 — Comparative account of bioactive compounds identified in different essential oil samples (detected by GC-MS)

S. No.	Bioactive compounds	Oil sample 1 (%)	Oil sample 2 (%)	Oil sample 3 (%)	Oil sample 4 (%)
1	5-Hepten-2-one, 6- methyl-	0.11	0.16	-	-
2	3,6-Heptadien-2-ol, 2,5,5- trimethyl-, (E)-	0.35	0.21	-	-
3	1,5-Heptadien-4-one, 3,3,6-trimethyl-	1.19	1.65	0.81	0.47
4	1,5-Heptadien-4-one, 3,3,6-trimethyl-	0.91	0.54	-	-
5	1,5-Heptadien-4-ol, 3,3,6- trimethyl-	0.25	0.55	0.27	-
6	Camphor	1.02	-	-	-
7	Cyclohexanone, 5- methyl-2-(1-methylethyl)-, cis-	1.05	-	-	-
8	Fluopicolide	1.35	-	-	-
9	Cyclohexanol,5-methyl2-(1-methylethyl)-, (1α,2β,5α)-(±)-	14.74	-	-	-
10	α-Terpineol	0.22	-	-	-
11	cis-3-Hexenyl isovalerate	0.34	-	-	-
12	2-Cyclohexen-1-one, 3- methyl-6-(1-methylethyl)-	0.23	-	-	-
13	Cyclohexanol, 5-methyl-2-(1-methylethyl)-, acetate, (1α,2β,5β)-	2.14	0.48	0.38	0.46
14	Cyclohexane,1-ethenyl-1-methyl-2,4-bis(1-methylethenyl)-, [1S-(1α,2β,4β)]-	0.66	-	0.67	0.49
15	Caryophyllene	0.21	-	-	-

(*Contd.*)

Table 4 — Comparative account of bioactive compounds identified in different essential oil samples (detected by GC-MS) (*Contd*.)

S. No.	Bioactive compounds	Oil sample 1 (%)	Oil sample 2 (%)	Oil sample 3 (%)	Oil sample 4 (%)
16	cis-β-Farnesene	3.84	4.54	4.34	3.37
17	(1R,3S,4S)-1,3-Dimethyl-3-(4-methylpent-3-en-1-yl)-2-oxabicyclo[2.2.2]oct-5-ene	1.83	2.52	1.66	1.49
18	Germacrene D	1.07	1.24	0.89	0.67
19	(1S,2E,6E,10R)- 3,7,11,11- Tetramethylbicyclo[8.1.0]undeca-2, 6-diene	0.37	0.40	0.29	0.28
20	α-Farnesene	0.36	0.42	0.34	0.25
21	1H-Cycloprop[e]azulen-7-ol,decahydro-1,1,7-trimethyl-4-methylene-,[1ar-(1aα,4aα,7β,7aβ-	0.3	0.45	0.33	-
22	3,7,7-Trimethyl-8-(2-methyl-propenyl)- bicyclo[4.2.0]oct-2-ene	0.59	-	-	0.40
23	7-Hydroxyfarnesen	0.7	-	0.42	0.47
24	3-((3R)-2,3-Dimethyltricyclo[2.2.1.02,6]heptan-3-yl)propanal	2.06	2.69	2.35	2.07
25	2H-Pyran-3-ol,tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*)	0.94	1.36	1.05	0.66
26	.tau.-Cadinol	1.44	1.98	1.66	1.02
27	2-Furanmethanol,tetrahydro-α,α,5-trimethyl-5-(4-methyl-3-cyclohexen-1-yl)-, [2S-[2α,5β-	13.86	16.89	19.21	17.63
28	2H-Pyran-3-ol,tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*)	1.91	2.21	18.81	2.09
29	trans-Valerenyl acetate	0.25	-	-	-
30	α-Bisabolol	13.12	-	19.24	-
31	(S)-2,2,6-Trimethyl-6-((S)-4-methylcyclohex-3-en-1-yl) dihydro-2H-pyran-3(4H)-one	1.72	18.21	3.15	20.86
32	α-Kessyl acetate	0.12	-	-	-
33	Chamazulene	4.39	2.95	3.77	2.93
34	2H-Pyran-3-ol,tetrahydro-2,2,6-trimethyl-6-(4-methyl-3-cyclohexen-1-yl)-, [3S-[3α,6α(R*)	18.01	18.87	-	23.48
35	2-((2R,4aR,8aS)-4a-Methyl-8-methylenedecahydronaphthalen-2-yl)prop-2-en-1-ol	0.23	0.32	0.25	0.18
36	(Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6- dioxaspiro[4.4]non-3-ene	6.14	8.08	7.42	8.77
37	(Z)-2-(Hexa-2,4-diyn-1-ylidene)-1,6- dioxaspiro[4.4]non-3-ene	1.32	2.16	1.15	1.45
38	(E)-2-(Hepta-2,4-diyn-1-ylidene)-1,6- dioxaspiro[4.4]non-3-ene	0.22	0.29	0.23	0.24
39	(+)-2-Bornanone	-	1.65	0.98	1.09
40	Cyclopropanemethanol,2,2-dimethyl-3-(2-methyl1-propenyl)-	-	0.25	-	-
41	Citronellal	-	0.28	0.7	0.39
42	Isoborneol	-	0.44	-	0.41
43	Cyclohexanol,5-methyl2-(1-methylethyl)-, (1α,2β,5α)-(±)-	-	0.71	5.89	7.36
44	Azulene,1,2,3,5,6,7,8,8a-octahydro-1,4-dimethyl-7-(1-methylethenyl)-, [1S-(1α,7α,8aβ)]-	-	0.68	-	-
45	Naphthalene,1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, [1S-(1α,4aβ,8aα)]-	-	0.23	0.16	-
46	Caryophyllene oxide	-	0.55	0.24	0.21
47	(1R,4S,5S)-1,8-Dimethyl-4-(prop-1-en-2-yl)spiro[4.5]dec-7-ene	-	-	0.16	-
48	3,7,7-Trimethyl-8-(2-methyl-propenyl)-bicyclo[4.2.0]oct-2-ene	-	-	0.42	-
48	(E)-2-((8R,8aS)-8,8a-Dimethyl-3,4,6,7,8,8a-hexahydronaphthalen-2(1H)-ylidene)propan-1	-	-	0.17	-
50	Xanthoxylin	-	-	0.24	-
51	trans-Chrysanthemol	-	-	-	0.24
52	(-)-Spathulenol	-	-	-	0.29
53	Lanceol, cis	-	-	-	0.27

Oil sample 1: oil obtained from flowers of plant treated with K1
Oil sample 2: oil obtained from flowers of plant treated with K2
Oil sample 3: oil obtained from flowers of plant treated with K3
Oil sample 4: oil obtained from flowers of plant treated with NPK fertilizer.
- indicates compound not detected

Conclusion

Flower is the economically most useful part of the chamomile plant. In the present study, treatment with herbal Kunapjala promoted flowering attributes like early flowering and flower size. More to this, Kunapjala treatment also enhanced the quantity and quality of essential oil of chamomile. Oil content showed a dose dependent increase with increasing Kunapjala doses. Based on the results of the current investigation, it can be concluded that the Vrikshayurveda- based herbal Kunapjala prepared from readily available farm waste, other biowastes and locally found weeds, offers a sustainable and eco-friendly alternative to the chemical fertilizers. This fermented decoction is a rich bioresource which helps in enriching the soil by addition of readily available form of nutrients and beneficial soil microflora as well.

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Conflict of Interest

The authors declare there is no conflict of interest.

Author Contributions

The study was conducted by AK under the guidance of PC. Basic idea of the study was given by STP and PC. The field experiment was planned by MSN and chemical data was analysed by OP. Original draft was prepared by AK and all the other authors contributed to development of final manuscript.

Data Availability

The data that supports the findings of the study are available from the corresponding author upon reasonable request.

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