STUDIES ON BIO-CHEMICAL FERTILIZERS AND MICRONUTRIENTS ON FLOWERS YIELD AND OIL QUALITY OF *Matricuria Chamomilla* Linn. IN SODIC SOIL CONDITIONS

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CERTIFICATE-I

This is to certify that the thesis entitled **"Studies on bio-chemical fertilizers and micronutrients on flowers yield and oil quality of *Matricaria chamomilla* Linn. in sodic soil conditions" submitted for the degree of "Doctor of Philosophy" in the subject of Horticulture, Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad,** is a bonafide research work carried out by **Sri Sunil Kumar, I.D. No. A-1841/98** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

Narendra Nagar, Faizabad
December, 2002

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Major Advisor & Chairman
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CERTIFICATE –II

This is to certify that the thesis entitled **"Studies on bio-chemical fertilizers and micronutrients on flowers yield and oil quality of *Matricaria chamomilla* Linn. in sodic soil conditions"** submitted for the degree of "Doctor of Philosophy" in the subject of Horticulture, from Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Faizabad, in partial fulfilment of the requirements for the degree of "Doctor of Philosophy" in the subject of Horticulture has been approved by the student's Advisory Committee after oral examination of the same in collaboration with an external examiner.

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INTRODUCTION

Chapter-I

INTRODUCTION

German Chamomile (*Matricaria chamomilla* Linn), an important aromatic crop and medicinal, belongs to natural order compositae. There are three species of Chamomile viz., German or Hungarian Chamomile (*Matricaria chamomilla* L.), Roman or Egyptian or English Chamomile (*Anthemis noblis* L.) and Morocon Matricaria (*Ornemis multicaulis* Braun-blanquet and Maire), which are widely cultivated in various parts of the world for the production of dried herbs, flowers and essential oils, (Sharma *et al.*, 1983). Among these, German and Roman Chamomile have been listed as of greater significance with respect to their medicinal and economic values, high potential and productivity to wide range of soils from acidic to sodic soil conditions.

The Roman Chamomile is extensively cultivated in Belgium, France and England; however, German Chamomile is indigenous to Europe, and is widely cultivated in Germany and Belgium and now its cultivation is fairly done in other countries viz., France, Hungary, Russia and Argentina. In India, it was first introduced in Jammu and Kashmir in 1957 from Arab. It is most suited to grow under temperate regions, but can be cultivated in sub-tropical parts as winter seasons crop. It is also reported to grow under sodic soil condition (Chandra *et al.*, 1968). However, so far its cultivation is being done in meager area of a few selected districts of Uttar Pradesh such as Lucknow, Kanpur Dehat, Kannauj, Farrukhabad, Etawah, Eta, Manpuri, Agra, Raibareilly, Hardoi, Unnao and also in some parts of M.P. and Himanchal Pradesh.

In India, the cultivation of Matricaria is done for the production of dried herb known as "Babuna" and the flower, known as "Gule

Babuna" in trade. Flowers are extensively used as herbal teas (FFDC, 2002). The blue oil content in flowers varies from 0.3 to 1.3 per cent. The oil is endowed with antispasmodic, antiphlogistic, expectorant, carminative, anthelmintic, sedative diuretic and attenurant properties. It also helps in therapy for gastric ulcers, respiratory tract inflammation, pharyngitis, inflammation of the ophthalmic mucosa and uterus, hemorrhoids, healing of wounds and inhibits the ulceration through acidic reactions (Szelenyi, *et al.*, 1979 and Gould, *et al.*, 1974). It is also considered to be more useful particularly in the ailment of children such as dentition troubles, stomach disorders, earache and neuralgic pain (Jakolev, 1979).

The flowers are carminative, stimulant, emmenagogue, attenuant and discontent. They are prescribed for dyspepsia, flatulent, colic fevers, menstrual disorder, hysteria, suppression of menses and very effective in uterine reflex-disturbances of women. It has also aromatherapy values and is used in acne, allergies, boils, earache, eczema, hair care, inflamed joints, muscular pains, neuralgia, rheumatism, sprains, headache, insomnia, nervous tension, migraine and stress related complaints (Jagat aroma oil distillery, 2002).

True Matricaria oil is used in very less quantity in high-class perfumes, hair and bath products, cosmetics, soaps and detergents because of loss of rich undertone due to evaporation process. It blends well with geranium, lavender, patchouli, rose, benzoin, neroli, bergamot, marjoram, lemon, ylang- ylang, Jasmine, clary sage and labdanum that are of great to perfumery significance in world trade (personal communication of Jagat aroma oils distillery and FFDC, Kannauj, 2002). Beside the oil is also used in ice creams, chewing gums and in flavouring of tea, alcoholic and non-alcoholic beverages.

Flowers are used in pillow to sooth nerves of brain. The herbs are also used as dye for imparting orange colour to wool, moisturizing

creams for skin, invigorating bath for jet fatigue rinse, blend hairs and prevent hair loss. The extract of Matricaria is also known to have bactericidal and fungicidal effect. It completely inhibits the growth of *Staphylococcus auveus* and *S. mutense.* Its extracts also have bactericidal effects on *Bacillus megaterium* and *Laptospira iceterohoemorrhagia,* whereas the growth of *S. epidermidis* and *S. foecalis* are significantly reduced. It also exhibits antitrichomonical activity (Cimco, 1983). Ethanolic extract of chamomile inhibits the growth of poliovirus and shows anti-hepatic effect. (Pasechnic, 1966).

The economic importance of Matricaria oil is much higher in world trade due to its wider use and applications. The oil extracts from Matricaria flowers is known as "Blue oil" in the market that contains Farnesene, Germacene, Non-Guazlene, Bisabolol oxide-B, Bisabolon oxide-B, Bisabolol, Chamozuline, Bisabolol oxide-A, Tras-dicyloether and Cis-dicyloether. Besides major derivatives, a few minor components such as monoterpenes gammo- terpinene and muurolene and calamenene were also found in essential oil. 2 hydroxy-4, 6-dimethoxy acetophenone (Xanthoxyline) is also found in larger amount. A new azulenic, intensely violet aldehyde C14 H14 O, named "Chamavialin" has also been detected (Motl *et al.*, 1983). The productivity and quality of blue oil of Matricaria flowers is influenced by number of factors viz. temperature, light, soil moisture, soil fertility, plant nutrients, time of planting, distillation process etc. The production of high quality flowers and blue oil is very important to promote the perfume industry which would be very helpful to meet and the annual demand of about 22500 tonnes of dried flowers and 12 tonnes of oil (FFDC, 2002). The export value of blue oil in international market is very high and usually feature Rs. 38,000/kg (Anonymous, 2002). In addition to blue oil, the dried flower have also

great demand in India and abroad fetching a price of Rs. 40 per Kg in India and Rs. 150 per Kg in international market (Anonymous, 2002).

Thus, keeping in view the increasing demands of Matricaria flowers and blue oil in India as well as in international markets, there is dire need to increase the acreage under chamomile cultivation to increase production of the flowers and blue oil. However, the yield and quality of essential oil in different oil bearing aromatic crops is affected significantly by biotic and abiotic factors which have yet not been established so for.

Among the number of factors responsible for improving the yield and oil quality of aromatic crop, the balance supply of nutrients is one of them that is know to improve the yield and quality of herbal produce. The use of biofertilizers, organic manures and organic farming are now consider to the best and cheapest source supply of balance nutrients, which will be more beneficial for the in production of high quality produce. The application of biofertilizers like the inoculation of Azotobacter as free-living aerobic nitrogen-fixing bacteria can be used as substitute to inorganic fertilizers Azotobacter inoculation has been found to economics the use of fertilizer nitrogen by 10-20% and also helps in synthesis of plant growth hormone like Cytókinins, IAA and Gibberellins by improving vegetative growth of plant. (Asokan *et al.*, 2000).

In addition to nitrogen, the application of phosphorus, potash and micronutrients have also been found to play an important role in improving the productivity and quality of produce, especially under adverse soil conditions. Matricaria being a potential aromatic crop, suitable for economic utilization of sodic lands and having great significance to perfume and flavors industries, no systematic research works have been carried out to assess the yield and quality of Matricaria under variable soil fertility and agronomical factors.

Keeping in view its pharmaceutical and perfumery significance, economic potential, wider adaptability, high market values and demands, the present research work entitled "Studies on bio-chemical fertilizers and micro-nutrients on flowers yield and oil quality of *Matricaria chamomilla* Linn.in sodic soil condition," was carried out with the following Objectives:

1.1 To work out the optimum dose of fertilizer with Azotobacter for improving the flowers yields and oil quality of Matricaria.

1.2 To find out the optimum dose of fertilizer with PSB for improving the flowers yields and oil quality of Matricaria.

1.3 To find out the optimum dose of fertilizer in conjunction with Azotobacter + PSB for improving flowers yield and oil quality of Matricaria.

1.4 To work out the *optimum* dose of fertilizer and supplemented with bio-fertilizer and micronutrient on improving the flowers yield and oil quality of Matricaria.

1.5 To estimate the cost/benefit ratio of bio-chemical fertilizers with micronutrients for production of Matricaria.

REVIEW OF LITERATURE

Chapter -II

REVIEW OF LITERATURE

A first approach has been initiated in present investigation to workout the effect of integrated nutrients management through application of organic manures (F.Y.M.), N.P.K. levels, biofertilizers and micronutrients under sodic soil conditions for improving the growth, flowering, yield and oil quality of *Matricaria chamomilla* Linn. The survey of literatures with respect to research works carried out earlier on Matricaria indicated that very few research work has been done on nutritional aspects, uses of biofertilizers and micronutrients for improving the flowers and oil yield of Matricaria. However, the information available in literatures on nutritional studies, biofertilizers and micronutrients for improving the yield and quality of the aromatic crops are summarized herewith in following heads:

2.1 Effect of nutrients on plant growth characters:

(1977) reported that no manure was required to the *Ocimum bosiliaum,* but application of 20-25 Kg N and 10-15 Kg P_2O_5/ ha ensured good vegetative growth and herb yield. **Bhattacharjee and Diwakar (1983)** have observed that application of 100gN/plant produced more number of branches per plant in *Jasminum grandiflorum.*

Bopaiah and Khader (1989) noted that maximum plant height of black pepper (*Piper nigrum*) was due to combined treatments of Azotobacter and Azospirillum, followed by VAM treatment. **Sudheendra *et al.* (1993)** has work out the N requirement of celery (*Apium graveolens*) and found that the plant height (87.32 cm and 76.06 cm.) and number of branches (7.66 and 16.18) were the maximum with the application of (200 Kg N/ha) and (60 Kg P_2O_5/ha).

Letchamo (1990) reported that the plant height, number of primary and secondary branches per plant of Matricaria were maximum with application higher dosed of nitrogen.

Shukla and Prasad (1998) studied the nutritional requirement on Matricaria, with treatments combinations, consisting four doses of nitrogen (0, 30, 60 and 90 Kg/ha) and three doses of phosphorus (0,40, and 60 Kg/ha), and found that the maximum plant height (63.4 cm), plant spread (27.3 cm), number of primary and secondary branches per plants (12.7 and 29.4), were associated with treatment having combined application of 60 Kg N + 60Kg P/ha.

Chandrikapure *et al.* (1999) reported that african marigold (*Tagetes erecta* L) produced latter plants with the maximum number of branches with application of 100% N+inoculations with Azotobacter and PSB.**Ram *et al.* (1999)** conducted the pot experiment to evaluate the effect of different levels of soil sodicity and fertility on growth of chamomile and found that the chamomile could be successfully grown in sodic soil having ESP up to 53 without prior reclamation. Growth parameters such as plant height and plant spread were reduced due to increase in the sodicity levels, but increased with increasing the fertility levels.

Ram Sukh Jat and Sharma, (2000) Studied on fenugreek (*Trigonella foenum-graecum*) the influence of 5 fertility levels (control, 10Kg N + 20 Kg P_2O_5 / ha) and 4 biofertilizers (No inoculation, inoculate Rhizobium, PSB and Rhizobium + PSB) and found that there was significant enhancement in plant height and branches per plant with application of 20 Kg N + 40 Kg P_2O_5 / ha and with combined inoculation of biofertilizers (Rhizobium + PSB).

Khan (2000) found that foliar application of micronutrients viz., Zn and Fe (Zn and Fe) in form of Zn SO_4 (0.4%) and Fe SO_4 (0.4%) that significantly improved the plant height and branching habits on Dahlia. The positive role of zinc on plant growth is reported due to the more synthesis of tryptophan, which is a precursor of auixn- IAA (**Tusi, 1948**). **Gayathrisubramanian and Thamburaj (2000)** have suggested that the application of biofertilizers i.e. Azospirillum. phosphobacterium and VAM for improved the growth and flowering of carnation cv. Pamir. The maximum plant height was obtained by

Azospirillum and phosphabacterium with the regular dose of NPK (30,20 and 10_g/ sq.m.).

2.2 Effect of nutrients on flower characters:

Bhattacharjee and Diwaker (1983) reported that the application of 100g N/ plant induced early flowering in *J. grandiflorum.*

Shukla and Prasad (1998) reported that application of different doses of nitrogen and phosphorus did not show significant influence on number of days taken to appearance of first of flower buds and 50% flowering of Matricaria. However, the maximum number of days taken to appearance of the first flower and 50% flowering (71.9 and 77.5 days) were with the application of 90Kg N/ha, while minimum number of days (71.0 and 76.0 days) for first flower bud appearance and 50% flowering were taken in control. Further, it was observed that increasing the levels of nitrogen and phosphorus, the duration of flowering and number of flower pickings of Matricaria decreased. The maximum flowering span and number of flowers pickings (47 days and 5) were obtained when crop did not receive fertilizers. Application of 60Kg N and 60 Kg P/ha reduced the duration of flowering (34.3days) and number of pickings (4).

Chandrikapure *et al.* (1999) studied the effect of bio- inoculations and graded doses of N on flowering of Marigold (*Tagetes erecta* L.) and observed that 50% flowering took maximum days with the inoculation of Azotobacter and PSB and supplemented with full doses of nitrogen. Minimum number of days (73.11) was required in 50% flowering by application of Azotobacter with 100% N as compared to control (89.96). Further, it was also noticed that increasing the levels of nitrogen alone with bio- inoculations induced early flowering in marigold (***Anuradha et al.* 1990**).

2.3 Effect of nutrients on flowers and oil yield:

Datta and Singh (1961) observed that application of 40 Kg N/ha significantly increased the fresh flower and oil yield of chamomile, while the oil content was observed significantly over control. Further **Datta and Singh**

(1964) studied the effect of plant spacing on flower yield and oil content of chamomile and found that the maximum fresh flowers yield and oil content were obtained when planted at a spacing of 30 x 30 cm. However, the number of flowers and flower yield per plant were maximum when planted at a spacing of 45 × 45 cm.

El-Hamidii *et al.* **(1965)** recorded maximum flowers of Matricaria grown in Egypt at wider spacing (45× 45 cm) and NPK fertilizers. **Singh *et al.* (1971)** obtained maximum seed yield and essential oil content of *Anethum gravolens* with the application of 45Kg N and 30 Kg P_2O_5 /ha. Further increase in N and P levels resulted in the lowering of the oil content.

Singh *et al. (1976)* found that the application of NPK improved the essential oil content and the recovery of concrete from the flowers of tuberose with the fertilizer treatment of 80 Kg N, 80 Kg P_2O_5 and 80 Kg K_2O /ha, while the lower and higher doses reduced the production. **Gulati *et al.* (1977)** reported that the application of 20-25 Kg N and 10-15 Kg P_2O_5 /ha gave maximum oil yield of Indian basil (Ocimum basilium). **Pandey *et al.* (1978)** found that 25 tonnes of F.Y.M. 120Kg N and 80 Kg each P_2O_5 and K_2O /ha increased the oil content, herb and oil yield of Basil(Ocimum basilium).

Natarajan and Rao (1980) recorded maximum flower yield and essential oil of rose with the application of 15 Kg F.Y.M. + 60g N + 120 g P_2O_5 + 120g K_2O/m^2. **Singh and Murthy (1984)** studied the effect of *Ascorbic* acid on recovery of concrete in rose and found more production of oil glands and terpenic alcohol in flowers. **Chand *et al.* (1982)** reported that a spacing of 60 × 30 cm and application of 24 t of F.Y.M., 120 Kg N, 60 Kg P_2O_5 and 25 Kg Zinc per ha produced highest biomass and essential oil yield of Jamrosa.

Bhattacharjee and Diwakar (1983) observed that J. *grandiflorum* increase in flower bud, length and diameter and flowers weight per 100 flowers with the application of 100g N/ plant. It was reported that the flowers and concrete yield was significantly increased with application of 100g N + 150g P_2O_5 + 100g K_2O /plant.

Emonger *et al.* (1989) found that top dressing of Chamomile plants at 50 Kg N /ha at two week after transplanting, resulted in to higher vegetation growth and flowers yield, whereas, the phosphorus in combination with nitrogen did not show significant effect on vegetative growth and flowers yield. **Johri *et. al.* (1991)** reported that flowers and essential oil yield of *Matricaria chamomilla* Linn was maximum at when planted a 30 x 30 cm and with the application of 60 Kg N per ha. Further, **Johri *et.al.* (1992)** conducted an experiment and obtained higher flowers and oil yield (15.32- 16.51 q/ha and 12.14-12.78 liters /ha, respectively) by planting of crop on 15 Feb. and fertilized w h 60 Kg N / ha.

Gowda *et al.* (1991) suggested that essential oil yield of Chamomile can be significantly enhanced by planting crop at a spacing of 30 x20 cm and fertilization with 60Kg nitrogen per ha. **Shukla and Prasad (1998)** reported that fresh and dry weight of flowers per plant and yield of flowers of Matricaria increased significantly with increasing the levels of nitrogen and phosphorus. However, maximum fresh and dry flowers yields (14.80 and 12.74 q/ha) were recorded with the application of 60 Kg N and 60 Kg P_2O_5 /ha. Further, it was also reported that maximum percentage of oil content (0.60 %) and oil yield (7.64l/ha) was obtained at higher dose of N (60 Kg /ha) and (P 60 kg/ha).

Badiyala *et al.* (1993) found that the maximum number of flowers and dried flowers yield of Saffron per ha were observed at higher dose of N, P and K (90:60: 60 Kg/ ha). **Sudheendra *et al.* (1993)** conducted an experiment on celery and concluded that maximum recovery of essential oil (32.95 and 19.03 Kg/ha) was recorded at higher doses of N 200 Kg/ha and P_2O_5 60Kg/ha; with no fertilization, the oil yield were significantly decrease.

Wange and Patil (1994) reported that application of 100 Kg N/ha alone or inoculating with Azotobacter + Azospirillum mixtures significantly increased the number of flowers per stalk, bulb yield and the number of flowers spikes in *Polyanthes tuberosa*. **Johri *et al.* (1994)** concluded that the

application of 90 Kg nitrogen per ha gave the maximum number of flowers, dry flower yield, oil content and oil yield of Chamomile.

Prasad Rao *et al.* (1997) studied the effect of N and FYM on total biomass production in davana (*Artemisia pallens*) and found that the application nitrogen significantly enhanced the total biomass yield and recovery of essential oil with the application of 80 Kg/ha. **Rastogi *et al.* (1997)** reported that application of 90 Kg N/ ha increased the maximum shoot yield (60.52 q/ha) and essential oil (38.77 l/ha) in Calery Sage, which was found to be significantly higher over other levels of nitrogen application.

Gupta (1997) suggested that maximum flowers yield of Marigold per ha was recorded with application of Azotobacter +75% N (56.88 q) and Azotobacter + PSB + 100% N (43.85 q), which was due to synergistic action of bioinoculants and resulting in to better availability of nutrients and stimulation of plant growth promoting substances like, auxin, gibberelins, vitamins and organic acids.

Muthumanickan *et al.* (1999) studied the effect of micronutrients on flowers production in Gerbera and found that the spraying of $MnSO_4$ + Fe SO_4 + $ZnSO_4$ (0.2 % each) increased flowers yield per plant. **Nikolova *et al.* (1999)** reported that application of optimum doses of nitrogen and potassium increased the flower yield of Matricaria, whereas, phosphorus affected the oil content. Further, it was noticed that sulphur and phosphorus increased flower weight and essential oil content.

Gupta *et al.* (1999) found that yield *T. erecta* L. with various combinations of Azotobacter, phosphate solubilizing bacteria (PSB) and nitrogen and obtained maximum flowers yield with inoculation of Azotoabcter +PSB in combination of 75 or 100 % nitrogen application as compared to other treatments and control.

2.4 Effect of nutrients on quality of Blue oil:

Emongor and Chweya (1992) reported that N application significantly increased alpha-bisabolol and Chamazuline content, but it significantly

decreased alpha- bisabolol oxide- A and bisabolol oxide-B content in blue oil. The quality of essential oil of Matricaria flowers is related to alpha- bisabolol and chamazuline content in blue oil.

Ram *et al.* (1999) have conducted pot- experiment to study the effect of fertility levels on essential oil content and quality in *M. chamomilla* Linn. The results indicated that the concentration of chamazuline and bisabolol oxide- B increased with P and K application; whereas, N application had a positive effect upon Farnesene and Bisabolol oxide-A concentration in the essential oil, but bisabolol oxide-B concentration decreased with increasing N rate.

Nikolova *et al.*(1999) reported that the highest yield oil of chamomile was recorded with ratio of nutrients (1:1:1) i.e.120 Kg /ha active ingredients, whereas, differences in the nutrients level changed the quality of essential oil. The alpha- bisabolol content was increased by elevated P_2O_5 levels, while chamazuline content in the oil was relatively more stable characteristic and not affected greatly by variation in nutrients.

MATERIALS AND METHODS

Chapter-III

MATERIALS AND METHODS

The present investigation entitled "Studies on bio-chemical fertilizers and micronutrients on flowers yield and oil quality of *Matricaria chamomilla* linn in sodic soil conditions" was carried out at the Main Experiment Station, Department of Horticulture, Narendra Deva University of Agriculture and Technology, Narendra Nagar, (Kumarganj), Faizabad (U.P.) during the years 1999-2000 and 2000-2001. The details of the experimental methodology and materials used in present investigation are given below:

3.1 Experimental site:

The experimental site is situated at 42 Km away from Faizabad district headquarter on Faizabad- Raibareilly road and lines between a latitude of 24.17^0 and 26.56^0 and longitude of 31.12^0 and 83.89^0 at an elevation of about 113.0 meters above means sea level.

3.2 Meteorological conditions:

The Faizabad district falls under the sub-tropical region of India and is located in eastern part of Utter Pradesh. The annual climatic conditions are distributed into three distinct season viz., rainy, winter and summer. During experimental years; the rainfall was erratically distributed throughout both the years (1999-2000 and 2000-2001). The temperature ranged from 38.0^0C to 4.8^0C during the experimentation. The maximum temperature was recorded during summer months (March and April), while the minimum temperature was recorded during winter months (January and February). The meteorological observation on temperature, rainfall, relative humidity and sunshine were recorded at weekly intervals during the experimentation (1999-2000 and 2000-2001), which is presented in table 1 and illustrated in Fig. 1.

Table 1: Average weekly meteorological data during the experimentation (1999-2000 and 2000 - 2001)

Months	*Weeks*	*Temperature (°C)* Max.		Min.		*Relative Humidity (%)*		*Rainfall (mm)*		*Sunshine (hrs)*	
		99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01
November (1999-2000)	1st Week	32.9	31.7	18.7	15.2	67.1	67.3	0.0	0.1	9.0	7.9
	2nd Week	31.3	30.1	14.9	12.3	64.2	82.7	0.0	0.0	8.7	8.4
	3rd Week	29.9	28.3	11.8	14.3	59.0	92.2	0.0	0.0	5.5	8.1
	4th Week	28.8	26.2	11.8	9.4	64.4	80.5	0.0	0.0	7.8	7.2
December (1999-2000)	1st Week	26.2	25.5	10.3	6.4	66.4	77.7	0.0	0.0	6.1	8.0
	2nd Week	26.0	25.2	9.6	6.2	68.2	80.2	0.0	0.0	8.2	7.9
	3rd Week	25.0	24.7	8.0	7.5	60.6	92.3	0.0	0.0	5.6	6.5
	4th Week	24.6	24.6	7.3	7.1	68.9	70.6	0.0	0.0	3.5	7.5
January (2000-2001)	1st Week	15.12	18.5	5.8	7.3	80.1	77.4	0.0	0.0	5.9	8.0
	2nd Week	20.2	18.8	7.3	3.3	78.1	79.0	16.0	0.0	1.9	6.7
	3rd Week	19.3	22.7	6.4	3.3	71.9	61.6	0.0	0.0	2.3	7.5
	4th Week	24.3	23.2	7.8	6.3	67.9	61.0	0.0	0.0	7.6	5.1
February (2000-2001	1st Week	23.4	24.4	9.1	7.4	53.9	64.0	0.0	0.0	4.5	3.9
	2nd Week	23.2	25.5	8.4	6.3	75.3	69.5	0.0	0.0	6.5	5.7
	3rd Week	23.5	26.1	6.6	8.5	55.4	67.1	0.0	3.3	9.5	7.7
	4th Week	25.8	28.3	7.0	10.9	62.7	59.9	0.0	0.0	10.1	9.0
March (2000-2001)	1st Week	26.8	28.5	7.0	10.1	60.5	52.0	0.0	0.0	8.4	8.4
	2nd Week	30.1	28.0	11.3	9.8	49.7	51.5	0.0	0.0	8.5	9.0
	3rd Week	30.3	32.4	10.8	12.1	48.8	55.1	0.0	0.0	7.0	9.0
	4th Week	31.7	32.5	12.7	12.4	52.9	54.1	0.0	0.0	8.5	6.2
April (2000-2001)	1st Week	33.5	37.7	13.3	17.8	42.6	54.2	0.0	0.0	9.7	8.9
	2nd Week	34.8	37.0	14.9	16.7	30.0	40.8	0.0	0.0	9.7	8.8
	3rd Week	36.3	38.0	19.5	20.2	40.0	28.9	1.4	3.8	9.1	7.7
	4th Week	39.3	34.0	21.7	19.3	55.0	43.4	0.0	0.0	8.1	8.2

3.3 Phyisco-chemical characteristics of soil:

The initial phyisco- chemical properties of the soil before planting of crop and application of fertilizers were determined during both the experimental years (1999-2000 and 2000-2001). The soil samples were collected randomly from the different places of the experimental field with the help of soil auger at 15cm depth. The soil samples of each replication were mixed together and a composite soil sample were made and dried in oven at temperature 105^0C till the final constant weight of sample. The phyisco-

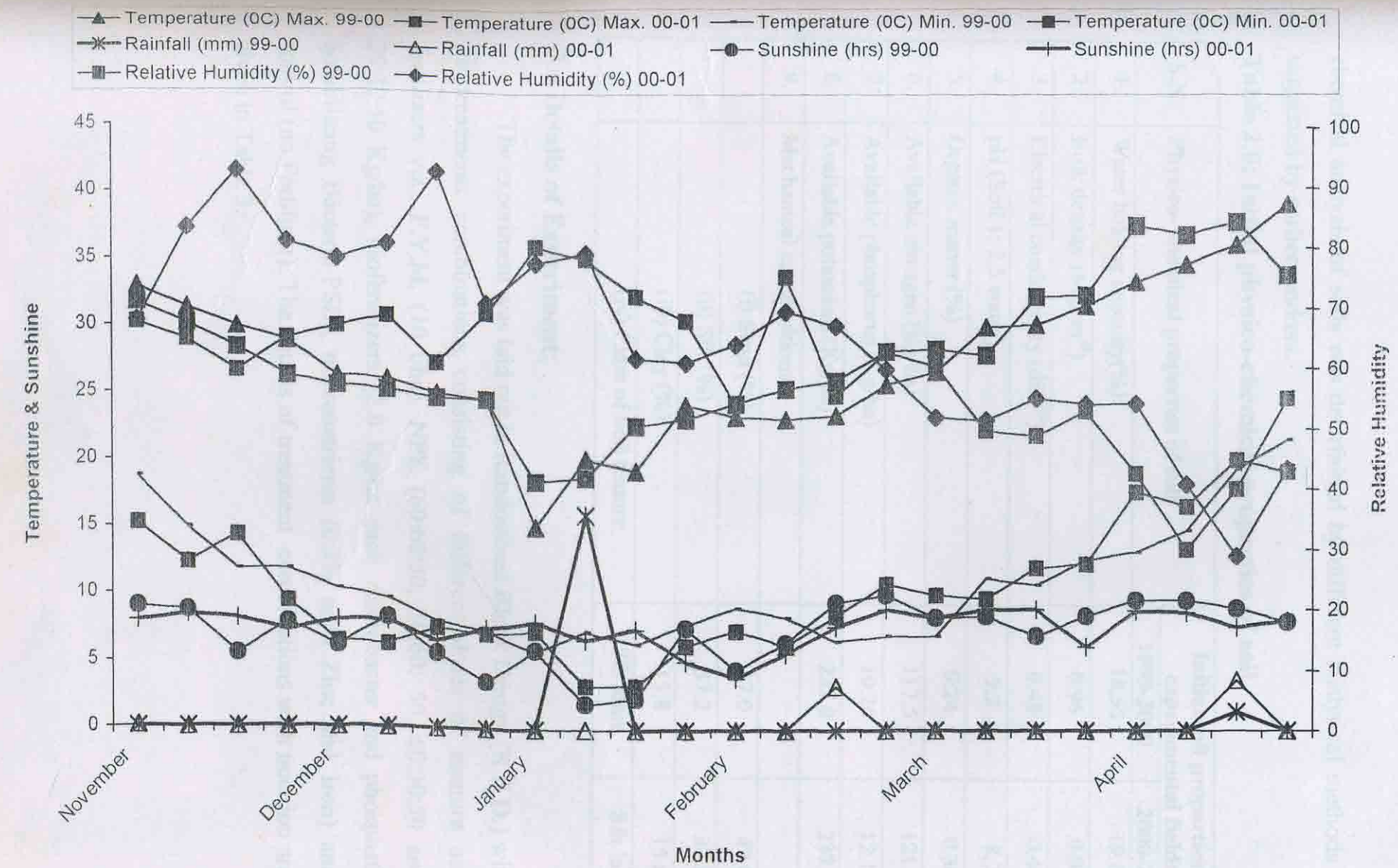


Fig. 1: Average Weekly meterological data during the experimentation (1999-2000 and 2000-01)

chemical analysis of soils was determined by different analytical methods as suggested by earlier workers.

Table 2.0: Initial physico-chemical properties of soil

S.N.	Physico- chemical properties of soil	Initial soil properties of experimental fields	
		1999-2000	2000-2001
1.	Water holding capacity(%)	18.53	19.61
2.	Bulk density (Mg/ m^{-3})	0.96	0.94
3.	Electrical conductivity (dS^{m-1})	0.48	0.44
4.	pH (Soil 1: 2.5 water)	9.2	8.7
5.	Organic matter (%)	0.24	0.30
6.	Available nitrogen (Kg/ha)	117.5	121.7
7.	Available phosphorus (Kg/ha)	10.26	12.19
8.	Available potassium (Kg/ha)	235.0	237.2
9.	Mechanical compositions		
	(i) Sand (%)	47.0	47.0
	(ii) Silt (%)	37.2	37.2
	(iii) Clay (%)	15.8	15.8
	(iv) Class of Soil texture	Silt loam	Silt loam

3.4 Details of Experiment:

The experiment was laid out in Randomised Block Design (R.B.D.) with 16 treatments combinations, consisting of different doses of manure and fertilizers viz., F.Y.M. (10 t/ha), NPK (60:60:50, 30:60: 50, 60:30:50 and 30:30:50 Kg/ha), biofertilizers (2.0 Kg/ha each Azotobacter and phosphate Solubilizing Bacteria-PSB), micronutrients (0.3% each Zinc and Iron) and control (no Fertilizer). The details of treatment combinations with notation are given in Table 3.

Table 3.0: Treatment combinations and their notation

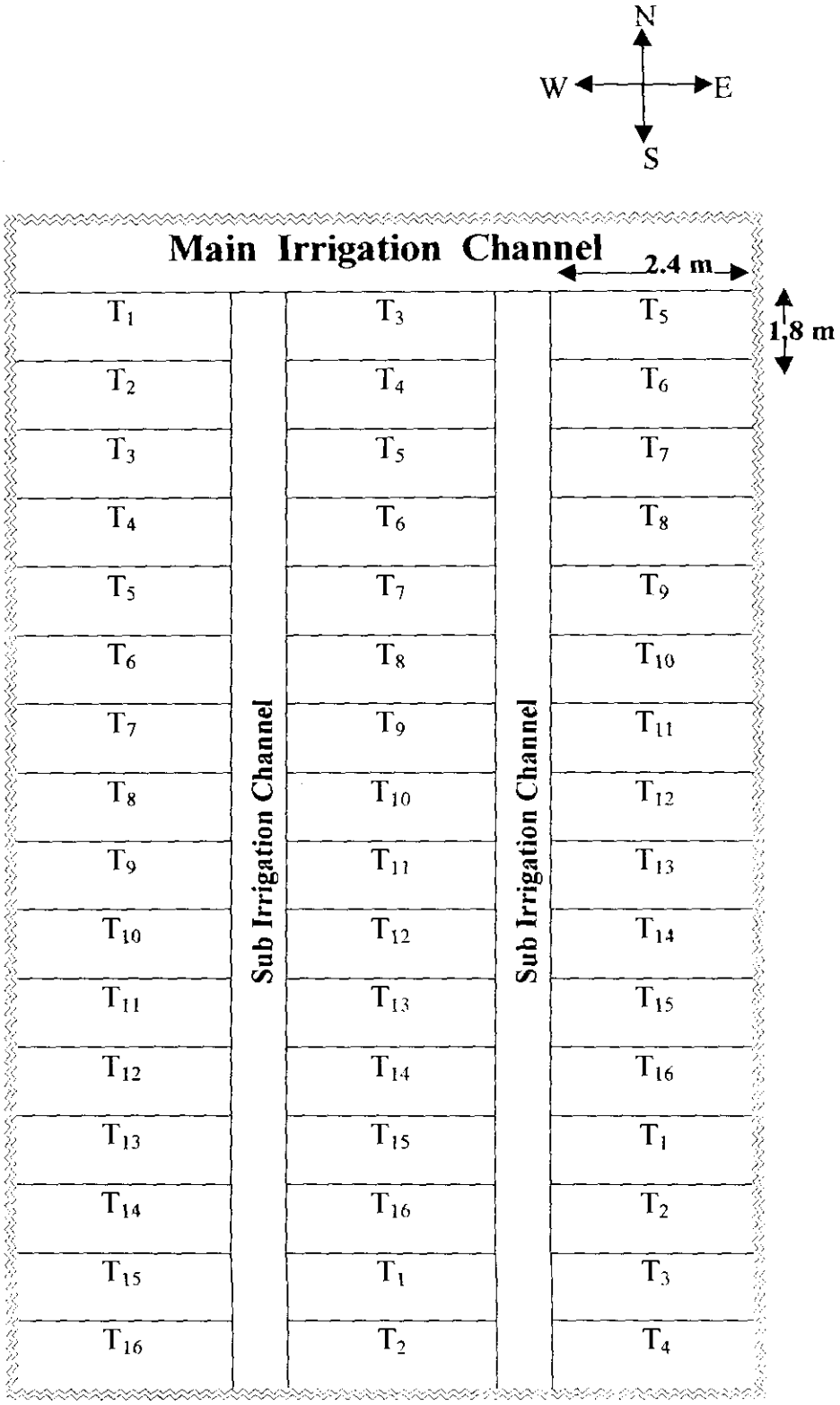
S. N.	Treatment Combinations	Notation
1.	F.Y.M. (10 t/ha)	T_1
2.	F.Y.M. (10 t/ha) + Azotobacter (2.0 Kg/ ha)	T_2
3.	F.Y.M (10 t/ha) + PSB (2.0 Kg /ha)	T_3
4.	F.Y.M. (10 t/ha) + Azotobacter + PSB	T_4
5.	NPK-60:60:50 Kg/ha	T_5
6.	NPK-30:60:50 Kg/ha + Azotobacter	T_6
7.	NPK-60:30:50 Kg/ha + PSB	T_7
8.	NPK-30:30:50 Kg/ha + Azotobacter + PSB	T_8
9.	NPK-30:60:50 Kg/ha + Azotobacter + Zinc EDTA (0.3%)	T_9
10.	NPK-30:60:50 Kg/ha + Azotobacter + Iron EDTA (0.3%)	T_{10}
11.	NPK-30:60:50 Kg/ha + Azotobacter + Zinc + Iron	T_{11}
12.	NPK-60:30:50 Kg/ha + PSB + Zinc	T_{12}
13.	NPK-60:30:50 Kg/ha + PSB + Iron	T_{13}
14.	NPK-60:30:50 Kg/ha + PSB + Zinc + Iron	T_{14}
15.	NPK-30:30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron	T_{15}
16.	Control (no fertilisation)	T_{16}

3.5 Experimental layout plan:

The experimental field was ploughed with the help of tractor and the well-prepared field was divided into three main blocks. Each block consists of 16 plots having size 2.4 x 1.8 m. The total number of plots were 48 as per treatment combinations and replications. The each experimental plot was provided with irrigation channel. The experimental layout and details of experimental plan is illustrated in Fig. 2.

3.6 Experimental details:

1.	Design	Randomised Block Design
2.	Number of replications	3
3.	Number of treatments	16



Experimental lay out plan (1999-2000 & 2000-2001)

4.	Total number of plots	48
5.	Net plot size	2.4 x 1.8 m
6.	Plot border	0.30 m
7.	Field border	0.50 m
8.	Replication border	0.40 m
9.	Main irrigation channel	0.60 m
10.	Sub- irrigation channel	0.40 m
11.	Planting distance	30 × 15 cm.
12.	Plant population per plot ($4.32m^2$)	96 (8 rows × 12 plants)
13.	Variety used	Soraksor-60
14.	Date of nursery raising	20 Nov. (1999and 2000)
15.	Date of transplanting	20 Dec. (1999and 2001)
16.	Date of harvesting of crop	29 April (2000 and 2001)

3.7 Methodology of experiment:

3.7.1 Method of nursery raising:

The nursery of matricaria raised by seeds. In some place, broadcasting of seeds in the field is also done for cultivation. The nursery was raised in the month of November and seedlings were matured for transplanting in month of December. Nearly 600g seeds is required for one hectare planting. The nursery was raised in beds having size of 3x1 m. The nursery beds were well prepared and mixed with well-decomposed F.Y.M. The seeds were spread on seed beds and covered with fine dust of F.Y.M. After sowing of seeds, it was mulched with paddy straw and sprinkled with light irrigation. The seeds germinated within 5 days and seedlings became ready to transplanting after 30 days.

3.7.2 Transplanting of seedlings:

After completion of land preparation and layout, each experimental plot was supplemented with recommended doses of F.Y.M. and chemical fertilizer. The seedlings were uprooted from nursery beds with the help of

khurpi. The individual plant was separated and planted in each plot at a plant spacing of 30x15 cm., followed by light irrigation.

3.7.3 Application of manure and fertilizers:

The doses of different fertilisers, biofertilizers and micronutrients were applied as per treatments. The basal dose of 10 tonnes/ ha well rotten F.Y.M. was applied at the time of land preparation and half dose of nitrogen, full dose of phosphors and potassium were also applied as basal dose before planting of crop. The application of biofertilizers i.e. Azotobacter and phosphate solubilizing bacteria (PSB) were also applied at the rate of 2.0 kg/ha in the soil before planting. The rest dose of nitrogen was applied in two split dose by top dressing at 35 days and 50 days after transplanting of crop. Whereas, the foliar spraying of Zinc (0.3%) and Iron (0.3%) was done in form of Zinc EDTA (12% Zn) and Fe EDTA (12 %Fe) at 35 days after transplanting.

3.7.4 Irrigation:

The optimum level of soil moisture was maintained during the growth and flowering period by giving irrigation at 3 week intervals. Six irrigations were given from transplanting to harvesting of crop.

3.7.5 Flowering and picking of flowers:

The picking of flowers was done from second week of March to the last week of April. The picking of full bloomed flowers were done by manually in the early morning (6 A.M. to 10 A.M.). The 4 to 5 pickings were done at 10 days intervals during the flowering duration.

3.7.6 Processing of flowers:

The freshly picked flowers contain 80-85% moisture, which required shade drying. The flowers were spread over ground in thin layers of 1-2 cm. and allowed to dry till they lose 70-75% moisture. During the drying period, care was taken, so that flowers should not show any brown/ black colour due to excessive moisture or excessive sun drying. The shaking of flowers were done regularly very carefully to avoid any breaking of petals and discoloration of original whitish and yellowish colour of flowers/flower buds.

3.7.7 Distillation of Blue oil:

The extraction of blue oil from the dry flowers of Matricaria was done through steam distillation process with the help of Stainless steel made clavengar's apparatus. The 250g of dried flowers of Matricaria were kept in to flask of clavengar's apparatus and added 1.5 litre water. The slow heating was done under the controlled temperature (60^0C) to avoid any over heating. During the process of steaming the volatile oil mixed with water vapour passed in to the condenser and cooled by flowing of cool water. The cooled blue oil deposit on the lower part of condenser tube, which later separate out into oil collecting tubes and stored in glass bottles and kept under cool ventilated places.

3.8 Observations recorded:

The observations on plant growth characteristics, flowering, flowers yield, oil content and yield, oil quality analysis, nutrients status of plants and soil and cost / benefit ratio were recorded according to each treatments. The methodology used in recording of observations and chemical estimations are described below.

3.8.1 Plant growth characters:

(1) Plant height (cm): The average plant height were measured in centimetre with help of metre scale at flowering stage (120 days after transplanting -DAP).

(2) Plant spread (cm): The average plant spread was also recorded in centimetre with help of metre scale in East - West and North - South direction of plant at flowering stage (120 DAP).

(3) Number of primary branches per plant: The number of primary branches per plant were counted from each sampled plant and the average number of primary branches per plant were recorded in each treatment at flowering stage (120DAP) of plant.

(4) **Number of secondary branches per plant:** The number of secondary branches per plant were counted at flowering stage (120 days after transplanting of plant-DAP).

3.8.2 Flower characteristics:

(5) **Number of days taken to appearance of first flower:** The number of days taken from date of planting (DAP) to emergence of first flower buds were visually observed in each beds and counted in days.

(6) **Days taken to 50% flowering:** The observation on total number of days taken in appearance of 50% flowering were recorded from date of planting (DAP) and their average number of days taken in each treatment.

(7) **Duration of flowering (day):** The duration of flowering was recorded in days from the date of first opening of flower to last date of blooming of flowers.

(8) **Number of flower picking:** The total number of flower picking was recorded from first to the last picking. The peak period of flower picking was also counted for harvesting of maximum fully bloom flowers.

3.8.3 Flowers yield:

(9) **Number of flowers per plant:** The total number of flower buds appeared on each sampled plant were counted and taken as number of flowers per plant.

(10) **Fresh weight of flower (g):** The fresh weight of flowers were weighed from one thousand flowers, which were picked at peak stage of flowering and recorded as average fresh weight of flowers in g per thousand flowers.

(11) **Dry weight of flower (g):** The fresh flowers harvested were dried under shade by maintaining of 10-15% moisture in flowers, weighed and recorded as dry weight of flowers (g/1000 flowers).

(12) **Moisture content in flower (%):** The percentage of moisture in flowers was also measured by using the following formula:

$$\text{Percentage of moisture} = \frac{\text{Fresh weight of flowers} - \text{Dry weight of flowers}}{\text{Fresh weight of flowers}} \times 100$$

(13) Flower yield (q/ha): The picking wise, fresh and dry yield of flowers per hectare were estimated on the basis of fresh and dry yield of flowers obtained in each experimental plots.

3.8.4 Oil content, yield and quality:

(14) Oil content (%): The oil content was determined in percentage on dry weight basis (DWB) of flowers by using steam distillation process.

(15) Oil yield (L/ha): Total oil yield was calculated by multiplying the percentage of oil content at DWB and flowers yield obtained per hectare.

Oil yield (L/ha) = Dry flower yield per ha × average oil content (%)

(16) Determination of Oil quality: The quality of blue oil of Matricaria was determined by well standardised method used Gas Liquid Chromatography (GLC) which was carried out in collaboration with Laboratory of **Fragrance & Flavour Development Centre (FFDC) Kannauj** (U.P.). The following physico-chemical properties were evaluated in blue oil of Matricaria.

(A) Evaluation of physical properties of blue oil: The important physical properties as prescribed in trade of aroma chemicals i.e. colour, odour, flavour, specific gravity, acid value and solubility per cent were done by organolepitic quality- olfactory test, gustation test and visually for colour as per Bureau of Indian standard (BIS) 326-1968.

(i) Organoleptic test: The quality of blue oil and other aroma chemical is evaluated on the basis of natural odour/ aroma values. The methods used for evaluation of odour/ aroma is called organoleptic test which was evaluated by using alfactory test and gustation test as standardized by Essential Oil Association of India and Perfume Industries.

(ii) **Olfactory test:** Smelling strips should be dipped about 5 mm in to sample of blue oil as well as in reference standard and their comparative profile of odour wise were studied at different intervals with following note index of volatile oils.

(a) Top note: More volatile constituents start dissipating.

(b) Middle note: Less volatile constituents well fallow.

(c) End note: Least volatile are left on the strip.

(iii) **Gustation test:** This test was done for evaluation of flavouring materials. The blue oil are mostly evaluated by incorporating them in to carried solution at particular concentrations. The flavour evaluation includes odour taste and mouth feel, and combined effect is called flavour.

The physical properties of blue oil were done by standardised methods as described below:

Table 4.0: Evaluation of physical properties of blue oil

S.N.	Physical properties	Methods used
1.	Colour	Visually
2.	Odour	Olfactory test
3.	Flavour	Gustation test
4.	Specific gravity	BIS 326-1968
5.	Acid value	BIS 326-1968
6.	Solubility per cent in alcohol	BIS 326-1968

(B) Evaluation of chemical properties of blue oil:

The most important chemical constituents available in blue oil were determined by using Gas Liquid Chromatography (G.L.C.), model-HP 5890 series II which was facilitated by Director, FFDC, Kannauj. The functioning of GLC is based on heating process of blue oil which is passed through standard glass column made with 2 meter length and 55 mm diameter packed with 10% carbo- wax 20M, coated on chromosarb WAW and separated with FID detector.

The temperature of the column was kept between 50^0C to 200^0C, which was increased by 4.5 ^{0}C/ minute and the use of carrier gas flowing at the rate of 1.0 ml/minute. The blue oil dilution (1:4 μ liter) was injected by microsyring

and the chart speed was kept at 0.5 cm/minute. The chemical compounds available in blue oil were evaluated through Gas Liquid Chromatography (G.L.C.). The exact amount and percentage of desired constituent in blue oil can be calculated (ISO 7357) with following equations by comparing with standard curve.

$$\mathbf{Cx = [(Ax \times MEx \times K) / AE \times M] \times 100}$$

Where,

Cx = percentage by mass of the constituent to be determined.

Ax = peak area in integrator units corresponding to the constituent to be determined.

M = mass in mg of the blue oil.

ME = mass in mg of the internal standard added in blue oil.

K = response factor for the constituent to be determined relative to the internal standard

Following equation can be used for calculation of response factor (K):

$$\mathbf{K = (AE \times mR) / (AR \times mE)}$$

Where,

AE = peak area in integrator units for internal standard.

AR = peak area in integrator units for substance.

mR = mass in mg of which reference substance.

mE = mass in mg of the internal standard.

Table 5.0 Chemical derivatives of blue oil:

S.N.	Chemical derivatives	Quantitative estimations
1.	Bisabolol	Percentage of each chemical component can be calculated (ISO 7357) by following equation: **Cx = [(Ax X ME X K)/ AE x M] X 100** **K = (AE X mR) / (AR x mE).**
2.	Chamazulene	
3.	Bisabolon oxide-B	
4.	Bisabolol oxide-B	
5.	Cis- dicyloether	
6.	Bisabolol oxide –A	
7.	Farnesene	
8.	Germasene	
9.	Non-guazlene	
10.	Trans-dicyloether	

3.8.5 Nutritional status of plant and soil:

(17) Biomass yield (g/plant): After picking of flowers, the plants were uprooted and root were washed with water and weighed after dried in oven at temperature of 70^0C for 24 hrs to get constant weight and average values of fresh and dried sample of plant foliage and roots were recorded in each treatment (g/plant).

Biomass yield = weight of flowers + weight of plant with roots.

(18) Nutrients analysis of plants: The dried samples of plant parts were taken and the grinding was done to make powder. The chemical analysis of available nitrogen, phosphorus and potassium with plant part were determined by the following methods:

(i) Nitrogen: The 1.0 g of powdered samples of plant parts were taken at each treatment and digested with conc. H_2SO_4 and analysis by modified Kjeldahl's method as described by Jackson (1973).

(ii) Phosphorus: The 1.0g of powdered samples were taken from each treatment and digested in triacid mixture containing nitric, perchloric and sulphuric acid (10:4:1 ratio) and determined by Vanadomolybdhosphoric yellow colour method as descried by Jackson (1973).

(iii) Potassium: The 1.0 g powdered samples were taken for each treatment and determined by using Flamephotometer as described by Jackson (1973).

19) Nutrients analysis of soil: Samples collected for the chemical analysis of soil after harvest of crop was done for determination of pH, EC, organic matter, available nitrogen, phosphorus and potassium as methods suggested below:

Table 6: Chemical properties of soil and their methods

S.N.	Chemical properties	Methods used
1.	pH (Soil 1:2.5 water)	pH metre using glass electrode.
2.	EC (Soil 1:2.5 water)	Conductivity bridge method.
3.	Organic matter	Walkley and black's rapid titration method.(Walkley and black, 1934)
4.	Available N	Alkaline permanganate method.(Subbiah and Asija, 1956).
5.	Available P	Olsen,s method (Olsen *et al.*, 1954).
6.	Available K	Flamephotometer method (Jackson, 1973).

3.9 Economic analysis of Matricaria production:

The cost/ benefit ratio per hectare was worked out at prevailing rates of cultural operations practice followed during the experimentation. The Grass Income, Net Returns and cost / benefit ratio were estimated as below:

(i) Grass Income (Rs./ha) = Cost of flowers and oil yield.

(ii) Net Return (Rs. /ha) = Gross return – Total cost of cultivation (Rs./ ha).

$$\text{(iii) Cost/ benefit ratio} = \frac{\text{Gross return (Rs./ ha)}}{\text{Total cost of cultivation (Rs./ha)}}$$

3.10 Statistical analysis:

Data recorded on each parameter i.e. growth, flowering, yield, oil quality, soil and plant analysis were statistically computed as per treatments and replications as per methods suggested by Fisher and Yates (1949). The significance of various treatments was judged by comparing calculated 'F' value with Fisher's 'F' value at 5 per cent probability level against appropriate degree of freedom (d.f.).

The standard error of mean (SEm ±) and critical difference (C.D.) at 5 per cent level, incorporated in table, were also calculated to compare the relative performance of various treatments by using the following formula:

$$SEm = \pm\sqrt{\frac{2\,MSE}{r}}$$

Where,

SEm = Standard error of mean

MSE = Mean sum of square due to error

r = Replication

C.D. = SE x t value at 5 % error degree of freedom

Transformed values were calculated by arsine or inverse sine transformation method and given by following equation:

$$Sin^{-1}\sqrt{\frac{P}{100}}$$

Where,

P= Observing value

EXPERIMENTAL FINDINGS

Chapter-IV

EXPERIMENTAL FINDINGS

The experimental data recorded in present investigation due to influence of different level of nutrients (NPK), biofertilizers and micronutrients on plant growth, flowering, yield, oil quality characters and soil improvements by growing of *Matricaria* variety Soraksor-60 in sodic soil conditions during the years 1999-2000 and 2000-2001which are presented in this chapter with help of appropriate tables, figures and plates under following heads:

4.1 Effect of levels of different nutrients on plant growth characters.

4.2 Effect of levels of different nutrients on floral characteristics.

4.3 Effect of levels of different nutrients on flowers and oil yields.

4.4 Effect of levels of different nutrients on quality of blue oil.

4.5 Effect of levels of different nutrients on nutrient status of plant.

4.6 Effect of levels of different nutrients on nutrient status of soil after crop harvest.

4.7 Economic analysis of Matricaria production

4.1 Effect of levels of different nutrients on plant growth characters.

4.1.1 Plant Height (cm):

Data pertaining to plant height (cm) recorded due to application of different treatments combination of nutrients i.e. F.Y.M., biofertilizers and micronutrients (Zinc and Iron) at flowering stage (120 DAP) have been portrayed in Table 7 and graphically represented in Fig-3 which *indicated* that the plant height was significantly influenced due to different treatment during both the years (1999-2000 and 2000-2001). The plant height Varied from 31.43 to 51.20 and 30.03 to 52.73 cm during the years 1999-2000 and 2000-2001 respectively. Maximum plant height (51.20cm and 52.73 cm) was recorded with application of NPK- 30:60:50 Kg/ha + Azotobacter + Zinc (T_9) followed by T_{12} (49.40 cm and 51.40 cm), T_{10} (48.87 cm and 50.06 cm), T_{11}

Table 7: Effect of levels of nutrients, biofertilizers and micronutrients on plant height and plant spread (cm) of Matricaria grown in sodic soil conditions.

Treat. Code No.	*Treatments*	*Plant height (cm) at flowering stage (120 DAP)*			*Plant spread (cm) at flowering stage (120 DAP)*		
		1999-2000	2000-2001	Means	1999-2000	2000-2001	Mean
T_1	F.Y.M. (10 t/ha)	36.67	37.86	37.26	21.75	23.75	22.75
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	39.30	40.96	40.13	23.32	25.42	24.37
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	38.40	38.53	38.46	22.86	24.86	23.86
T_4	F.Y.M. + Azoto + PSB	45.73	46.73	46.23	25.07	27.07	26.07
T_5	NPK- 60:60:50 Kg/ha	47.50	49.88	48.69	28.52	29.06	28.79
T_6	NPK- 30:60:50 + Azoto	48.43	50.63	49.53	27.76	28.95	28.355
T_7	NPK- 60:30:50 + PSB	47.09	49.96	48.52	26.65	27.74	27.195
T_8	NPK- 30:30:50 + Azoto + PBS	48.40	50.53	49.46	27.56	28.53	28.045
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	51.20	52.73	51.96	31.88	31.89	31.885
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	48.87	50.06	49.46	29.19	29.40	29.295
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	48.87	49.73	49.30	29.20	29.66	29.43
T_{12}	NPK-60:30:50 +PSB+ Zn	49.40	51.40	50.40	29.53	30.30	29.915
T_{13}	NPK-60:30:50 + PSB + Fe	47.66	49.96	48.81	28.32	29.40	28.86
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	46.86	48.06	47.46	28.64	29.32	28.98
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	47.99	49.52	48.75	29.83	29.88	29.855
T_{16}	Control	31.43	30.03	30.73	19.30	19.00	19.3
Em ±		0.63	0.66		0.32	0.31	
.D. =(P=0.05)		1.81	1.91		0.93	0.90	

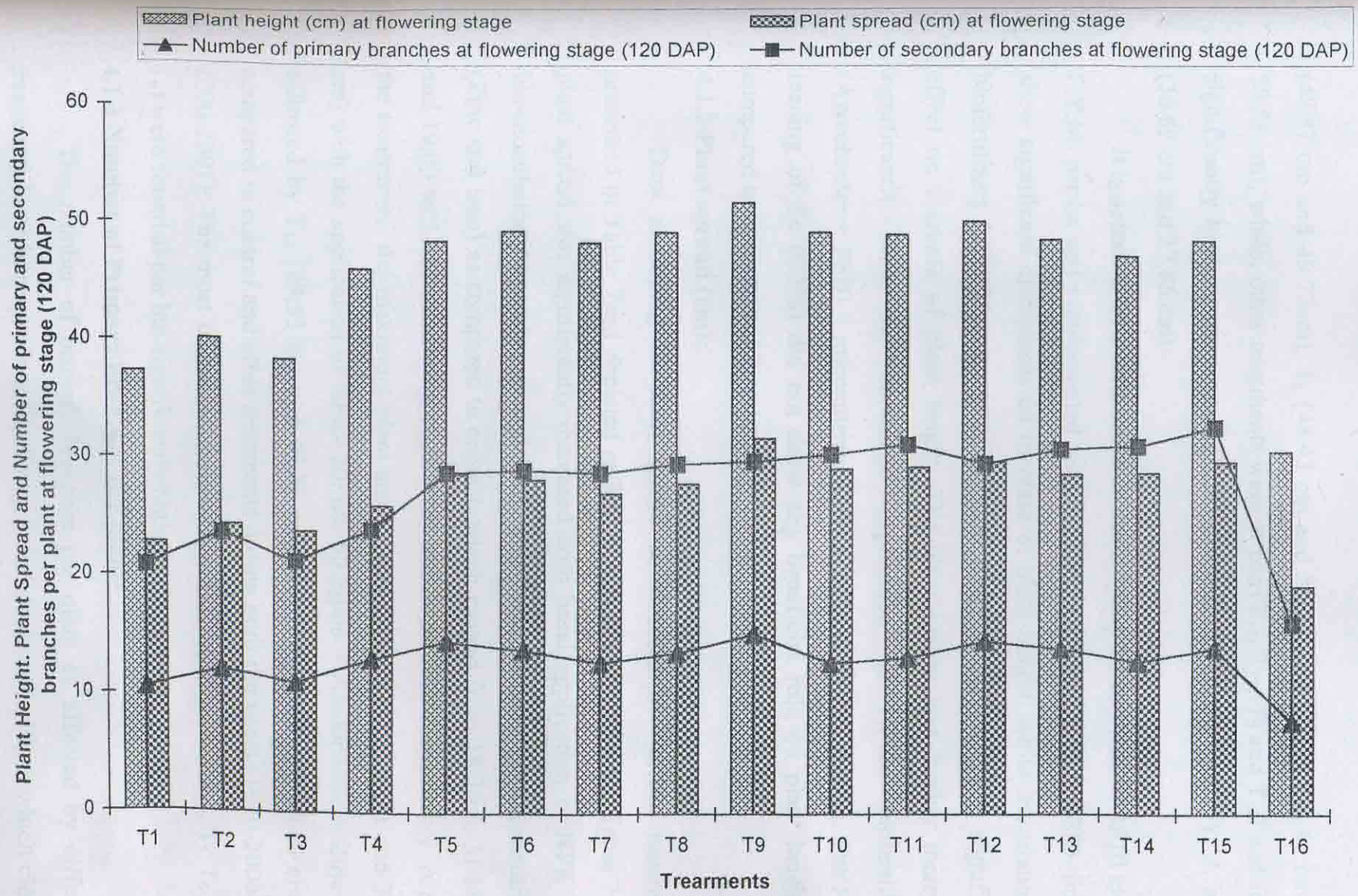


Fig.3: Effect of levels of nutrients, biofertilizers and micronutrients on plant height, plant spread, number of primary and secondary branches per plant of *Matricaria*

(48.87 cm and 49.73cm), T_6 (48.43 cm and 50.63 cm) and T_8 (48.40 cm and 50.53 cm), while, other treatments were at par (T_{15}, T_{13}, T_5 and T_{14}) and found significantly higher over control (31.43 cm and 30.03 cm) and F.Y.M. alone (36.67 cm and 37.86 cm).

It is apparent from data sown in Table 7 that the application of 10 tonnes F.Y.M. per ha and supplemented with 2.0 Kg/ ha (Azotobacter + PSB) did not show significant differences on increase of plant height, while inoculation of biofertilizers incombination with different doses of NPK showed significant effect on increase of plant height. The plant height was further increased significantly with the combined application of NPK+ biofertilizers (Azotobacter + PSB) + miconutrient (Zinc) i.e. T_5 to T_{15} treatments. The foliar feeding of Fe (0.3%) did not show any beneficial role on plant height as compared to treatment of Zinc (0.3%).

4.1.2 Plant spread (cm):

Data pertaining to plant spread as affected by various treatments presented in Table 7and depicted in Fig. 3. It is evident from the Table 7 that plant spread was significantly increased with basal application of NPK with bio-inoculation (Azotobacter and PSB) and foliar feeding of micronutrients (Zinc and Iron) as compared to control, which ranged from 19.30 to 31.88 cm and 19.00 to 31.89 cm during 1999-2000 and 2000-2001 respectively. Among the treatments, the maximum plant spread was recorded (31.88 cm and 31.89 cm) with the application of NPK- 30: 60: 50 kg/ha + Azotobacter + Zinc (T_9) followed by T_{12} (29.53 cm and 30.30 cm), T_{15} (29.83 cm and 29.40 cm) as compared to control and other treatments during both the years (1999-2000 and 2000-2001). The most of the treatments (T_{10}, T_{11}, T_{12}, T_{15}, T_{14}, T_{13}, T_5, T_6 and T_8) were found at par but significantly higher over control.

4.1.3 Number of Primary branches per plant:

The number of primary branches per plant as affected by different treatments have been presented in Table 8 and depicted in Fig 3 which clearly indicates that number of primary branches per plant were increased

Table 8: Effect of levels of nutrients, biofertilizers and micronutrients on number of primary and secondary branches per plant of Matricaria grown in sodic soil conditions

Treat. Code No.	*Treatments*	*Number of primary branches at flowering stage (120 DAP)*			*Number of secondary branches at flowering stage (120 DAP)*		
		1999-2000	2000-2001	Means	1999-2000	2000-2001	Means
T_1	F.Y.M. (10 t/ha)	9.96	10.97	10.46	20.53	21.08	20.80
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	11.53	12.53	12.03	23.41	23.87	23.64
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	10.53	11.53	11.03	20.96	21.66	21.31
T_4	F.Y.M. + Azoto + PSB	12.50	13.50	13.00	23.76	24.31	24.03
T_5	NPK- 60:60:50 Kg/ha	14.20	15.07	14.58	28.77	29.08	28.92
T_6	NPK- 30:60:50 + Azoto	13.31	14.30	13.86	28.53	29.73	29.13
T_7	NPK- 60:30:50 + PSB	12.43	13.20	12.81	28.54	29.22	28.88
T_8	NPK- 30:30:50 + Azoto + PBS	13.42	13.99	13.65	29.22	30.22	29.72
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	14.66	15.90	15.28	29.49	30.32	29.90
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	12.21	13.40	12.80	30.09	30.95	30.52
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	12.84	13.64	13.24	30.86	31.88	31.37
T_{12}	NPK-60:30:50 +PSB+ Zn	14.10	15.10	14.65	29.52	29.98	29.75
T_{13}	NPK-60:30:50 + PSB + Fe	13.53	14.50	14.01	30.75	31.17	30.96
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	12.52	13.30	12.91	30.75	31.73	31.24
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	13.66	14.43	14.04	32.18	33.44	32.81
T_{16}	Control	7.96	7.76	7.86	16.66	15.66	16.16
SEm ±		0.32	0.36		0.36	0.43	
C.D. =(P=0.05)		0.94	1.04		1.03	1.23	

Plate No.1: Showing the effect of F.Y.M.10 t/ha on flowering of Matricaria grown in sodic soil conditions

Plate No. 2: Showing the effect of Azotobacter along with 10t/ha F.Y.M on flowering of Matricaria grown in sodic soil conditions

Plate No. 3: Showing the effect of combined inoculation of biofertilizers (Azoto. +PSB) with 10t/ha F.Y.M on flowering of Matricaria grown in sodic soil conditions

Plate No. 4: Showing the effect of NPK without inoculation of biofertilizers on flowering of Matricaria grown in sodic soil conditions

Plate No. 5: Showing the effect of NPK with inoculation of Azotobacter on flowering of Matricaria grown in sodic soil conditions

Plate No. 6: Showing the effect of NPK with PBS on flowering of Matricaria grown in soidc soil conditions

Plate No. 7: Showing the effect of combined inoculation of biofertilizers with NPK on flowering of Matricaria gown in sodic soil conditions

Plate No. 8: Showing the effect of NPK + Azotobacter + Zn (0.3%) on flowering Matricaria gown in sodic soil conditions

Plate No. 9: Showing the effect of NPK + Azotobacter + Zn + Fe on flowering of Matricaria grown in sodic soil conditions

Plate No. 10: Showing the effect of NPK + Azotobacter + PSB+Zn + Fe on flowering of Matricaria grown in sodic soil conditions

clearly indicates that number of primary branches per plant were increased significantly due to application of various treatments over control during both the years (1999-2000 and 2000-2001) which varied from 7.96 to 14.66 and 7.76 to 15.90. The data recorded on number of primary branches per plant at flowering stage (120 DAP) reveals that the maximum number of primary branches per plant (14.66 and 15.90) was due to treatment of NPK- 30:60:50 Kg /ha + Azotobacter +Zinc (T_9) followed by T_{12} (14.20 and 15.10), T_{15} (13.66 and 14.43), T_{13} (13.53 and 14.50) and T_6 (13.42 and 14.30) which showed significantly higher over control and other treatments.

4.1.4 Number of Secondary branches per plant:

Data shown in Table 8 and depicted in Fig. 3 have also indicates that there was similar trends in number of secondary branches per plant as number of primary branches due to application of different levels of nutrients and supplemented with biofertilizers (Azotobacter and PSB) and micronutrients (Zinc and Iron) during both the years (1999-2000 and 2000-2001), which ranged from 16.66 to 32.18 and 15.66 to 33.44 respectively. However, maximum number of *secondary branches (32.18 and 33.44)* per plant were recorded due to treatment of NPK- 30:30:50 Kg/ha + Azotobacter +PSB +Zinc + Iron (T_{15}) during both the years, which was found significantly more than other treatments. The treatment combinations of T_{11},T_{13}, T_{10}, T_{12},T_9,T_8 and T_6 where found very closely at par and significantly higher over other treatments. The minimum number of secondary branches per plant were found with basal application of 10t/ha F.Y.M. alone and plus inoculation with bioagents (Azotobacter + PSB). The applications of foliar feeding of micronutrients (Zinc and Iron) have also shown significant effect on the number of secondary branches per plant in combination of NPK and inoculation of bio-fertilizers.

4.2 Effect of levels of different nutrients on floral characteristics:

4.2.1 Number of days taken to appearance of first flower:

A perusal of data recorded in Table 9 and graphically represented in Fig.4 revealed that application of various treatments significantly influenced the number of days taken to appearance of the first flower buds, which ranged from 58.66 to 62.52 days (DAP) and 58.78 to 62.62 days (DAP) during 1999-2000 and 2000-2001, respectively. The minimum number of days (58.66 and 58.78 days) were taken in appearance of first flower buds with the application of NPK-30: 30:50Kg/ha+ Azotobacter + PSB + Zinc + Iron (T_{15}) followed by T_8 (59.09 and 59.20 days), T_9 (59.42 and 59.31 days) and T_{12} (59.53 and 59.30 days) during the years 1999-2000 and 2000-2001 respectively. Whereas, the emergence of first flower buds was delayed in control as well as F.Y.M. alone (62.57 and 62.54 days). The other treatments have shown very little differences in days taken to first flower buds appearance.

4.2.2 Days taken to 50% flowering:

Data assembled due to influence of different treatments on days taken to 50% flowering have been presented in Table 9 and graphically represented in Fig. 4. Similar response of different levels of nutrients, biofertilizers and foliar spray of micronutrients have been recorded on days taken to 50% flowering, which ranged from 72.30 to 79.56 and 73.00 to 79.90 during the years 1999-2000 and 2000-2001, respectively. Minimum days were recorded to 50% flowering (72.30 and 73.00 days) due to treatment of NPK-30: 30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}) followed by T_{11} (72.40 and 73.20 days) and T_9 (72.46 and 73.23 days). However, maximum number of days was required to 50% flowering in control (79.56 and 79.90 days). It is apparent from the data shown in Table 9, the application of NPK in combination of Azotobacter and micronutrients have shown better response to early flowering and induced flowering within 73 to 74 days (DAP).

Table 9: Effect of levels of nutrients, biofertilizers and micronutrients on number of days taken to appearance of first flowers, 50% flowering and duration of flowering of Matericaria grown in sodic soil conditions

Treat. Code No.	*Treatments*	*First flowering (days)*		*Means*	*50% flowering (days)*		*Means*	*Duration of flowering(days)*		*Means*
		99-00	00-01		99-00	00-01		99-00	00-01	
T_1	F.Y.M. (10 t/ha)	62.44	62.54	62.49	76.50	76.41	76.45	46.20	45.06	45.63
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	59.66	59.72	59.54	73.20	73.40	73.30	45.60	44.63	45.11
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	60.11	60.00	60.05	74.50	74.39	74.44	43.30	43.53	43.41
T_4	F.Y.M. + Azoto + PSB	59.87	59.84	59.85	73.10	73.30	73.05	42.60	42.56	42.58
T_5	NPK- 60:60:50 Kg/ha	60.20	60.17	60.18	77.60	77.50	77.55	39.20	38.53	38.86
T_6	NPK- 30:60:50 + Azoto	59.74	59.87	59.80	72.66	73.40	73.03	40.40	40.93	40.66
T_7	NPK- 60:30:50 + PSB	60.30	60.17	60.23	73.50	73.46	73.48	40.90	40.83	40.86
T_8	NPK- 30:30:50 + Azoto + PBS	59.09	59.20	59.14	72.63	73.20	72.91	41.50	41.63	41.56
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	59.42	59.31	59.36	72.46	73.23	72.84	41.40	41.63	41.51
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	59.97	59.80	59.53	72.50	73.20	72.85	41.40	41.40	41.40
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	59.87	59.72	59.59	72.40	73.36	72.88	41.70	41.76	41.73
T_{12}	NPK-60:30:50 +PSB+ Zn	59.53	59.76	59.64	73.53	74.10	73.81	40.80	40.73	40.76
T_{13}	NPK-60:30:50 + PSB + Fe	59.97	59.70	59.68	73.73	74.00	73.86	40.60	40.63	40.61
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	59.93	59.30	59.61	73.40	74.27	73.83	41.70	41.63	41.66
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	58.66	58.78	58.72	72.30	73.00	72.66	41.70	42.07	41.88
T_{16}	Control	62.52	62.62	62.57	79.56	79.90	79.73	38.00	37.53	37.76
Em ±		0.31	0.30		0.82	0.86		0.30	0.34	
D.= (P=0.05)		0.89	0.87		2.38	2.54		0.90	0.98	

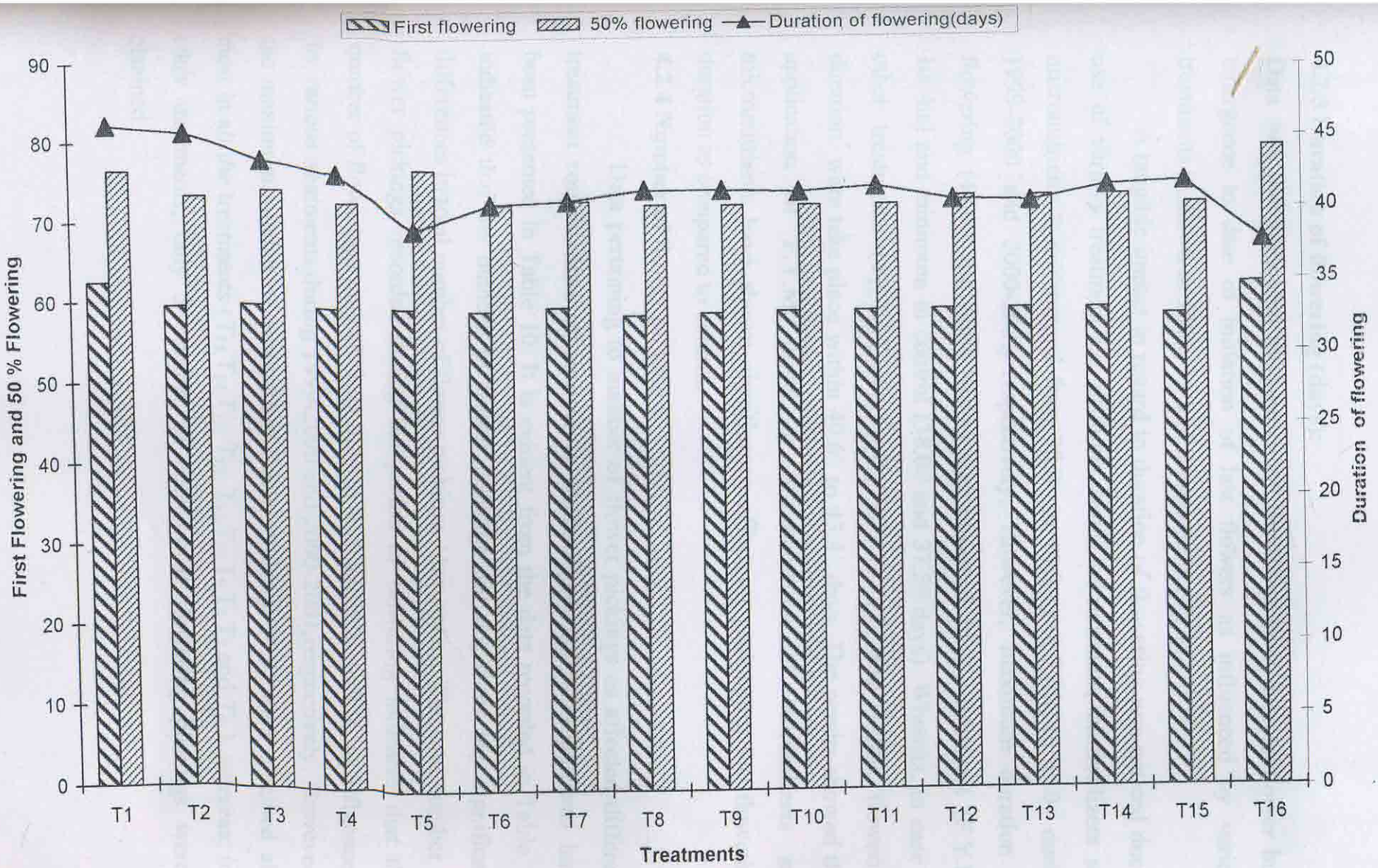


Fig. 4: Effect of levels of nutrients, biofertilizers and micronutrients on number of days taken to appearance of first flower, 50 % flowering and duration of flowering of *Matricaria*

4.2.3 Duration of flowering (days):

Data pertaining to duration of flowering from date of flower buds emergence to date of initiation of last flowers as influenced by various treatments is shown in Table 9 and illustrated in Fig.4.

A tangible impact in regard to duration of flowering was noticed due to use of various treatment i.e. different levels of nutrients, biofertilizers and micronutrients. The duration ranged from 38.0 to 46.2 and 37.5 to 45.0 during 1999-2000 and 2000-2001, respectively. However, maximum duration of flowering (46.0 and 45.0 days) was observed in T_1 treatment (F.Y.M. 10 /ha) and minimum in control (38.0 and 37.5 days). Whereas, in case of other treatments (T_{13},T_{14},T_{15},T_{12},T_{11},T_{10},T_9,T_8,T_7,T_6,T_5 and T_3)the flowering duration were take place within 40.6 to 43.4 days. The results showed that application of F.Y.M. alone or incombination of biofertilizers and micronutrients have shown significance effect on prolonging the flowering duration as compared to control.

4.2.4 Number of flower pickings:

Data pertaining to number of flower pickings as affected different treatment combinations of nutriments, biofertilizers and micronutrients have been presented in Table 10. It is evident from the data recorded in Table 10 indicated that the number of flower pickings did not show any significant differences in total number of flower pickings / harvesting. The total number of flower pickings recorded during the period of flowering indicated that the number of flowerings noticed from 5.2 to 4.1 and 5.2 to 4.0 as influenced by various treatments during 1999-2000 and 2000-2001, respectively. However, the maximum number of economical flower pickings (4) were obtained all most in all the treatments (T_{15},T_{14},T_{13}, T_{12}, T_{11},T_{10},T_9,T_8,T_7 and T_6), whereas in other treatments, only 3 number of economical flowering pickings were obtained.

Table 10: Effect of levels of nutrients, biofertilizers and micronutrients on number of flowers picking of Matericaria grown sodic soil conditions

Treat. Code No.	*Treatments*	*Total number of flowers pickings*		
		1999-2000	2000-2001	Means
T_1	F.Y.M. (10 t/ha)	5.20	5.20	5.20
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	4.86	5.20	5.03
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	4.96	4.96	4.96
T_4	F.Y.M. + Azoto + PSB	5.20	5.20	5.20
T_5	NPK- 60:60:50 Kg/ha	4.50	4.60	4.55
T_6	NPK- 30:60:50 + Azoto	5.10	5.10	5.10
T_7	NPK- 60:30:50 + PSB	4.70	4.63	4.66
T_8	NPK- 30:30:50 + Azoto + PBS	4.70	5.06	4.88
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	4.96	4.90	4.93
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	5.20	5.00	5.10
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	5.20	5.06	5.13
T_{12}	NPK-60:30:50 +PSB+ Zn	4.96	4.90	4.93
T_{13}	NPK-60:30:50 + PSB + Fe	4.96	4.80	4.88
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	5.06	5.20	5.13
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	5.00	5.10	5.05
T_{16}	Control	4.10	4.00	4.05
SEm ±				
C.D. =(P=0.05)		N S	N S	

4.3 Effect of levels of different nutrients on flowers and oil yield:

4.3.1 Number of flowers per plant:

A perusal of data shown on Table 11 and graphically depicted in Fig.6 indicated that total number of flowers per plant significantly influenced by different treatments combinations of nutrients, biofertilizers and micronutrients and ranged from 92.33 to 211.10 and 90.30 to 230.90 during 1999-2000 and 2000-2001, respectively. However, the maximum number of flowers (211.10 and 230.90 per plant) were recorded with an application of NPK- 30:30:50 Kg/ ha + Azotobacter + PSB + Zinc + Iron (T_{15}) followed by T_{14} (211.00 and 224.53), T_{11} (210.73 and 225.20), T_9 (210.40 and 221.33) and T_8 (207.70 and 218.33) during both the years (1999-2000 and 2000-2001).

Table 11: Effect of levels of nutrients, biofertilizers and micronutrients on number of flowers per plant of Matricaria grown in sodic soil conditions

Treat. Code No.	Treatments	Number of flower per plants		
		Number of flowers		Means
		99-00	00-01	
T_1	F.Y.M. (10 t/ha)	132.86	143.20	138.03
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	148.30	154.53	151.14
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	141.43	150.76	146.09
T_4	F.Y.M. + Azoto + PSB	154.13	161.20	157.66
T_5	NPK- 60:60:50 Kg/ha	200.17	212.63	206.40
T_6	NPK- 30:60:50 + Azoto	200.40	215.30	207.85
T_7	NPK- 60:30:50 + PSB	199.73	209.33	204.53
T_8	NPK- 30:30:50 + Azoto + PBS	207.70	218.33	213.01
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	210.40	221.33	215.86
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	208.30	217.17	212.73
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	210.73	225.20	217.96
T_{12}	NPK-60:30:50 +PSB+ Zn	207.73	214.76	211.24
T_{13}	NPK-60:30:50 + PSB + Fe	208.33	211.83	210.08
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	211.00	224.53	217.76
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	211.10	230.90	221.00
T_{16}	Control	92.33	90.30	91.31
SEm ±		1.15	2.38	
C.D. (P=0.05)		3.34	6.89	

4.3.2 Fresh test weight of flowers (g/ 1000 flowers):

Data pertaining to fresh test weight of flowers (g/1000 flowers) as affected by various treatments have been presented in Table 12 and illustrated in Fig.5, which obviously indicates that there was significant increase in fresh weight of flowers due to inoculation of biofertilizers and foliar feeding of micronutrients in conjunction with different levels of nutrients. The average fresh weight of flowers varied from 140.6 to 161.9 and 141.8 to 162.4 g/1000 flowers during 1999-2000 and 2000-2001, respectively. Most of the treatments were significantly superior over control. However, the maximum fresh weight of flowers was recorded (161.9 and 162.4 g/1000 flowers) with an application of NPK- 30:30:50 Kg/ha +Azotobacter + PSB + Zinc + Iron (T_{15}) followed by T_{11},T_{13} and T_{14}, while lowest fresh weight of flowers was obtained (140.6 and 141.8 g/1000 flowers) in control during both the years. However, there were no significant differences in fresh weight of flower per 1000 flowers obtained during the years 1999-2000 and 2000-2001.

4.3.3 Dry test weight of flowers (g/ 1000 flowers):

Data recorded on dry test weight of flowers shown in Table12 and depicted in Fig.5, indicated that there was similar trend in dry test weight of flowers as fresh test weight due to influence of various treatments which varied from 37.53 to 46.83 and 38.66 to 46.61g per 1000 flowers during 1999-2000 and 2000-2001, respectively. However, the maximum dry \weight of flowers (46.83 and 46.11 g/1000 flowers) was obtained due to treatment NPK-60:30:50 Kg/ha + PSB+ Zinc +Iron (T_{14}) followed by T_{13} (45.89 g), T_{15} (45.84g), T_7 (45.82g), T_{10} (45.59g) and T_9 (45.05g) which were found significantly higher over control (38.10g) and other treatments. It is also apparent from the data recorded in Table-12 that there was no significant variation in average dry weight of flowers per 1000 flowers obtained in 1999-2000 and 2000-2001.

Table 12:Effect of levels of nutrients, biofertiflizers and micronutrients on fresh and dry weight (g) of 1000 flowers and moisture content (%) in fresh flowers of Matricaria grown in sodic soil conditions

Treat. Code No.	*Treatments*	*Fresh and dry weight(g) and essential content(%) in flower*								
		Fresh flower weight (g)			Dry flower weight (g)			Moisture content (%)		Means
		99-00	00-01	Means	99-00	00-01	Means	99-00	00-01	
T_1	F.Y.M. (10 t/ha)	144.4	144.8	144.6	38.11	38.36	38.24	72.42	72.63	72.52
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	147.6	147.8	147.7	39.62	40.16	39.89	72.79	72.98	72.88
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	144.8	144.1	144.4	39.72	40.50	40.11	72.10	72.25	72.17
T_4	F.Y.M. + Azoto + PSB	149.2	150.1	149.6	40.54	40.94	40.70	72.83	72.72	72.77
T_5	NPK- 60:60:50 Kg/ha	157.3	158.5	157.9	42.53	43.67	43.10	73.60	73.09	73.34
T_6	NPK- 30:60:50 + Azoto	157.9	159.4	158.6	42.43	43.64	43.04	72.33	72.63	72.48
T_7	NPK- 60:30:50 + PSB	156.1	158.4	157.2	45.66	45.98	45.82	71.46	71.54	71.50
T_8	NPK- 30:30:50 + Azoto + PBS	156.8	158.2	157.5	43.53	44.33	43.93	71.70	71.94	71.82
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	160.2	160.9	160.5	44.86	45.23	45.05	72.03	72.38	72.20
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	160.2	160.8	160.5	44.47	44.70	45.59	72.23	72.39	72.31
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	161.6	161.8	161.7	44.33	44.16	44.25	72.56	72.42	72.49
T_{12}	NPK-60:30:50 +PSB+ Zn	160.0	160.5	160.2	44.73	46.45	45.59	71.46	71.88	71.62
T_{13}	NPK-60:30:50 + PSB + Fe	160.7	160.8	160.7	45.80	45.97	45.89	71.55	71.62	71.58
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	160.5	160.9	161.0	46.83	46.61	46.72	71.35	71.38	71.36
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	161.9	162.4	162.1	45.63	46.04	45.84	71.82	71.59	71.70
T_{16}	Control	140.6	141.8	141.2	37.53	38.66	38.10	72.86	72.98	72.92
SEm ±		0.44	0.48		0.23	0.22		0.28	0.15	
C.D. =(P=0.05)		1.28	1.40		0.67	0.65		0.80	0.45	

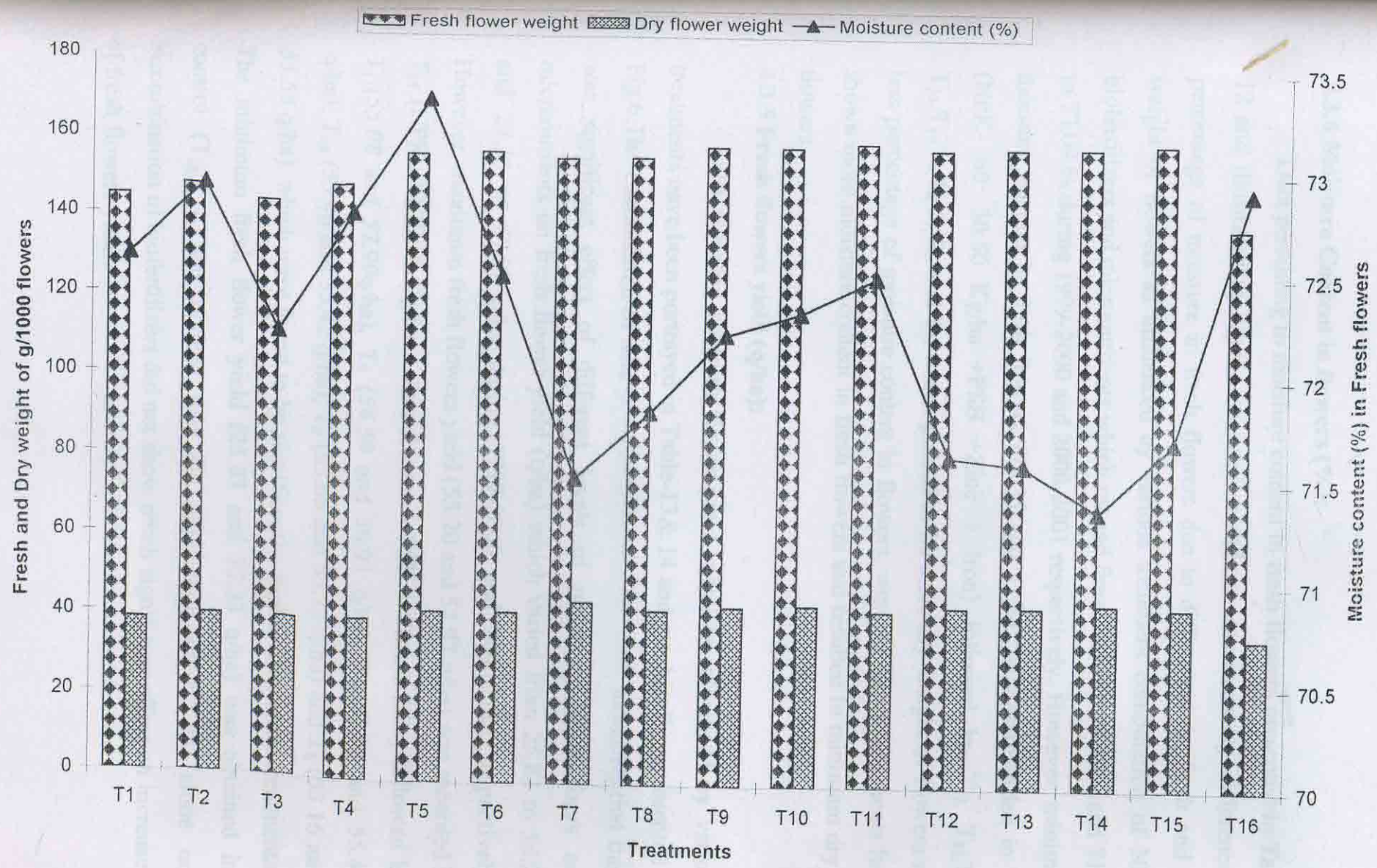


Fig. 5: Effect of levels of nutrients, biofertilizers and micronutrients on fresh and dry weight of g/1000 flowers and moisture content (%) in fresh flowers of *Matricaria*

4.3.4 Moisture Content in flowers (%):

Data pertaining to moisture content in fresh flowers are presented in Table-12 and illustrated in Fig.5. There was markedly difference in percentage of moisture in fresh flowers due to differences in fresh and dry weight of flowers as influenced by various treatment combination of NPK, biofertilizers and micronutrients which ranged from 71.35 to 73.60% and 71.38 to 73.09 % during 1999-2000 and 2000-2001 respectively. However, minimum moisture content in fresh flowers (71.35 and 71.38 %) was recorded in T_{14} (NPK- 60: 30:50 Kg/ha +PSB +Zinc + Iron) followed by T_{15}, T_{13},T_{12}, T_{11},T_{10},T_9,T_8,T_7,T_6, and T_3, which proved to be more dry weight of flowers and less percentage of moisture content in flowers, were of other treatments have shown more moisture content in fresh flowers and resulted to minimum dry of flowers.

4.3.5 Fresh flowers yield (q/ha):

Data recorded on fresh flower yield (q/ha) as influenced by various treatments have been portrayed in Table-13& 14 and graphically represented in Fig.6.The examination of data indicates that there was significant effect of different levels of nutrients, biofertilizers and micronutients on fresh flower yield (q/ha) which varied from 25.83 to 55.20 and 25.33 to 57.97 q/ha during 1999-2000 and 2000-2001 respectively. However, maximum fresh flowers yield (55.20 and 57.97 q/ha) was recorded in T_{15} (NPK- 30:30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron) followed by T_{11}(55.08 and 57.90q/ha), T_9 (54.39 and 56.93 q/ha), T_{12}(53.51 and 55.47 q/ha), T_{14} (53.40 and 55.42 q/ha), T_6 (53.66 and 55.72 q/ha) and T_8 (53.16 and 55.58 q/ha), which were found to be significantly higher over other treatments. The minimum fresh flower yield (25.83 and 25.33 q/ha) was obtained in control (T_{16}). It was noticed that the application of F.Y.M. alone or incombination of biofertilizers did not show much significant effect on increase of fresh flowers yield.

Table 13: Effect of levels of nutrients, biofertilizers and micronutrients on fresh and dry yield of flower (q/ha) of Matricaria grown in sodic soil conditions

Treat. Code No.	Treatments	Fresh and dry yield of flowers					
		Fresh flowers yield (q/ha)			Dry flowers yield (q/ha)		
		99-00	00-01	Means	99-00	00-01	Means
T_1	F.Y.M. (10 t/ha)	32.90	33.10	33.00	9.06	9.07	9.06
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	34.09	36.07	35.08	9.27	9.74	9.50
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	33.43	35.07	34.25	9.32	9.73	9.52
T_4	F.Y.M. + Azoto + PSB	36.98	39.27	38.12	10.04	10.74	10.39
T_5	NPK- 60:60:50 Kg/ha	52.46	54.56	53.51	13.85	14.68	14.26
T_6	NPK- 30:60:50 + Azoto	53.66	55.72	54.69	14.49	15.28	14.88
T_7	NPK- 60:30:50 + PSB	52.41	54.22	53.31	15.30	15.92	15.61
T_8	NPK- 30:30:50 + Azoto + PBS	53.16	55.58	54.37	15.04	15.27	15.15
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	54.39	56.93	55.66	14.96	15.31	15.13
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	52.06	55.65	53.85	14.51	15.02	14.76
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	55.08	57.90	56.49	14.64	15.27	14.96
T_{12}	NPK-60:30:50 +PSB+ Zn	53.51	55.47	54.49	15.28	15.97	15.62
T_{13}	NPK-60:30:50 + PSB + Fe	52.09	54.42	53.25	14.80	15.81	15.30
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	53.40	55.42	54.41	15.77	16.58	16.17
T_{15}	NPK-30:30:50 +Azoto + PSB+ Zn + Fe	55.20	57.97	56.58	15.55	16.46	16.00
T_{16}	Control	25.83	25.33	25.58	6.90	6.80	6.85
SEm ±		0.24	0.36		0.17	0.19	
C.D. (P=0.05)		0.70	1.05		0.51	0.54	

4.3.6 Dry flowers yield (q/ha):

Data recorded on dry flowers yield (q/ha) influenced by different levels of NPK, biofertilizers and micronutrients shown in Table 13 &14 and illustrated in Fig.6. It is evident from the results that there was also significant effect of different levels of nutrients, biofertilizers and micronutrients on dry flower yield per ha, which varied from 6.90 to 15.77 and 6.80 to 16.58 q/ha during 1999-2000 and 2000-2001, respectively. However, maximum dry yield of flowers (15.77 and 16.58 q/ha) was obtained with treatments of NPK- 60:30:50 Kg/ ha + PSB + Zinc + Iron (T_{14}) followed by T_{15} (15.55 and 16.46 q/ha), T_{12} (15.28 and 15.97 q/ha), T_7 (15.30 and 15.92 q/ha), T_{13} (14.80 and 15.81 q/ha), T_5 (15.04 and 15.27 q/ha) and T_9 (14.96 and 15.31 q/ha), while other treatments did not show any significant differences

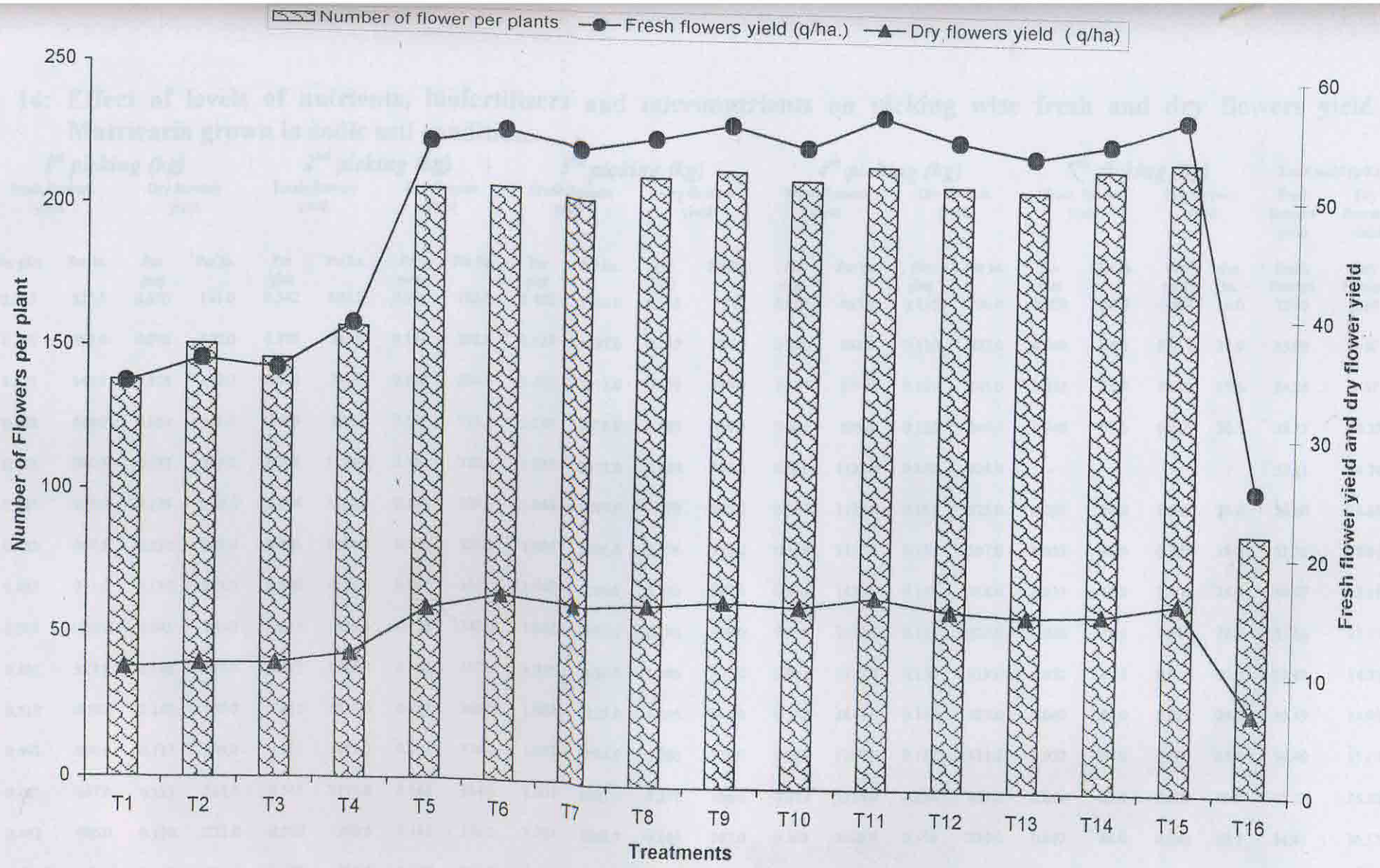


Fig. 6 : Effect of levels of nutrients , biofertilizers and micronutrients on number of flowers per plant, fresh and dry flower yield (q/ha) of *Matricaria*

...ect of levels of nutrients, biofertilizers and micronutrients on picking wise fresh and dry flowers yiel... Matricaria grown in sodic soil conditions

S.N.	1st picking (kg)				2nd picking (kg)				3rd picking (kg)				4th picking (kg)				5th picking (kg)				Total yield (q/ha,	
	Fresh flowers yield		Dry flowers yield		Fresh flowers yield		Dry flowers yield		Fresh flowers yield		Dry flowers yield		Fresh flowers yield		Dry flowers yield		Fresh flowers yield		Dry flowers yield		Fresh flowers yield	Dry flowers yield
	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Per plot	Per ha.	Fresh flowers	Dry flowers
T_1	0.263	527.5	0.070	141.0	0.342	684.5	0.091	182.0	0.466	1162.0	0.155	310.0	0.437	865.0	0.115	230.0	0.030	60.0	0.008	16.0	33.00	8.84
T_2	0.281	563.0	0.076	152.0	0.372	745.0	0.101	202.0	0.618	1237.0	0.167	336.0	0.440	881.0	0.119	257.0	0.040	81.0	0.011	22.0	35.08	9.50
T_3	0.273	546.5	0.076	152.0	0.359	733.0	0.100	204.0	0.607	1215.0	0.169	338.0	0.437	874.0	0.121	243.0	0.035	71.0	0.010	19.5	34.25	9.52
T_4	0.308	618.0	0.084	168.0	0.409	820.0	0.111	223.0	0.689	1379.0	0.187	376.0	0.464	898.0	0.126	246.0	0.048	97.0	0.013	26.5	38.12	10.39
T_5	0.483	966.5	0.132	265.0	0.586	1174.0	0.161	322.0	1.035	2071.0	0.284	569.0	0.569	1139.0	0.156	328.0	-	-	-	-	53.51	14.26
T_6	0.487	975.0	0.139	278.0	0.594	1190.0	0.169	339.0	1.044	2089.0	0.298	595.0	0.567	1134.0	0.161	323.0	0.035	70.0	0.010	20.0	54.60	14.88
T_7	0.483	967.5	0.133	266.0	0.586	1173.0	0.161	322.0	1.004	2008.0	0.276	552.0	0.558	1117.0	0.153	307.0	0.033	66.0	0.009	18.0	53.31	15.61
T_8	0.485	971.0	0.137	273.0	0.592	1186.0	0.167	334.0	1.042	2084.0	0.293	587.0	0.564	1130.0	0.159	318.0	0.033	66.0	0.009	18.5	54.37	15.15
T_9	0.504	1009.5	0.143	286.0	0.613	1226.0	0.173	347.0	1.042	2085.0	0.295	590.0	0.568	1137.0	0.161	322.0	0.038	78.0	0.011	22.0	55.66	15.13
T_{10}	0.491	983.5	0.140	279.0	0.593	1187.0	0.168	337.0	1.015	2030.0	0.288	577.0	0.561	1122.0	0.159	319.0	0.032	67.0	0.010	20.0	53.85	14.76
T_{11}	0.517	1036.0	0.148	297.0	0.619	1257.0	0.180	360.0	1.064	2129.0	0.305	610.0	0.572	1144.0	0.164	327.0	0.042	84.0	0.012	24.0	56.49	14.95
T_{12}	0.493	990.0	0.137	274.0	0.601	1202.0	0.167	334.0	1.032	2064.0	0.286	574.0	0.563	1127.0	0.157	313.0	0.033	67.0	0.009	19.0	54.49	15.02
x	0.483	967.5	0.133	268.0	0.585	1171.0	0.162	324.0	1.001	2003.0	0.277	554.0	0.557	1114.0	0.154	308.0	0.034	69.0	0.009	19.0	53.25	15.30
	0.492	986.0	0.135	271.0	0.600	1200.5	0.165	330.0	1.031	2062.0	0.284	567.0	0.563	1126.0	0.154	310.0	0.032	66.0	0.009	18.5	54.41	16.17
	0.518	1036.5	0.147	293.0	0.630	1262.0	0.178	356.0	1.065	2130.0	0.301	603.0	0.574	1148.0	0.162	325.0	0.041	82.0	0.012	23.5	56.58	16.00
	0.209	420.0	0.056	114.0	0.289	577.0	0.078	156.0	0.453	906.0	0.123	245.0	0.327	655.0	0.088	177.0	-	-	-	-	25.58	6.85

and they were found to be at par in dry flower; yield. It also reveals that application of F.Y.M. alone or incombination of biofertilizers on did not reflect much difference in dry flowers yield per hectare. The lowest average dry flowers yield was obtained in control (6.85 q/ha). It is evident from the result that the optimum yield of Matricaria flowers can not be obtained without application of balanced doses of nutrients (NPK and micronutrients) under sodic soil conditions.

4.3.7 Percentage of blue oil recovery in flowers:

A perusal of data recorded on percentage of recovery of blue oil in flowers (DWB) due to effect of various treatments have been presented in Table 15 and depicted in Fig.7. It is obvious from the result that the blue oil content in flowers was markedly increased with the application of different levels of nutrients, biofertilizers and micronutrients, which ranged from 0.41 to 0.60 and 0.40 to 0.60% during 1999-2000 and 2000-2001, respectively. However, maximum recovery of oil content (0.60%) was obtained with treatment of NPK- 60:30:50 Kg/ha + PSB +Zinc + Iron (T_{14}), while minimum recovery of blue oil was found in control (0.40%). The percentage of oil content in flowers have also shown significant variation due to effect of other treatments ($T_{15}, T_{11}, T_{13}, T_{12}, T_{10}, T_9$, T_5, T_8, T_7 and T_4) and they were found at par (0.56 to 0.59%). Whereas, other treatments (T_1, T_2, T_3) showed poor recovery of blue oil (0.45 to 0.49%), clearly indicating that the oil content in flowers did not influence due to application of F.Y.M. alone or incombination of biofertilizers (Azotobacter and PSB).

4.3.8 Oil yield (L/ha):

Data pertaining to oil yield (l/ha) as influenced by various treatments have been presented in Table 15 and graphically represented in Fig.7, which indicates that the oil yield (l/ha) was significantly increased by application of different levels of nutrients, biofertilizers and micronutients, which varied from 2.76 to 9.30 and 2.72 to 9.94 l/ha during the years 1999-2000 and 2000-2001, respectively. However, maximum oil yield was obtained (9.62 l/ha) with

Table 14: Effect of levels of nutrients, biofertilizers and micronutrients on oil content (%) in dry flowers and oil yield (L/ha) of Matricaria grown in sodic soil conditions

Treat. Code No.	*Treatments*	*Oil content (%)*			*Oil yields (L/ha.)*		
		1999-2000	2000-2001	Means	1999-2000	2000-2001	Means
T_1	F.Y.M. (10 t/ha)	0.45 (3.85)	0.44(3.80)	0.45	3.98	4.08	4.03
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	0.48 (3.97)	0.49(4.01)	0.49	4.45	4.77	4.61
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	0.44(3.80)	0.45(3.85)	0.45	4.10	4.37	4.28
T_4	F.Y.M. + Azoto + PSB	0.54(4.21)	0.57(4.33)	0.56	5.42	6.12	5.77
T_5	NPK- 60:60:50 Kg/ha	0.57(4.33)	0.58(4.36)	0.58	7.89	8.51	8.20
T_6	NPK- 30:60:50 + Azoto	0.55(4.25)	0.56(4.29)	0.56	7.97	8.55	8.26
T_7	NPK- 60:30:50 + PSB	0.56(4.29)	0.57(4.32)	0.57	8.57	8.78	8.67
T_8	NPK- 30:30:50 + Azoto + PBS	0.56(4.29)	0.57(4.32)	0.57	8.42	8.70	8.56
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	0.58(4.36)	0.59(4.40)	0.59	8.68	9.03	8.85
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	0.58(4.63)	0.58(4.36)	0.58	8.41	8.71	8.56
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	0.60(4.44)	0.60(4.45)	0.60	8.78	9.16	8.97
T_{12}	NPK-60:30:50 +PSB+ Zn	0.58(4.36)	0.59(4.40)	0.59	8.86	9.42	9.14
T_{13}	NPK-60:30:50 + PSB + Fe	0.58(4.36)	0.58(4.36)	0.58	8.58	9.17	8.87
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	0.59(4.40)	0.60(4.45)	0.60	9.30	9.94	9.62
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	0.59(4.40)	0.60(4.45)	0.60	9.17	9.87	9.52
T_{16}	Control	0.40(3.63)	0.40(3.63)	0.40	2.76	2.72	2.74
SEm ±		0.02	0.02		0.08	0.06	
C.D.= (P=0.05)		0.06	0.07		0.25	0.17	

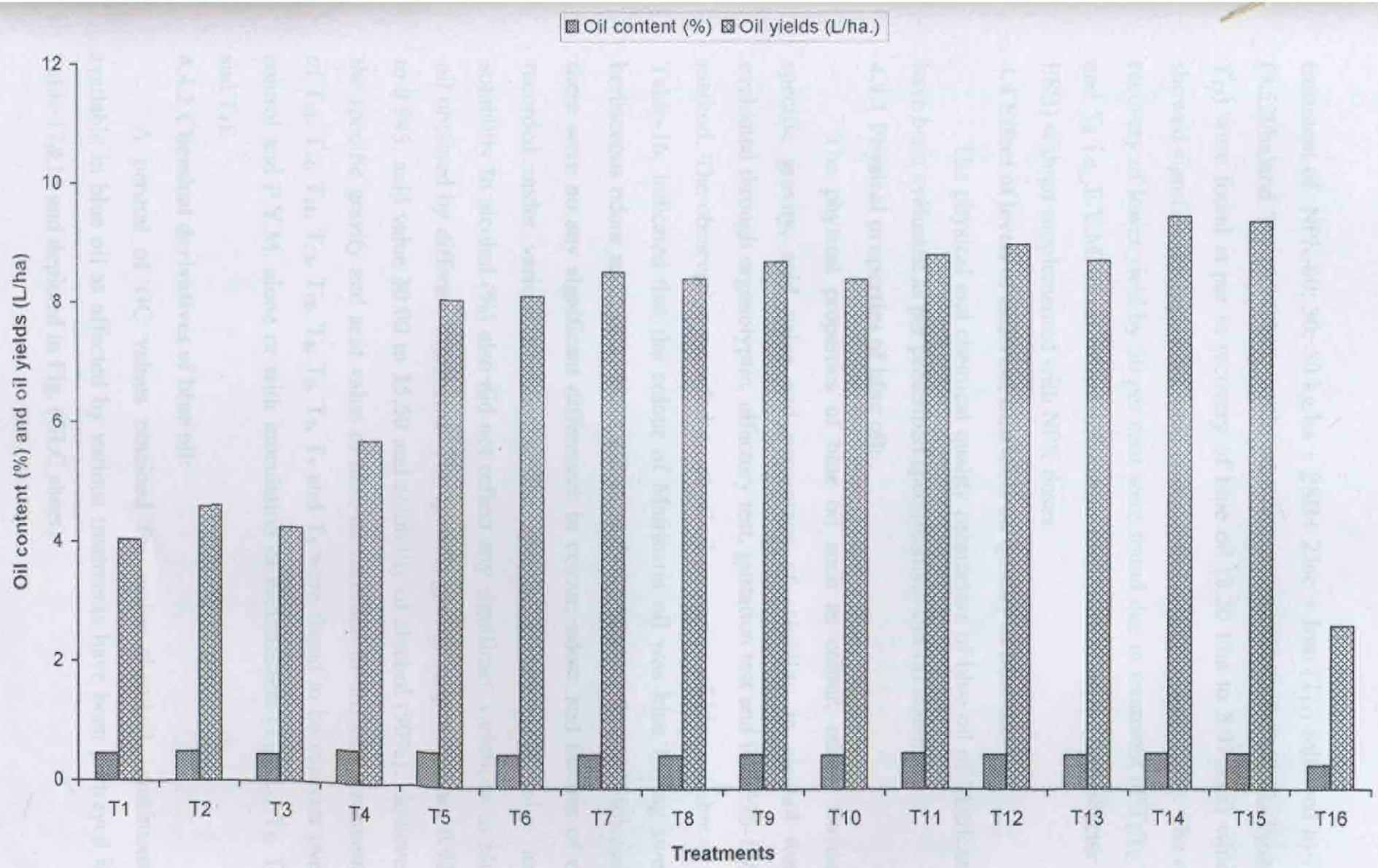


Fig.7: Effect of levels of nutrients, biofertilizers and micronutrients on oil content (%) in dry flowers and oil yield (l/ha) of *Matricaria*

treatment of NPK-60: 30: 50 kg/ha + PSB+ Zinc + Iron (T_{14}) followed byT_{15} (9.52l/ha)and T_{12} (9.14l/ha), while other treatments (T_5,T_6,T_7,T_8,T_9,T_{10},$T_{11}$and T_{13}) were found at par in recovery of blue oil (8.20 l/ha to 8.97 l/ha) which showed significantly higher oil yield over control and other treatments. The oil recovery of lower yield by 50 per cent were found due to treatment of T_1,T_2,T_3 and T_4 i.e. F.Y.M. alone or incombination with biofertilizers (Azotobacter + PSB) without supplemented with NPK doses.

4.4 Effect of levels of different nutrients on quality of blue oil:

The physical and chemical quality parameters of blue oil of Matricaria have been evaluated as per prescribed specifications and ISI standards.

4.4.1 Physical properties of blue oil:

The physical properties of blue oil such as colour, odour, flovour, specific gravity, acid value and percentage of solubility in alcohol were evaluated through organolyptic, olfactory test, gustation test and BIS 326-1968 method. The observation recorded on physical properties of blue oil is shown in Table-16, indicated that the colour of Matricaria oil was blue having sweet herbaceous odour and warm, bitter and strongly herbaceous flavour. However, there were no any significant differences in colour, odour and flovour of oil recorded under various treatments. The specific gravity, acid value and solubility in alcohol (%) also did not reflect any significant variations in blue oil obtained by different treatments. The specific gravity ranged to from 0.932 to 0.945, acid value 30.00 to 35.50 and solubility of alcohol (90%). However, the specific gravity and acid value of blue oil recorded in different treatments of T_{15}, T_{14}, T_{11}, T_{13}, T_{12}, T_8, T_9, T_7, T_5 and T_6 were found to be superior over control and F.Y.M. alone or with inoculation of biofertilizers (T_{16}, T_1, T_2, T_3 and T_4).

4.4.2 Chemical derivatives of blue oil:

A perusal of GC values obtained for major chemical constituents available in blue oil as affected by various treatments have been portrayed in Table 17&18 and depicted in Fig. (GLC sheet).

Table 16: Effect of levels of nutrients, biofertilizers and micronutrients on physical properties of blue oil of Matricaria grown in sodic soil conditions

Treat. Code No.	*Treatments*	*Physical properties of blue oil*					
		Colour	Odour	Flavour	Specific gravity	Acid value	Solubility (%) in Alcohal
T_1	F.Y.M. (10 t/ha)	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.932	30.81	90
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.932	32.18	90
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.933	30.98	90
T_4	F.Y.M. + Azoto + PSB	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.937	33.53	90
T_5	NPK- 60:60:50 Kg/ha	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.944	34.63	90
T_6	NPK- 30:60:50 + Azoto	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.943	33.70	90
T_7	NPK- 60:30:50 + PSB	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.944	33.68	90
T_8	NPK- 30:30:50 + Azoto + PBS	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.945	34.18	90
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.944	34.95	90
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.943	34.43	90
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.945	35.68	90
T_{12}	NPK-60:30:50 +PSB+ Zn	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.944	34.58	90
T_{13}	NPK-60:30:50 + PSB + Fe	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.943	34.10	90
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.945	35.55	90
T_{15}	NPK-30:30:50 +Azoto + PSB+ Zn + Fe	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.945	35.82	90
T_{16}	Control	Blue	Intensely sweet, herbaceous	Warm, bitter and strongly herbaceous	0.932	30.16	90

Among the 10 chemical compounds indicated in blue oil such as bisabolol, Chamazuline, bisabolon oxide-B, bisabolol oxide-B, cis-dicyloehter, bisabolol oxide-A, farnesene , germacene, Non-guazlene and trans-dicyloether. The higher proportions were observed for bisabolol, chamazuline, bisabolon xide-B and bisabolol oxide-B, while other compounds viz., cis-dicylother, bisabolol oxide-A, farnesene, germacene, Non-guazlene and trans-dicyloether were found in trace amount.

(i) Bisabolol:

Data presented in Table 17&18 obviously indicated that the bisabolol content (%) in blue oil was significantly affected by use of various treatments which ranged from 30.121 to 39.585 and 30.370 to 39.457 % during 1999-2000 and 2000-2001, respectively. However, the highest percentage of bisabolol (39.585 % and 39.457%) was obtained with the application of NPK-30: 60:50 kg/ha + Azotobacter + Zinc + Iron (T_{11}) followed by T_5, T_6, T_8, T_9, T_{10} and T_{15}, which were found significantly higher over rest of the treatments. Minimum percentage of bisabolol content in blue oil was obtained in control (30.121 % and 30.370%).

(ii) Chamazuline (%):

Data obtained on the percentage of chamazuline content in blue oil due to influence of various treatments have been concised in Table 17&18 which indicated that there was significant variation in percentage of chamazuline content in blue oil, which varied from 8.000 to 15.783 and 8.010 to 16.768 during 1999-2000 and 2000-2001, respectively. The maximum chamazuline content in blue oil (15.783 % and 16.768%) was found with the use of treatments NPK-30: 30:50 kg/ha + Azotobacter + PSB+ Zinc + Iron (T_{15}) followed by T_9 (15.580 % and 16.642 %) and T_{11} (15.679 % and 16.730 %), while minimum percentage of chamazuline in blue oil was obtained in control. Other treatments did not show any significant effects on increases of percentage of chamazuline content in blue oil.

Table 17 (a): Effect of levels of nutrients, biofertilizers and micronutrients on chemical derivation of blue oil of Matricaria grown in sodic soil conditions during 1999-2000

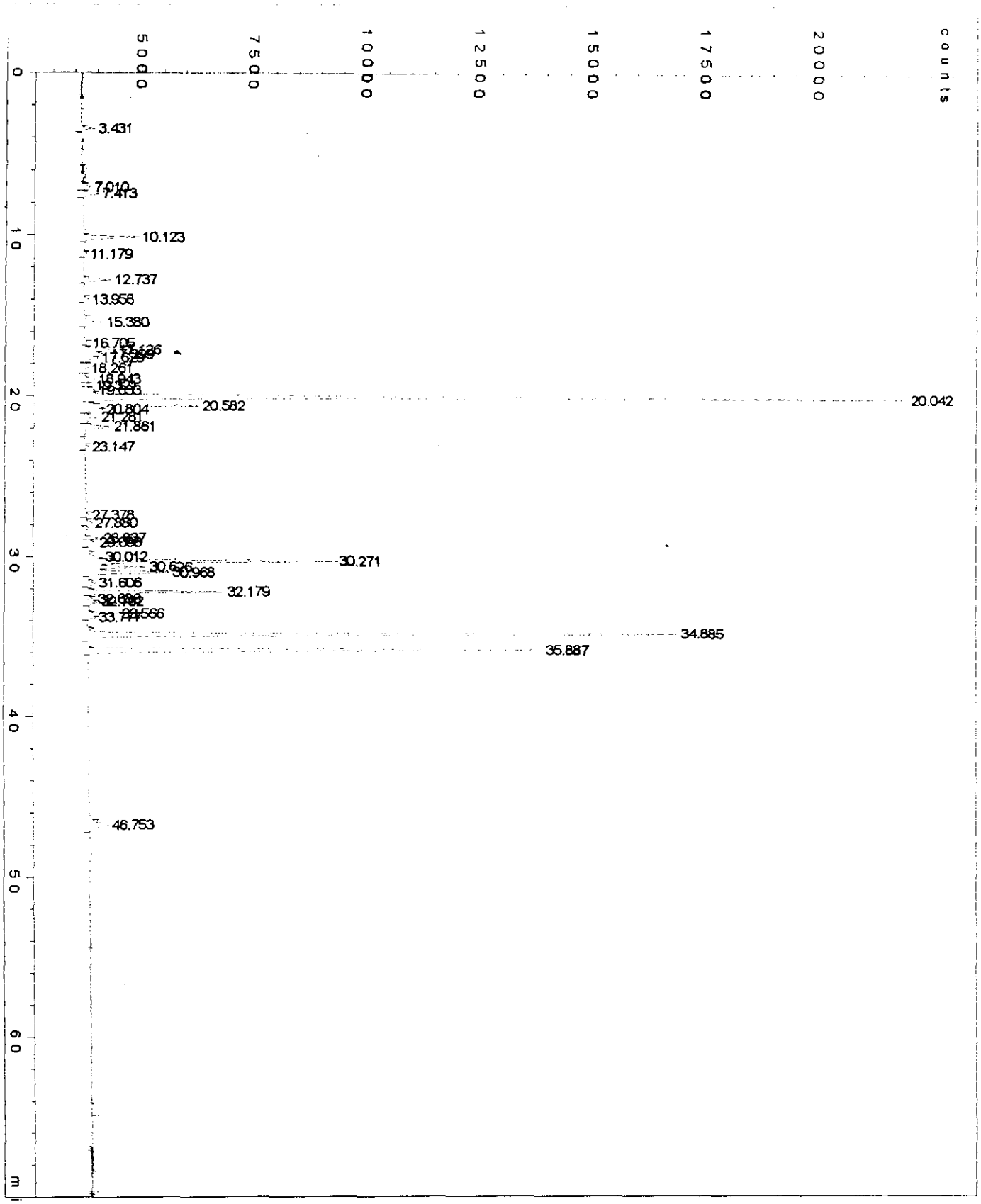
S.No.	*Bisabalol (%)*	*Chemozuline (%)*	*Bisabalon oxide-B (%)*	*Bisabalol oxide-B (%)*	*Cis-dicyloether (%)*	*Bisabalol oxide-A (%)*	*Farnesene (%)*	*Germacene (%)*	*Non-guaziene (%)*	*Trans-dicyloether (%)*
T_1	32.411(34.70)	8.458 (16.91)	4.247(11.89)	1.316(6.60)	4.097(11.68)	2.829(9.68)	0.882(5.39)	0.731(4.90)	1.646(7.37)	0.353(3.41)
T_2	33.436(35.33)	9.576 (18.03)	5.136(13.10)	2.569(9.21)	4.127(11.72)	3.337(11.15)	0.994(5.72)	0.869(5.35)	1.657(7.39)	0.389(3.57)
T_3	32.659(34.85)	8.673 (17.13)	5.159(13.13)	4.642(12.44)	4.424(12.14)	2.669(9.40)	0.928(5.52)	0.766(5.02)	1.646(7.37)	0.386(3.56)
T_4	35.543(36.59)	9.790 (18.23)	6.104(14.30)	4.234(11.87)	5.444(13.49)	3.450(10.70)	1.1.52(6.18)	0.889(5.41)	1.616(7.32)	0.577(4.36)
T_5	39.220(38.77)	13.630(21.66)	7.530(15.89)	4.492(12.23)	7.359(15.74)	5.404(13.44)	1.442(6.90)	1.702(7.49)	0.611(4.48)	0.623(4.53)
T_6	39.315(38.83)	13.459 (21.52)	7.634(16.04)	4.539(12.29)	7.352(15.73)	5.478(15.53)	1.486(7.00)	1.644(7.44)	0.637(4.57)	0.684(4.74)
T_7	36.380(37.10)	13.462(21.52)	8.660(17.11)	5.439(13.48)	6.499(14.77)	6.513(14.78)	1.367(6.71)	1.566(7.19)	0.634(4.57)	0.664(4.67)
T_8	39.226(38.77)	13.414(21.48)	7.464(15.86)	5.542(13.61)	7.482(15.87)	6.598(14.88)	1.546(7.44)	1.754(7.61)	0.766(4.93)	0.614(4.49)
T_9	39.343(38.43)	15.580(23.25)	7.444(15.83)	6.731(15.04)	7.309(15.68)	5.718(13.83)	1.743(7.59)	1.846(7.81)	0.789(5.09)	0.927(5.52)
T_{10}	39.585(38.99)	13.630(21.66)	7.457(15.84)	4.421(12.14)	7.148(15.51)	5.737(13.86)	1.544(7.14)	1.713(7.52)	0.776(5.06)	0.718(4.86)
T_{11}	39.577(38.99)	15.679(23.33)	7.729(16.14)	6.825(15.14)	7.380(15.76)	5.573(15.65)	1.879(7.88)	1.921(7.97)	0.779(5.06)	1.220(6.34)
T_{12}	36.540(37.20)	14.669(22.52)	8.571(17.02)	5.760(13.88)	6.322(14.56)	6.627(14.92)	1.768(7.64)	1.579(7.22)	0.748(4.94)	0.967(5.64)
T_{13}	36.365(36.89)	13.676(21.70)	8.643(17.10)	5.660(13.76)	6.432(14.69)	6.596(14.88)	1.574(7.21)	1.618(7.32)	0.726(4.92)	0.770(5.03)
T_{14}	36.353(36.88)	14.649(22.50)	8.668(17.12)	4.816(12.68)	6.349(14..59)	6.559(14.84)	1.785(7.68)	1.635(7.34)	0.690(5.03)	1.242(7.59)
T_{15}	39.413(38.88)	15.783(23.41)	8.295(16.74)	6.842(15.14)	7.155(15.73)	6.580 (14.86)	1.896(7.91)	1.949(8.02)	0.639(4.98)	1.240(7.58)
T_{16}	30.121(32.95)	8.000(16.43)	3.430(10.67)	0.894(5.41)	3.981(11.5)	2.130 (8.39)	0.710(4.87)	0.660(4.67)	1.690(7.47)	0.300(3.14)
SEm ±	0.13	0.20	0.13	0.15	0.12	0.23	0.08	0.04	0.04	0.06
C.D.	0.37	0.29	0.38	0.42	0.36	0.68	0.23	0.11	0.12	0.17

***Figures in parenthesis are angular transformed values**

Table 17(b): Effect of levels of nutrients, biofertilizers and micronutrients on chemical derivation of blue oil of Matricaria grown in sodic soil conditions during 2000-2001

S.No.	*Bisabalol (%)*	*Chemozuline (%)*	*Bisabalon oxide-B (%)*	*Bisabalol oxide-B (%)*	*Cis-dicyloether (%)*	*Bisabalol oxide-A (%)*	*Farnesene (%)*	*Germacene (%)*	*Non-guazlene (%)*	*Tras-dicyloether (%)*
T_1	32.08(34.50)	8.992(17.38)	4.372(12.07)	1.572(7.20)	4.769(12.61)	2.521(9.13)	0.948(5.59)	0.744(4.96)	1.657(7.39)	0.367(3.47)
T_2	34.104(35.73)	9.961(18.40)	5.065(13.00)	2.727(9.51)	4.456(12.19)	3.769(11.19)	1.003(5.75)	0.878(5.37)	1.661(7.40)	0.385(3.56)
T_3	32.196(34.57)	8.895(17.35)	5.095(13.09)	4.738(12.35)	4.582(12.36)	2.866(9.75)	1.118(6.07)	0.832(5.23)	1.649(7.38)	0.380(3.53)
T_4	35.102(36.33)	10.537(18.94)	6.092(14.29)	4.415(12.12)	6.494(14.76)	3.551(10.86)	1.174(6.32)	0.934(5.54)	1.643(7.36)	0.630(4.55)
T_5	39.218(38.77)	14.444(22.34)	7.629(16.03)	4.609(12.40)	8.250(16.69)	5.336(13.35)	1.549(7.15)	1.784(7.68)	0.648(4.74)	0.690(4.76)
T_6	39.220(38.77)	14.697(22.55)	7.798(16.21)	4.441(12.16)	8.310(16.76)	5.110(13.08)	1.519(7.08)	1.749(7.60)	0.657(4.65)	0.678(4.72)
T_7	36.376(37.10)	14.484(22.10)	8.887(17.34)	5.375(13.40)	6.314(14.55)	7.131(15.49)	1.476(6.98)	1.707(7.51)	0.652(4.63)	0.675(4.71)
T_8	39.285(38.81)	14.471(22.36)	7.295(15.67)	5.315(13.33)	8.318(16.76)	7.142(15.50)	1.683(7.45)	1.774(7.65)	0.687(4.75)	0.676(4.72)
T_9	39.402(38.88)	16.642(24.08)	7.549(15.95)	6.384(14.63)	8.113(16.55)	5.685(13.79)	1.903(7.93)	1.898(7.92)	0.786(5.09)	(0.9405.56)
T_{10}	39.274(38.80)	14.696(22.54)	7.470(15.86)	4.268(11.92)	8.564(17.02)	5.685(13.79)	1.694(7.47)	1.854(7.82)	0.778(5.06)	0.720(4.87)
T_{11}	39.457(38.91)	16.730(24.14)	7.509(15.90)	6.445(14.70)	8.146(16.58)	7.760(16.18)	1.959(8.04)	1.884(7.89)	0.781(5.07)	1.216(6.33)
T_{12}	36.513(37.18)	15.754(23.35)	8.378(16.82)	5.514(13.58)	6.078(14.27)	7.764(16.18)	1.885(7.89)	1.749(7.60)	0.764(5.02)	0.939(5.55)
T_{13}	36.577(37.22)	14.687(22.54)	8.477(16.92)	5.629(13.71)	6.652(14.95)	7.578(15.98)	1.782(7.67)	1.727(7.55)	0.739(4.93)	0.772(5.04)
T_{14}	36.657(37.26)	15.760(23.39)	8.555(17.00)	4.750(12.59)	6.146(14.35)	7.576(15.97)	1.892(7.90)	1.764(7.63)	0.729(4.89)	1.246(6.40)
T_{15}	39.275(38.80)	16.768(24.17)	8.328(16.77)	6.729(15.03)	7.150(15.51)	7.691(16.10)	1.995(8.13)	1.985(8.10)	0.725(4.87)	1.243(6.40)
T_{16}	30.370(33.44)	8.010(16.47)	3.430(10.67)	0.887(5.40)	3.990(11.52)	2.130(8.39)	0.713(4.85)	0.690(4.75)	1.693(7.48)	0.300(3.14)
SEm ±	0.05	0.13	0.14	0.16	0.23	0.19	0.07	0.11	0.07	0.05
C.D.	0.15	0.37	0.40	0.45	0.66	0.56	0.19	0.31	0.20	0.15

***Figures in parenthesis are angular transformed values**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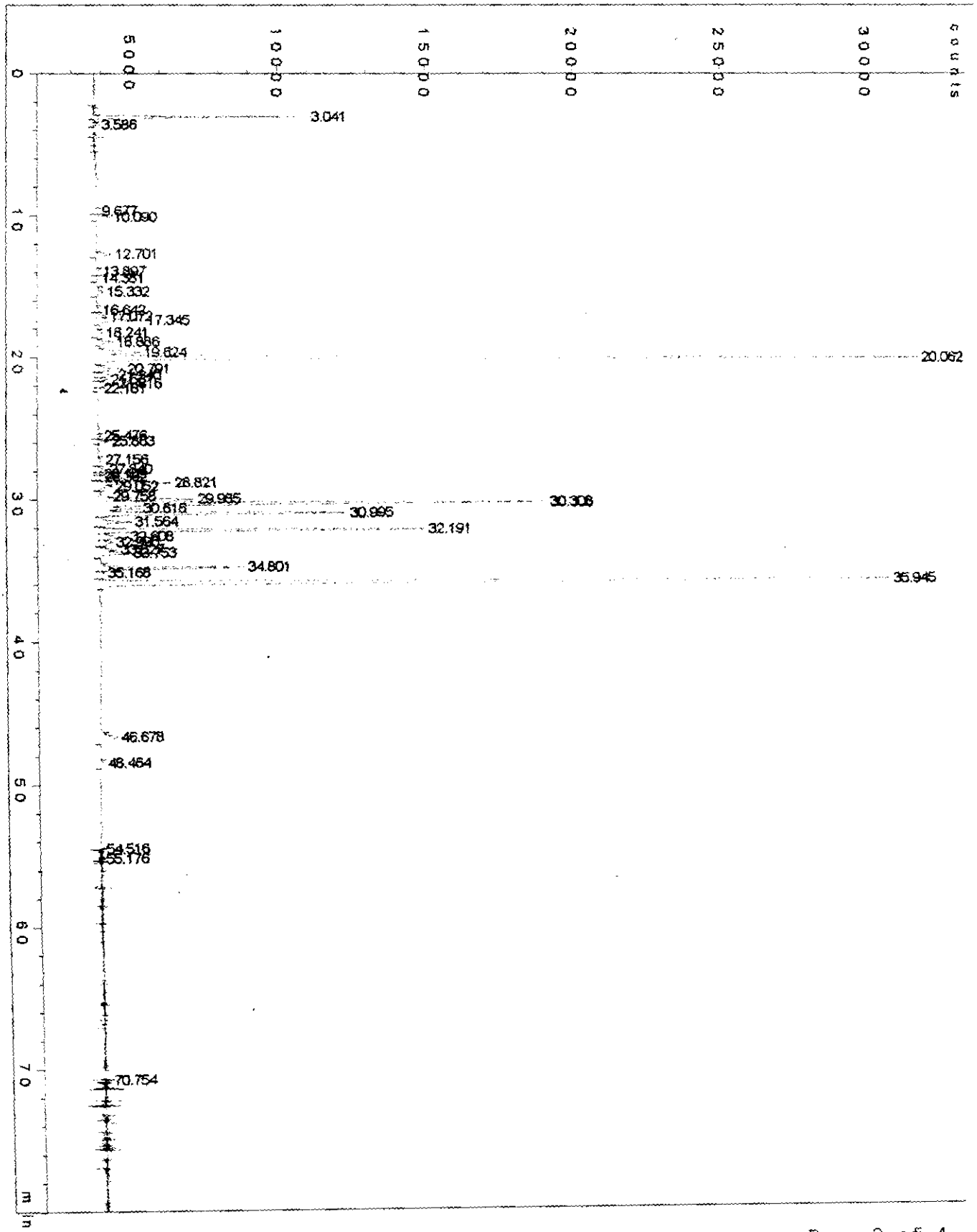
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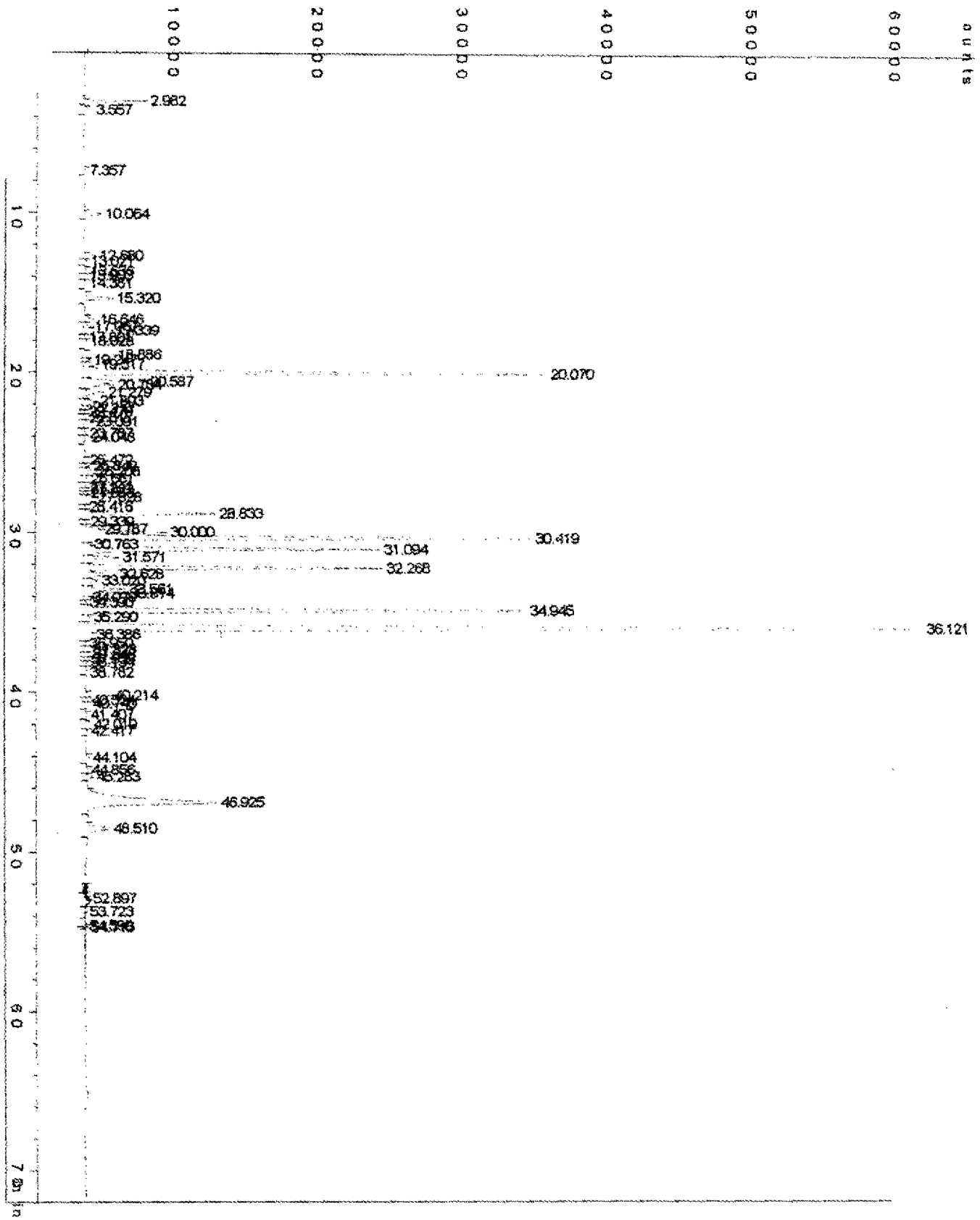
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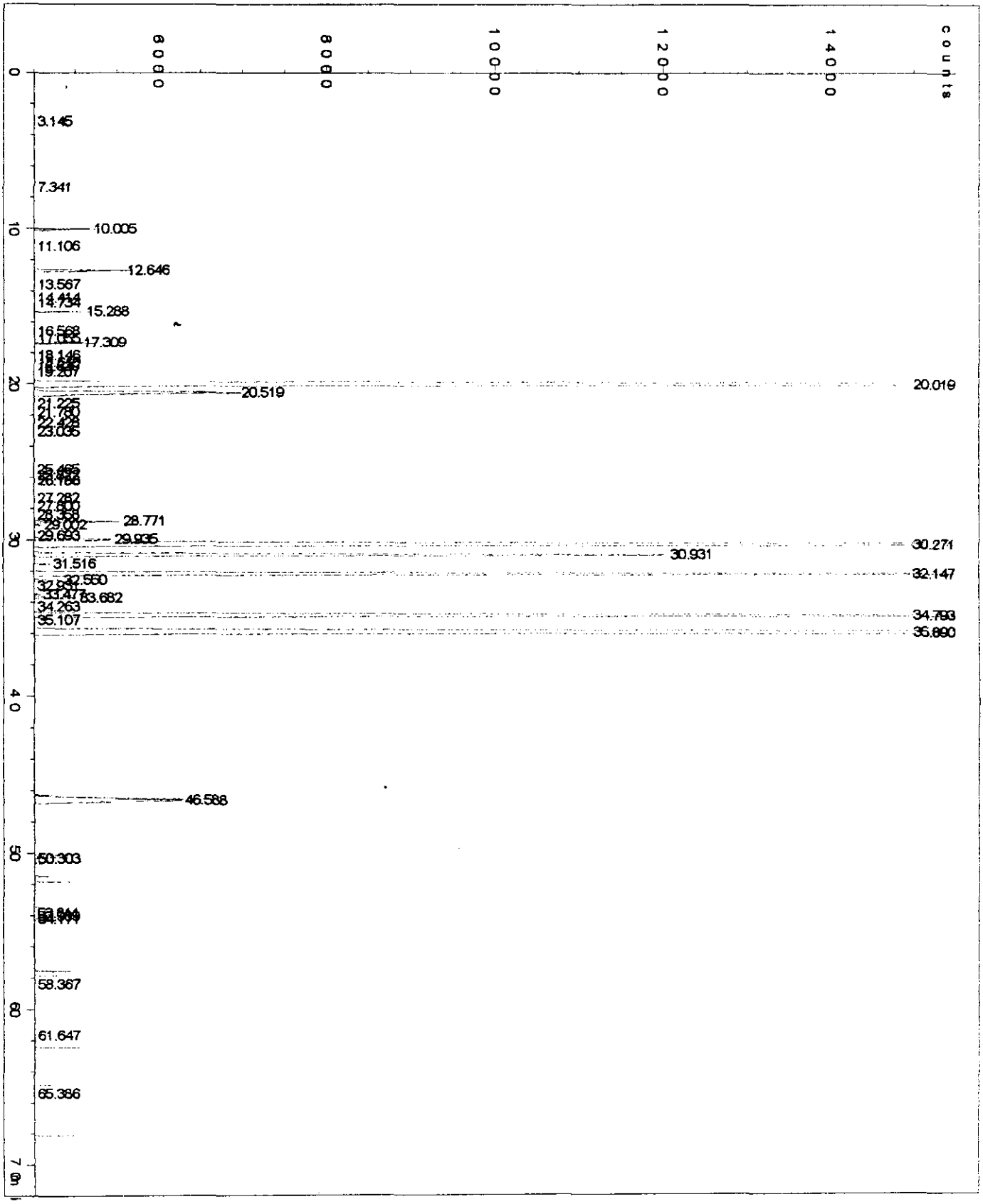
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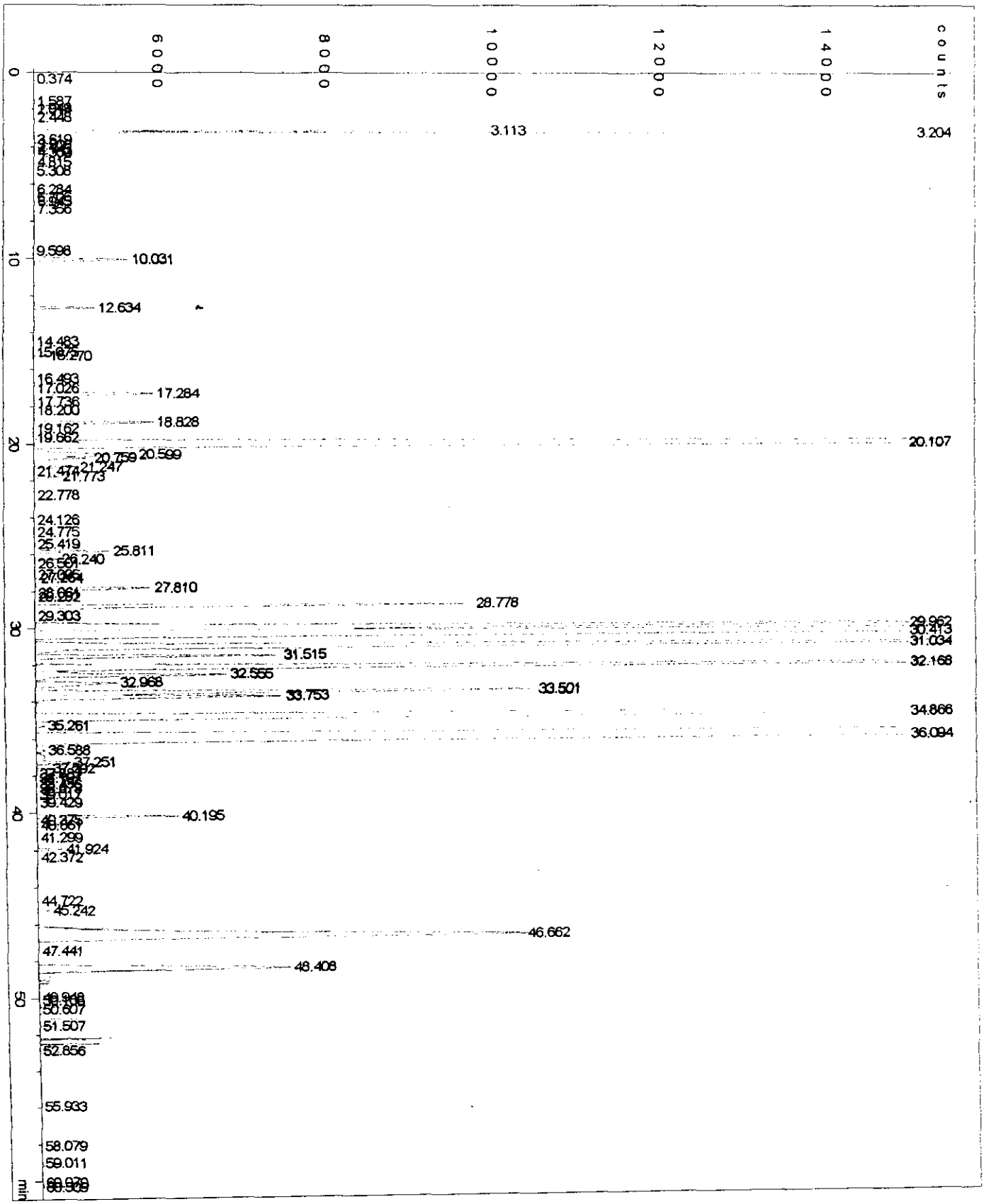
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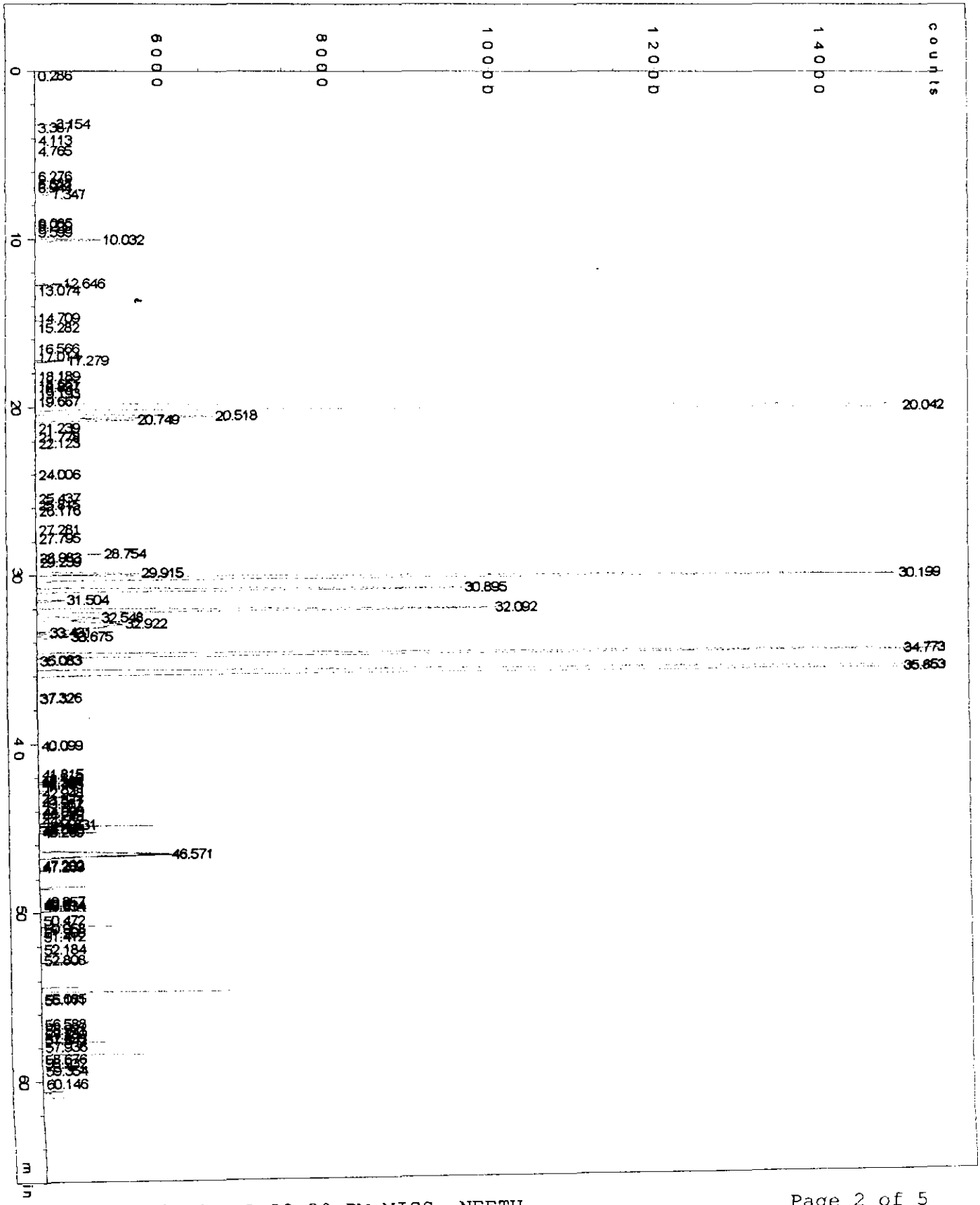
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Table 18 (a): GC Value of different chemical constituents in Matricaria blue oil as influenced by various treatments (1999-

Treatment –1 (F.Y.M. 10 t/ha)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.036	1.92731e4	0.882	VB	Farnesene
12.653	1.85796e4	0.731	VB	Germasene
14.719	2.73432	1.646	BP	Non-guazlene
17.281	1.78764e4	1.572	VV	Bisalbolol oxide-B
20.519	3.07147e4	4.372	VV	Bisalbolon oxide-B
20.046	3.16974e5	32.441	BP	Bisalbolol
30.198	2.69301e5	8.458	VV	Chamazulene
30.897	1.01072e5	2.829	BB	Bisalbolon oxide-A
34.781	1.19317e4	4.097	VV	Cis-dicyloether
46.601	1.33021e4	0.353	VV	Trans- dicyloether

Treatment – 2 (F.Y.M. 10 t/ha + Azotobacter)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.039	1.87565e4	0.994	VB	Farnesene
12.650	1.97357e4	0.869	VB	Germasene
14.721	2.67246e4	1.656	VB	Non-guazlene
17.286	2.87492e4	2.727	BP	Bisalbolol oxide-B
20.521	3.31973e4	5.065	VV	Bisalbolon oxide-B
20.040	3.17014e5	33.436	VB	Bisalbolol
30.200	2.7793e5	9.576	VV	Chamazulene
30.890	1.07203e5	3.37	BB	Bisalbolon oxide-A
34.774	1.19325e4	4.127	VV	Cis-dicyloether
46.607	1.33172e4	0.389	vv	Trans- dicyloether

Treatment – 3 (F.Y.M. + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.030	1.91463e4	0.928	VB	Farnesene
12.647	1.87356e4	0.766	BP	Germasene
14.709	2.74170e4	1.646	BP	Non-guazlene
17.270	1.97884e4	4.738	BP	Bisalbolol oxide-B
20.517	3.20914e4	5.095	VV	Bisalbolon oxide-B
20.050	3.18964e5	32.659	VV	Bisalbolol
30.189	2.70099e5	8.673	VV	Chamazulene
30.870	1.02011e5	2.669	VV	Bisalbolon oxide-A
34.760	1.21306e4	4.424	BP	Cis-dicyloether
46.589	1.33217e4	0.386	VV	Trans- dicyloether

Treatment – 4 (F.Y.M. +Azotobacter + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.032	1.79342e4	1.152	BP	Farnesene
12.598	1.96473e4	0.889	VB	Germasene
14.711	2.72152e4	1.616	BP	Non-guazlene
17.277	1.79931e4	4.415	VV	Bisalbolol oxide-B
20.514	3.61097e4	6.092	VV	Bisalbolon oxide-B
20.051	3.19917e5	35.543	BB	Bisalbolol
30.190	2.89791e5	9.790	VV	Chamazulene
30.900	1.09714e4	3.450	VV	Bisalbolon oxide-A
34.779	1.30172e4	5.444	VV	Cis-dicyloether
46.598	1.40163e4	0.577	VV	Trans- dicyloether

Cont....

Treatment –5 (NPK – 60:60:50 Kg/ha)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.030	2.12079e4	1.442	BP	Farnesene
12.647	2.5173e4	1.702	BP	Germasene
14.711	1.14836e4	0.611	VB	Non-guazlene
17.270	1.42175e4	4.609	VV	Bisalbolol oxide-B
20.616	3.66421e4	7.629	VV	Bisalbolon oxide-B
20.039	3.17194e5	39.220	VV	Bisalbolol
30.193	2.64721e5	13.630	VV	Chamazulene
30.891	1.07364e5	5.404	BP	Bisalbolon oxide-A
34.770	1.19147e5	7.359	VV	Cis-dicyloether
46.580	1.33012e4	0.629	VV	Trans- dicyloether

Treatment –6 (NPK – 30:60:50 Kg/ha + Azotobacter

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.032	2.07438e4	1.486	VB	Farnesene
12.646	2.4543e4	1.644	BP	Germasene
14.709	1.13824e4	0.637	BP	Non-guazlene
17.279	1.31395e4	4.441	VB	Bisalbolol oxide-B
20.518	3.79531e4	7.798	VV	Bisalbolon oxide-B
20.042	3.24096e5	39.315	VV	Bisalbolol
30.199	2.53141e5	13.459	BB	Chamazulene
30.895	1.08483e5	5.478	VV	Bisalbolon oxide-A
34.773	1.17111e5	7.352	VV	Cis-dicyloether
46.571	1.31219e4	0.684	VV	Trans- dicyloether

Treatment –7 (NPK – 60:30:50 Kg/ha + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.035	2.09567e4	1.367	VB	Farnesene
12.651	2.6012e4	1.566	VB	Germasene
14.716	1.13989e4	0.634	BP	Non-guazlene
17.268	1.62186e4	5.375	VB	Bisalbolol oxide-B
20.519	3.79872e4	8.553	VV	Bisalbolon oxide-B
20.046	3.26716e5	36.380	VV	Bisalbolol
30.199	2.76340e5	13.462	VV	Chamazulene
30.897	1.121732e5	6.513	VV	Bisalbolon oxide-A
34.687	1.19341e4	6.499	BP	Cis-dicyloether
46.587	1.73013e4	0.664	VV	Trans- dicyloether

Treatment –8 (NPK – 30:30:50 Kg/ha + Azoto. + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.029	2.08177e4	1.546	BP	Farnesene
12.653	2.4775e4	1.754	VP	Germasene
14.700	1.14876e4	0.766	VP	Non-guazlene
17.301	1.72297e4	5.315	BP	Bisalbolol oxide-B
20.451	3.87649e4	7.295	VV	Bisalbolon oxide-B
20.057	3.21731e5	39.226	BB	Bisalbolol
30.201	1.60721e5	13.414	VB	Chamazulene
30.907	1.09677e5	6.598	VV	Bisalbolon oxide-A
34.699	1.18133e5	7.482	VV	Cis-dicyloether
46.584	1.31301e4	0.614	VV	Trans- dicyloether

Cont....

Treatment –9 (NPK – 30:60:50 Kg/ha + Azoto. + Zn)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.0364	528.17726	1.743	VB	Farnesene
12.680	7143.20799	1.846	BP	Germasene
14.381	633.72301	0.789	BB	Non-guazlene
17.061	2.93832e4	4.7750	VB	Bisalbolol oxide-B
20.587	1.93797	7.549	BP	Bisalbolon oxide-B
20.070	2.81334e5	39.343	VV	Bisalbolol
30.419	1.61798e5	15.580	VV	Chamazulene
30.000	7.87932e4	5.718	VV	Bisalbolon oxide-A
34.945	4.87301e4	7.309	BP	Cis-dicyloether
46.925	1.09732e4	0.927	VV	Trans- dicyloether

Treatment –10 (NPK – 30:60:50 Kg/ha + Azoto. + Fe)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.090	532.18457	1.544	VB	Farnesene
12.701	6454.30859	1.713	BP	Germasene
14.381	624.48071	0.776	BB	Non-guazlene
17.345	2.72973e4	4.268	VB	Bisalbolol oxide-B
20.791	1.89941	7.470	BP	Bisalbolon oxide-B
20.062	2.73558e5	39.577	VB	Bisalbolol
30.308	1.41458e5	13.630	VV	Chamazulene
30.995	7.97637e4	5.737	VV	Bisalbolon oxide-A
34.801	4.75352e4	7.148	BP	Cis-dicyloether
46.678	1.06563e4	0.718	BB	Trans- dicyloether

Treatment –11 (NPK – 30:60:50 Kg/ha + Azoto. + Zn+Fe))

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.070	548.27314	1.879	VB	Farnesene
12.691	7415.30783	1.921	BB	Germasene
14.370	639.63912	0.779	BB	Non-guazlene
17.171	2.99788e4	5.629	VB	Bisalbolol oxide-B
20.674	1.80932	7.509	VV	Bisalbolon oxide-B
20.481	1.73693e5	39.578	VV	Bisalbolol
30.413	1.62197e5	15.679	VV	Chamazulene
30.883	7.76301e4	5.573	VV	Bisalbolon oxide-A
34.971	4.79671e4	7.380	BP	Cis-dicyloether
46.873	1.13276e4	1.220	VV	Trans- dicyloether

Treatment –12 (NPK – 60:30:50 Kg/ha + PSB + Zn)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.079	530.97142	1.768	VB	Farnesene
12.710	6317.50763	1.579	BB	Germasene
14.390	600.39726	0.748	VB	Non-guazlene
17.091	2.79793e4	5.514	VB	Bisalbolol oxide-B
20.567	1.73657	8.378	VV	Bisalbolon oxide-B
20.072	1.65601e5	36.540	BP	Bisalbolol
30.421	1.57036e5	14.669	BP	Chamazulene
30.801	7.97314e4	6.627	BB	Bisalbolon oxide-A
34.734	4.81936e4	6.322	VV	Cis-dicyloether
46.576	1.14738e4	0.967	VV	Trans- dicyloether

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Treatment –13 (NPK – 60:30:50 Kg/ha + PSB + Fe)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.010	2.35144e4	1.574	PB	Farnesene
12.578	7651.04102	1.618	PV	Germasene
14.380	2.29040e4	0.726	VP	Non-guazlene
17.275	2.02143e4	6.445	BP	Bisalbolol oxide-B
20.510	4.57848e4	8.477	VV	Bisalbolon oxide-B
20.060	9.35283e5	36.365	VV	Bisalbolol
30.190	3.70474e5	13.676	VV	Chamazulene
30.890	2.12643e5	6.596	VV	Bisalbolon oxide-A
34.775	2.03919e5	6.432	VV	Cis-dicyloether
46.810	2.44395e4	0.770	VV	Trans- dicyloether

Treatment –14 (NPK – 60:30:50 Kg/ha + PSB + Zn+Fe)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.030	2.44156e4	1.785	VB	Farnesene
12.607	2.43126e4	1.635	VB	Germasene
14.407	1.47165e4	0.690	VP	Non-guazlene
17.281	2.57627e4	6.384	VV	Bisalbolol oxide-B
20.497	4.63175e4	8.887	VV	Bisalbolon oxide-B
20.072	9.35998e5	36.353	BB	Bisalbolol
30.210	3.87615e5	14.649	VV	Chamazulene
30.901	2.12449e5	6.559	VV	Bisalbolon oxide-A
34.680	2.02829e5	6.349	VV	Cis-dicyloether
46.601	2.13243e5	1.242	VV	Trans- dicyloether

Treatment –15 (NPK–30:30:50 Kg/ha+Azoto. +PSB + Zn+ Fe)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.041	2.43172e4	1.896	VB	Farnesene
12.609	7963.06202	1.949	VB	Germasene
14.411	2.12252e4	0.639	VB	Non-guazlene
17.277	2.13172e4	6.729	BP	Bisalbolol oxide-B
20.576	4.46379e4	8.328	VP	Bisalbolon oxide-B
20.081	9.57394e5	39.413	VV	Bisalbolol
30.170	3.97836e5	15.783	VV	Chamazulene
30.900	2.12397e5	6.580	VV	Bisalbolon oxide-A
34.760	2.17439e5	7.155	VV	Cis-dicyloether
46.690	7240.06725	1.240	VV	Trans- dicyloether

Treatment –16 control (no fertilization)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.027	1.53791e4	0.710	PB	Farnesene
12.570	1.39378e4	0.660	VB	Germasene
14.397	2.51276e4	1.690	VB	Non-guazlene
17.279	1.53892e4	0.887	VB	Bisalbolol oxide-B
20.590	2.01127e4	3.353	VV	Bisalbolon oxide-B
20.091	8.30173e5	30.121	VV	Bisalbolol
30.217	2.78267e5	8.000	VV	Chamazulene
30.870	1.79547e5	2.130	VV	Bisalbolon oxide-A
34.810	1.87294e5	3.981	VV	Cis-dicyloether
46.714	5021.13124	0.300	VV	Trans- dicyloether

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Table 18 (b): GC Value of different chemical constituents in Matricaria blue oil as influenced by various treatments (2000-

Treatment –1 (F.Y.M. 10 t/ha)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.123	1.30706e4	0.948	PB	Farnesene
12.737	5342.05322	0.744	PP	Germasene
15.380	6246.94678	1.657	VV	Non-guazlene
17.126	6637.96094	1.316	BV	Bisalbolol oxide-B
20.582	2.43698e4	4.247	VV	Bisalbolon oxide-B
20.042	2.626865	32.081	VV	Bisalbolol
30.271	5.10889e4	8.992	VV	Chamazulene
30.968	1.71737e4	2.521	VP	Bisalbolon oxide-A
34.885	2.63578e4	4.769	BB	Cis-dicyloether
46.753	1886.45544	0.367	VB	Trans- dicyloether

Treatment – 2 (F.Y.M. 10 t/ha + Azotobacter)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.076	1.43652e4	1.003	VB	Farnesene
12.689	6239.16242	0.878	PB	Germasene
15.387	64246.98678	1.661	PP	Non-guazlene
17.109	13274.87462	2.569	BV	Bisalbolol oxide-B
20.583	2.69765e4	5.136	VV	Bisalbolon oxide-B
20.053	2.71786e5	32.104	VV	Bisalbolol
30.226	5.27893e4	9.961	VV	Chamazulene
30.909	2.13427e4	3.769	VV	Bisalbolon oxide-A
34.846	2.63047e4	4.456	VB	Cis-dicyloether
46.743	2286.45536	0.385	VV	Trans- dicyloether

Treatment – 3 (F.Y.M. + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.091	1.67320e4	1.118	VB	Farnesene
12.717	6552.15022	0.832	PP	Germasene
15.379	6242.94678	1.649	PB	Non-guazlene
17.137	2.67878e4	4.642	BV	Bisalbolol oxide-B
20.521	2.93012e4	5.159	VV	Bisalbolon oxide-B
20.063	2.62699e5	32.196	VV	Bisalbolol
30.276	5.10977e4	8.893	VV	Chamazulene
30.893	1.87365e4	2.866	BB	Bisalbolon oxide-A
34.867	2.63678e4	4.582	PP	Cis-dicyloether
46.756	1998.61561	0.380	VB	Trans- dicyloether

Treatment – 4 (F.Y.M. +Azotobacter + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.101	1.68732e4	1.174	VB	Farnesene
12.713	7349.17242	0.934	VB	Germasene
15.375	64244.98678	0.643	PB	Non-guazlene
17.130	2.734889e4	4.234	VB	Bisalbolol oxide-B
20.573	2.73875e4	6.104	VV	Bisalbolon oxide-B
20.064	2.83176e5	35.102	VV	Bisalbolol
30.260	6.11073e4	10.537	VV	Chamazulene
30.975	2.23457e4	3.551	VV	Bisalbolon oxide-A
34.871	2.98732e4	6.494	VV	Cis-dicyloether
46.751	3673.61732	0.30	VV	Trans- dicyloether

Treatment –5 (NPK – 60:60:50 Kg/ha)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.039	6.08634e4	1.549	VB	Farnesene
12.629	6.33592e4	1.784	BP	Germasene
14.986	2.44245e5	0.648	VP	Non-guazlene
17.260	1.45378e5	4.492	VP	Bisalbolol oxide-B
20.570	1.59785e6	7.530	VV	Bisalbolon oxide-B
21.030	5.199251e5	39.218	VV	Bisalbolol
30.501	5.75211e5	14.444	VV	Chamazulene
30.895	1.34985e6	5.336	VV	Bisalbolon oxide-A
34.776	3.28764e5	8.250	VV	Cis-dicyloether
46.643	2.63710e4	0.690	BP	Trans- dicyloether

Treatment –6 (NPK – 30:60:50 Kg/ha + Azotobacter

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
11.010	6.07385e4	1.519	VB	Farnesene
12.590	6.24732e4	1.749	VP	Germasene
15.300	2.47136e4	0.657	BP	Non-guazlene
17.290	1.53417e5	4.539	VP	Bisalbolol oxide-B
20.548	1.77389e5	7.634	VV	Bisalbolon oxide-B
20.122	5.19708e6	39.220	VV	Bisalbolol
30.437	5.93143e5	14.697	VV	Chamazulene
31.017	1.57683e6	5.110	VV	Bisalbolon oxide-A
34.827	3.37914e5	8.310	VV	Cis-dicyloether
46.673	2.52067e4	0.678	BP	Trans- dicyloether

Treatment –7 (NPK – 60:30:50 Kg/ha + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.69	6.08797e4	1.476	VB	Farnesene
12.636	6.24731e4	1.707	VB	Germasene
15.250	2.38761e4	0.652	VP	Non-guazlene
17.301	2.04939e5	5.439	BP	Bisalbolol oxide-B
20.583	1.97863e5	8.660	VV	Bisalbolon oxide-B
20.114	5.09386e6	36.376	VV	Bisalbolol
30.339	5.50397e5	14.484	VV	Chamazulene
30.903	2.03376e6	7.131	VV	Bisalbolon oxide-A
34.790	2.29389e5	6.314	VV	Cis-dicyloether
46.586	1.56086e4	0.675	VV	Trans- dicyloether

Treatment –8 (NPK – 30:30:50 Kg/ha + Azoto. + PSB)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.031	6.19943e4	1.683	VB	Farnesene
12.634	6.25519e4	1.774	BP	Germasene
15.270	2.49044e4	0.687	VP	Non-guazlene
17.284	2.06578e5	5.542	VP	Bisalbolol oxide-B
20.599	1.58762e5	7.464	VV	Bisalbolon oxide-B
20.107	5.27508e6	39.285	VV	Bisalbolol
30.413	5.52089e5	14.471	VV	Chamazulene
31.834	2.03499e6	7.142	VV	Bisalbolon oxide-A
34.866	3.37780e5	8.318	VV	Cis-dicyloether
46.662	2.52054e4	0.676	BV	Trans- dicyloether

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Treatment –9 (NPK – 30:60:50 Kg/ha + Azoto. + Zn)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.007	2.40972e4	1.903	VB	Farnesene
12.578	1.87734e4	1.898	VB	Germasene
15.301	1.43057e4	0.786	PB	Non-guazlene
17.279	1.79479e5	4.816	VP	Bisalbolol oxide-B
20.527	1.50034e5	7.444	VV	Bisalbolon oxide-B
20.027	4.98977e5	39.402	VV	Bisalbolol
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30.901	9.02345e4	5.685	VV	Bisalbolon oxide-A
[illegible]	1.77814e4	8.113	VV	Cis-dicyloether
[illegible]	1.00120e4	0.940	BV	Trans- dicyloether

Treatment –10 (NPK – 30:60:50 Kg/ha + Azoto. + Fe)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.029	2.21379e4	1.694	VB	Farnesene
12.590	1.78997e4	1.854	VB	Germasene
15.312	1.42056e4	0.778	VB	Non-guazlene
17.319	1.67892e5	4.421	PB	Bisalbolol oxide-B
20.312	1.50079e5	7.457	PB	Bisalbolon oxide-B
20.611	4.86306e5	39.274	VV	Bisalbolol
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30.317	9.02345e4	5.685	VV	Bisalbolon oxide-A
34.911	1.79926e4	8.264	VV	Cis-dicyloether
46.601	1.00010e4	0.720	PB	Trans- dicyloether

Treatment –11 (NPK – 30:60:50 Kg/ha + Azoto. + Zn+Fe))

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.036	1.52371e4	1.959	PB	Farnesene
12.607	1.87619e4	1.884	VB	Germasene
15.319	1.43041e4	0.781	VB	Non-guazlene
17.283	1.89671e5	5.660	PB	Bisalbolol oxide-B
20.531	1.67341e5	7.729	VP	Bisalbolon oxide-B
20.601	4.98987e5	39.457	VV	Bisalbolol
30.279	2.577132e5	16.730	VV	Chamazulene
30.898	9.37281e4	7.760	VV	Bisalbolon oxide-A
34.719	1.79836e4	8.146	BV	Cis-dicyloether
46.575	1.102779e4	1.216	VV	Trans- dicyloether

Treatment –12 (NPK – 60:30:50 Kg/ha + PSB + Zn)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.071	2.27867e4	1.885	VB	Farnesene
12.563	1.68832e4	1.749	PB	Germasene
15.278	1.39067e4	0.764	VB	Non-guazlene
17.301	1.89679e5	5.760	BP	Bisalbolol oxide-B
20.601	1.71234e5	8.571	VV	Bisalbolon oxide-B
20.032	4.63217e5	36513	VV	Bisalbolol
30.878	2.30179e5	15.754	BV	Chamazulene
30.314	9.73214e4	7.691	VV	Bisalbolon oxide-A
34.790	1.50213e4	6.078	VV	Cis-dicyloether
46.590	1.0010e4	0.939	VV	Trans- dicyloether

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Treatment –13 (NPK – 60:30:50 Kg/ha + PSB + Fe)

Reten time	Area (mvs)	Amount (%)	Peak type	Name of components
10.005	2.25792e4	1.782	BP	Farnesene
12.646	1.87416e4	1.727	PB	Germasene
15.288	1.24058e4	0.739	VP	Non-guazlene
17.309	1.40891e5	6.825	VB	Bisalbolol oxide-B
20.519	1.73185e5	8.643	VV	Bisalbolon oxide-B
20.019	4.90157e5	36.577	VV	Bisalbolol
30.271	2.15340e5	14.687	VV	Chamazulene
30.931	9.12781e4	7.578	VV	Bisalbolon oxide-A
34.793	1.44122e5	6.652	VV	Cis-dicyloether
46.588	1.13244e4	0.772	BV	Trans- dicyloether

Treatment –15 (NPK–30:30:50 Kg/ha+Azoto. +PSB +

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.027	2.45991e4	1.995	BP	Farnesene
12.617	1.99726e4	1.985	PB	Germasene
15.274	1.23048e4	0.725	VB	Non-guazlene
17.327	1.43789e5	6.842	VP	Bisalbolol oxide-B
20.611	1.70089e5	8.295	VV	Bisalbolon oxide-B
20.077	4.99786e5	39.275	VV	Bisalbolol
30.256	2.46479e5	16.768	VV	Chamazulene
30.880	9.32791e4	7.764	VV	Bisalbolon oxide-A
34.721	1.66327e4	7.150	VV	Cis-dicyloether
46.528	1.37892e4	1.243	BV	Trans- dicyloether

Treatment –14 (NPK – 60:30:50 Kg/ha + PSB +

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.021	2.34892e4	1.892	VB	Farnesene
12.573	1.86936e4	1.764	PB	Germasene
15.273	1.24043e4	0.729	VB	Non-guazlene
17.289	1.32793e5	6.731	VP	Bisalbolol oxide-B
20.527	1.73105e5	8.668	VV	Bisalbolon oxide-B
20.032	4.97253e5	36.657	VV	Bisalbolol
30.251	2.26501e5	15.760	VV	Chamazulene
30.877	9.12680e4	7.576	VV	Bisalbolon oxide-A
30.782	1.40012e5	6.146	VV	Cis-dicyloether
46.578	1.73201e4	1.246	BV	Trans- dicyloether

Treatment –16 control (no fertilization)

Reten. time	Area (mvs)	Amount (%)	Peak type	Name of components
10.011	1.20123e4	0.713	VB	Farnesene
12.629	1.07234e4	0.690	PB	Germasene
15.265	1.75895e4	1.693	VB	Non-guazlene
17.315	1.35064e4	0.894	VP	Bisalbolol oxide-B
20.523	2.75426e4	3.430	VV	Bisalbolon oxide-B
20.027	3.98857e5	30.370	VV	Bisalbolol
30.280	1.27832e5	8.010	VV	Chamazulene
30.935	2.50121e5	2.130	VV	Bisalbolon oxide-A
34.790	2.07218e4	3.990	BV	Cis-dicyloether
46.575	2270.83214	0.300	VV	Trans- dicyloether

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(iii) Bisabolon oxide-B:

GC value recorded on bisobolon oxide-B (%) is shown in Table 17&18 which clearly indicated that the percentage of bisabolon oxide-B in blue oil varied from 3.353 to 8.668 and 3.430 to 8.887% during 1999-2000 and 2000-2001, respectively. However, the highest content of bisabolon oxide-B was observed (8.668% and 8.887%) in 1999-2000 and 2000-2001, respectively by with treatment of T_{14} (NPK-60: 30: 50 kg/ha + PSB + Zinc + Iron) followed by T_7 (8.660 % and 8.555 %), T_{13} (8.643 % and 8.477 %), T_{12} (8.571 % and 8.378 %) and T_{15} (8.295 % and 8.328%) as compared to other treatments.

(iv) Bisabolol oxide-B:

The data presented in Table 17&18 revealed that the percentage of bisabolol oxide-B content in blue oil was also influenced by the treatments which ranged from 0.894 to 6.729 % and 0.887 to 6.824 % during 1999-2000 and 2000-2001, respectively. Among the various treatments, treatment of NPK-30: 30:50 kg/ha + Azotobacter +PSB + Zinc + Iron (T_{15}) have been found more responsive to increase the bisabolol oxide-B Content in blue oil (6.729 and 6.842%) followed by T_{13} (6.445 and 6.825 %), T_{14} (6.384 and 6.736%), T_{11} (5.629 and 5.660 %) and T_{12} (5.514 and 5.760%), which were found slightly significantly superior over control (0.894 and 0.887 %) and other treatments during both the years.

(V) Cis-dicyloether (%):

Data furnished in Table 17&18 clearly showed that the percentage of cis-dicylocther content in blue oil was found significantly higher in concentration ranging from 3.981 to 7.482 and 3.990 to 8.318 % as influenced by various treatments during 1999-2000 and 2000-2001, respectively. However, the highest percentage of cis-dicyloether (7.482 and 8.318%) content was evaluated in treatment of NPK-30: 30:50 kg/ha + Azotobacter +PSB (T_8) followed by T_{11} (7.380 to 8.146 %), T_5 (7.359 and 8.250%), T_6 (7.352 and 8.310 %), T_9 (7.309 and 8.113 %) and T_{10} (7.148 and 8.264 %), while lowest concentration was recorded in control (3.981 and 3.990%) and others were at

par T_{11} (7.380), T_5 (7.359), T_6 (7.352) and T_9 (7.309) during 1999-2000. Nevertheless, a slight variation was noticed during 2000-2001 and T_8 treatment were found to be at par with treatment T_6 (8.113), T_{10} (8.264), T_5 (8.250), T_{11} (8.146) and T_9 (8.113) and were significantly superior over rest of the treatments.

(VI) Bisabolol oxide-A (%):

Data recorded on bisabolol oxide-A content in blue oil (%) owing to various treatments have been presented in Table 17&18 which showed the conspicuous response of different treatments on percentage of bisabolol oxide-A in blue oil, which ranged form 2.130 to 6.627 and 2.130 to 7.764 % during 1999-2000 and 2000-2001, respectively. However, the highest percentage of bisabolol Oxide-A content in blue oil(6.627 and 7.764%) was recorded due to treatment of NPK-30:30:50 Kg/ha +Azotobacter +PSB +Zinc +Iron (T_{15}) and followed by T_{12} (6.627 and 7.691%), T_{13} (6.596 and 7.578%), T_{14} (6559 and 7.576%), T_8 (6.598 and 7.142 %) and T_7 (6.513 and 7.131%) and found significantly higher over control (2.130%) and other treatments.

(VII) Farnesene:

Data presented in Table17 &18 indicated that there was significantly improvement towards percentage of farnesene content in blue oil which ranged from 0.710 to 1.896 and 0.713 to 1.995% during 1999-2000 and 2000-2001, respectively. The highest percentage of farnesene (1.896 and 1.995%) was obtained due to application of NPK-30: 30: 50kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}) followed by T_{11} (1.879 and 1.959%), T_{14} (1.785 and 1.892%), T_{12} (1.768 and 1.885%) and T_9 (1.743 and 1.903 %) during both the years (1999-2000 and 2000-2001), which were found significantly higher as compared to control and other treatments.

(VIII) Germacene:

Data pertaining to germacene content in blue oil shown in Table17&18 indicated that the significant differences were observed in percentage of germacene content due to use of various treatments, which ranged from 0.660 to 1.949 and 0.690 to 1.985% during 1999-2000 and 2000-2001, respectively. The application of NPK-30: 30: 50kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}) have shown significant effect on increase of germacene content (1.949

and 1.985 %) in blue oil and followed by T_{11} (1.921 and 1.884%), T_9 (1.846 and 1.898%) and T_{10} (1.713 and 1.854%). Lowest percentage of germacene (0.660 and 0.690%) was in control.

(IX) Non-guazlene:

The data pertaining to chemical composition of blue oil as presented in Table 17&18 indicated that there was markedly reduction in percentage of Non-guazlene content in blue oil which ranged from 0.611 to 1.690 and 0.652 to 1.693% during 1999-2000 and 2000-2001, respectively. However, maximum percentage of Non-guazlene content in blue oil (1.690 and 1.693%) was obtained in control (T_{16}) followed by T_1, T_2, T_3 and T_4 and minimum was in other treatments.

(X) Trans-dicyloether:

Data recorded on trans-dicyloether content in blue oil as affected by different treatments have been presented in Table17&18. Various treatments were found to be effective toward enhancement of trans-dicyloether content in blue oil, which ranged from 0.300 to 1.242 and 0.310 to 1.246% during 1999-2000 and 2000-2001, respectively. Among the various treatments, treatment of NPK-60: 30:50 kg/ha + PSB + Zinc + Iron (T_{14}) have shown better effect on increase on trans- dicyloether content in blue oil (1.242 and 1.246%) followed by T_{11} (1.220 and 1.216%), T_{15} (1.240 and 1.243%) during both the years, which were found significant higher over control (0.300 and 0.310 %) and other treatments. .

4.5 Effect of levels of different nutrients on nutritional status of plant:

4.5.1 Yield of biomass (Fresh and Dry weight g/plant):

Data pertaining to fresh and dry yield of biomass g/plant as affected by various treatments have been presented in Table19. The results revealed that fresh and dry biomass yield increased significantly due to use of different levels of nutrients, biofertilizers and micronutients and average values were found in the range of 160.73 to 194.36 and 48.62 to 60.19 g/plant during 1999-2000 and 2000-2001, respectively. The maximum fresh and dry biomass yields

Table 19: Effect of levels of nutrients, biofertilizers and micronutrients on biomass yields (g/plant) of Matricaria grown in sodic soil condition

S.No.	*Treatments*	*Yield of biomass (fresh / dry) g/plant*					
		Fresh yield (g/plant)			Dry yield (g/plant)		
		1999-2000	2000-2001	Means	1999-2000	2000-2001	Means
T_1	F.Y.M. (10 t/ha)	175.40	176.77	176.08	51.56	51.60	51.58
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	180.50	186.50	183.5	54.53	56.04	55.28
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	179.27	181.27	180.27	55.39	55.74	55.56
T_4	F.Y.M. + Azoto + PSB	185.44	188.20	186.82	55.95	57.17	56.56
T_5	NPK- 60:60:50 Kg/ha	191.70	195.73	193.71	58.75	59.44	59.09
T_6	NPK- 30:60:50 + Azoto	189.20	191.67	190.43	59.66	60.23	59.94
T_7	NPK- 60:30:50 + PSB	190.60	191.20	190.9	58.34	58.74	58.54
T_8	NPK- 30:30:50 + Azoto + PBS	192.03	194.93	193.48	60.11	60.28	60.19
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	191.77	192.57	192.17	59.84	59.93	59.88
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	190.77	191.47	191.12	58.85	69.67	64.26
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	192.67	192.37	192.52	59.15	60.08	59.61
T_{12}	NPK-60:30:50 +PSB+ Zn	189.47	192.73	191.10	58.86	59.01	58.93
T_{13}	NPK-60:30:50 + PSB + Fe	189.83	191.83	190.83	58.43	58.75	58.59
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	193.70	195.03	194.36	59.65	60.24	59.94
T_{15}	NPK-30:30:50 +Azoto + PSB+ Zn + Fe	191.40	193.00	192.20	59.67	60.16	59.91
T_{16}	Control	161.03	160.43	160.73	48.48	48.77	48.62
SEm ±		1.79	1.51		0.93	0.56	
C.D.=(P=0.05)		5.16	4.36		2.57	1.63	

(194.36 and 60.19 g/plant) were obtained with T_{11} treatment (NPK-30: 60:50 kg/ha + Azotobacter + Zinc + Iron) and T_{14} (NPK-60:30:50 Kg/ha +PSB +Zinc +Iron) respectively. Whereas, minimum fresh and dry biomass yields was obtained in control (160.73 and 48.62 g/plant). Remaining treatments did not exert significant difference in fresh and dry biomass yields g/plant, except the treatments T_1, T_2 and T_3 and values were found to be at par during both the years (1999-2000 and 2000-2001).

4.5.2 Nutrient levels in plant:

Data recorded on plant analysis for determinations of nutrient level i.e. nitrogen, phosphorus and potassium content is portrayed in Table-20. It is evident from the results shown in Table 20 that there was significant variation in nitrogen content in plants due to influence of different treatments of NPK, biofertilizers and micronutrients, which varied from 1.20 to 2.21 and 1.10 to 2.21% during 1999-2000 and 2000-2001, respectively. The maximum nitrogen content (2.21%) was found due to application of NPK 30:30:50 Kg/ha + Azotobacter + PSB +Zinc +Iron (T_{15}) followed by T_5, T_9, T_{10} and T_{11} treatments, while, lowest nitrogen content (1.20%) was estimated in control.

Similar response was also recorded for phosphorus and potassium content in plant parts. The phosphorus content varied from 0.09 to 0.15 and 0.07 to 0.15% during 1999-2000 and 2000-2001, respectively. However, maximum phosphorus content (0.15%) was noticed it T_{15} (NPK- 30:30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron), which was found at par with other treatments (T_{13},T_{12}, T_8, T_7 ,T_5 and T_3), while lowest phosphorus content (0.09 and 0.07%) in control during both the years.

The potassium content in plant in ranged from 1.01 to1.28 and 1.00 to 1.28% during 1999-2000 and 2000-2001, respectively. The maximum potassium content (1.28%) was observed in T_7 (NPK-60: 30:50 Kg/ha +PSB followed by T_5,T_6, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, and T_{15}. While, lowest potassium content (1.01 and 1.00%) was observed in control.

Table 20: Effect of levels of nutrients, biofertilizers and micronutrients on nutrients levels in plants of Matricaria grown in sodic soil conditions

S.No.	*Treatments*	*Nutrient content (%) in plant at flowering stage (120DAP)*								
		N			P			K		
		1999-2000	2000-2001	Means	1999-2000	2000-2001	Means	1999-2000	2000-2001	Means
T_1	F.Y.M. (10 t/ha)	1.85(7.82)	1.89(7.91)	1.87	0.13(2.07)	0.13(2.07)	0.13	1.11(6.05)	1.13(6.11)	1.12
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	2.07(8.27)	2.11(8.35)	2.09	0.13(2.07)	0.12(1.98)	0.12	1.16(6.16)	1.15(6.17)	1.15
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	1.97(8.08)	1.95(8.03)	1.96	0.15(2.22)	0.15(2.22)	0.15	1.14(6.13)	1.16(6.18)	1.15
T_4	F.Y.M. + Azoto + PSB	2.19(8.52)	2.20(8.54)	2.19	0.14(2.14)	0.15(2.22)	0.14	1.19(6.27)	1.21(6.31)	1.20
T_5	NPK- 60:60:50 Kg/ha	2.11(8.55)	2.20(8.54)	2.10	0.15(2.22)	0.13(2.07)	0.14	1.27(6.47)	1.27(6.47)	1.27
T_6	NPK- 30:60:50 + Azoto	2.19(8.52)	2.19(8.52)	2.19	0.14(2.14)	0.14(2.14)	0.14	1.26(6.46)	1.27(6.47)	1.26
T_7	NPK- 60:30:50 + PSB	2.00(8.13)	1.99(8.12)	1.99	0.15(2.22)	0.15(2.22)	0.15	1.28(6.50)	1.28(6.48)	1.28
T_8	NPK- 30:30:50 + Azoto + PBS	2.21(8.55)	2.21(8.55)	2.16	0.15(2.22)	0.15(2.22)	0.15	1.25(6.42)	1.25(6.42)	1.25
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	2.20(8.54)	2.20(8.54)	2.20	0.13(2.07)	0.14(2.14)	0.13	1.27(6.47)	1.27(6.47)	1.27
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	2.20(8.54)	2.20(8.54)	2.20	0.13(2.07)	0.13(2.07)	0.13	1.27(6.47)	1.27(6.47)	1.27
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	2.21(8.55)	2.21(8.55)	2.21	0.13(2.07)	0.13(2.07)	0.13	1.26(6.46)	1.26(6.46)	1.26
T_{12}	NPK-60:30:50 +PSB+ Zn	2.00(8.13)	2.00(8.13)	2.00	0.15(2.22)	0.15(2.22)	0.15	1.26(6.46)	1.27(6.47)	1.26
T_{13}	NPK-60:30:50 + PSB + Fe	1.98(8.10)	2.00(8.13)	1.99	0.15(2.22)	0.15(2.22)	0.15	1.27(6.47)	1.25(6.49)	1.26
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	1.99(8.12)	1.99(8.12)	1.99	0.14(2.14)	0.14(2.14)	0.14	1.26(6.46)	1.27(6.47)	1.26
T_{15}	NPK-30:30:50 +Azoto + PSB+ Zn + Fe	2.21(8.55)	2.21(8.55)	2.21	0.15(2.22)	0.15(2.22)	0.15	1.27(6.47)	1.27(6.47)	1.27
T_{16}	Control	1.20(6.29)	1.10(6.02)	1.15	0.09(1.72)	0.07(1.52)	0.08	1.01(5.78)	1.00(1.81)	1.00
SEm ±		0.11	0.07		0.06	0.05		0.04	0.04	
C.D.= (P=0.05)		0.32	0.21		0.16	0.15		0.13	0.11	

***Figures in parenthesis are angular transformed values**

4.6 Effect of levels of different nutrients on nutrient status of soil after crop harvest:

Data recorded in respect to chemical properties of soil like viz., electrical conductivity, pH, organic matter, available nitrogen, phosphors and potassium of the soils after harvest of the crops as affected by various treatments have been presented in Table 21 and depicted in Fig.8. Those chemical properties are described in ensuring paragraphs here under.

(1) Electrical conductivity (dsm^{-1}):

A perusal of data collected on electrical conductivity of soil shown in Table-21 indicated that electrical conductivity of soil varied from 0.42 to 0.47 and 0.39 to 0.46 dsm^{-1} during 1999-2000 and 2000-2001, respectively. The maximum value of EC (0.47 and 0.46 dsm^{-1}) was recorded in control, while lowest EC (0.42 dsm^{-1}) was found in T_2 (F.Y.M.10 t/ha +Azotobacter) and T_3 (F.Y.M. 10 t/ha +PSB).

The application of F.Y.M. either alone or with bio- inoculants have significantly reduced the EC over initial value (0.48 dsm^{-1}) during both the years, while other treatments did not show any significant variation in change of electrical conductivity of soil.

(ii) pH of Soil:

Data recorded on pH of soil shown in Table 21 indicated pH ranged from 8.7 to 9.2 and 8.4 to 9.1 due to various treatments during 1999-2000 and 2000-2001, respectively. However, maximum reduction in pH (8.5) was measured in the plot treated with F.Y.M. 10 t/ha + Azotobacter (T_2) and following by T_1 (8.7 and 8.4), T_3 (8.8 and 8.6) and T_4 (8.7 and 8.4), while highest value soil pH (9.2 and 9.00 was recorded in control plot during both the years.

(iii) Organic matter (%)

Data on organic matter content (%) of soil shown in Table 21 indicated that the organic matter content varied from 0.24 to 0.33 and 0.23 to o.38% due to different treatments during 1999-2000 and 2000-2001, respectively. The

Table 21(a): Effect of levels of nutrients, biofertilizers and micronutrients on nutritional status of soil after crop harvest of Matricaria grown in sodic soil conditions

S.No.	*Treatments*	*Properties of soil*								
		EC(dSm^{-1})			pH			Organic matter (%)		
		99-00	00-01	Means	99-00	00-10	Means	99-00	00-01	Means
	Initial status of soil	0.48			9.2			0.25(2.86)		
T_1	F.Y.M. (10 t/ha)	0.43	0.40	0.42	8.8	8.6	8.7	0.33(3.29)	0.38(3.53)	0.36
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	0.42	0.39	0.41	8.7	8.4	8.5	0.32(3.24)	0.37(3.49)	0.35
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	0.42	0.39	0.41	8.8	8.6	8.7	0.33(3.29)	0.39(3.58)	0.36
T_4	F.Y.M. + Azoto + PSB	0.43	0.40	0.42	8.7	8.4	8.5	0.32(3.24)	0.37(3.49)	0.35
T_5	NPK- 60:60:50 Kg/ha	0.47	0.45	0.46	9.1	9.0	9.0	0.26(2.92)	0.27(2.98)	0.27
T_6	NPK- 30:60:50 + Azoto	0.46	0.43	0.45	9.0	8.7	8.8	0.27(2.98)	0.28(3.03)	0.28
T_7	NPK- 60:30:50 + PSB	0.45	0.42	0.44	9.1	8.9	8.8	0.27(2.98)	0.28(3.03)	0.28
T_8	NPK- 30:30:50 + Azoto + PBS	0.45	0.43	0.44	9.0	8.7	8.9	0.27(2.98)	0.29(3.09)	0.28
T_9	NPK-30:60:50+Azoto + Zn (0.3%)	0.46	0.43	0.45	9.0	8.7	8.8	0.26(2.92)	0.28(3.03)	0.27
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	0.45	0.47	0.46	9.0	8.8	8.9	0.26(2.92)	0.27(2.98)	0.27
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	0.46	0.43	0.45	9.0	8.7	8.8	0.27(2.98)	0.28(3.03)	0.28
T_{12}	NPK-60:30:50 +PSB+ Zn	0.46	0.42	0.44	9.1	8.9	9.0	0.27(2.98)	0.28(3.03)	0.28
T_{13}	NPK-60:30:50 + PSB + Fe	0.46	0.42	0.44	9.1	8.9	9.0	0.27(2.98)	0.27(2.98)	0.27
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	0.46	0.43	0.45	9.1	8.9	9.0	0.27(2.98)	0.28(3.03)	0.28
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	0.46	0.44	0.45	9.1	8.9	9.0	0.28(3.03)	0.29(3.09)	0.29
T_{16}	Control	0.47	0.46	0.47	9.1	9.0	9.0	0.24(2.86)	0.23(2.75)	0.24
SEm ±		0.01	0.01		0.10	0.11		0.04	0.07	
C.D.= (P=0.05)		0.03	0.03		0.30	0.33		0.11	0.19	

***Figures in parenthesis are angular transformed values**

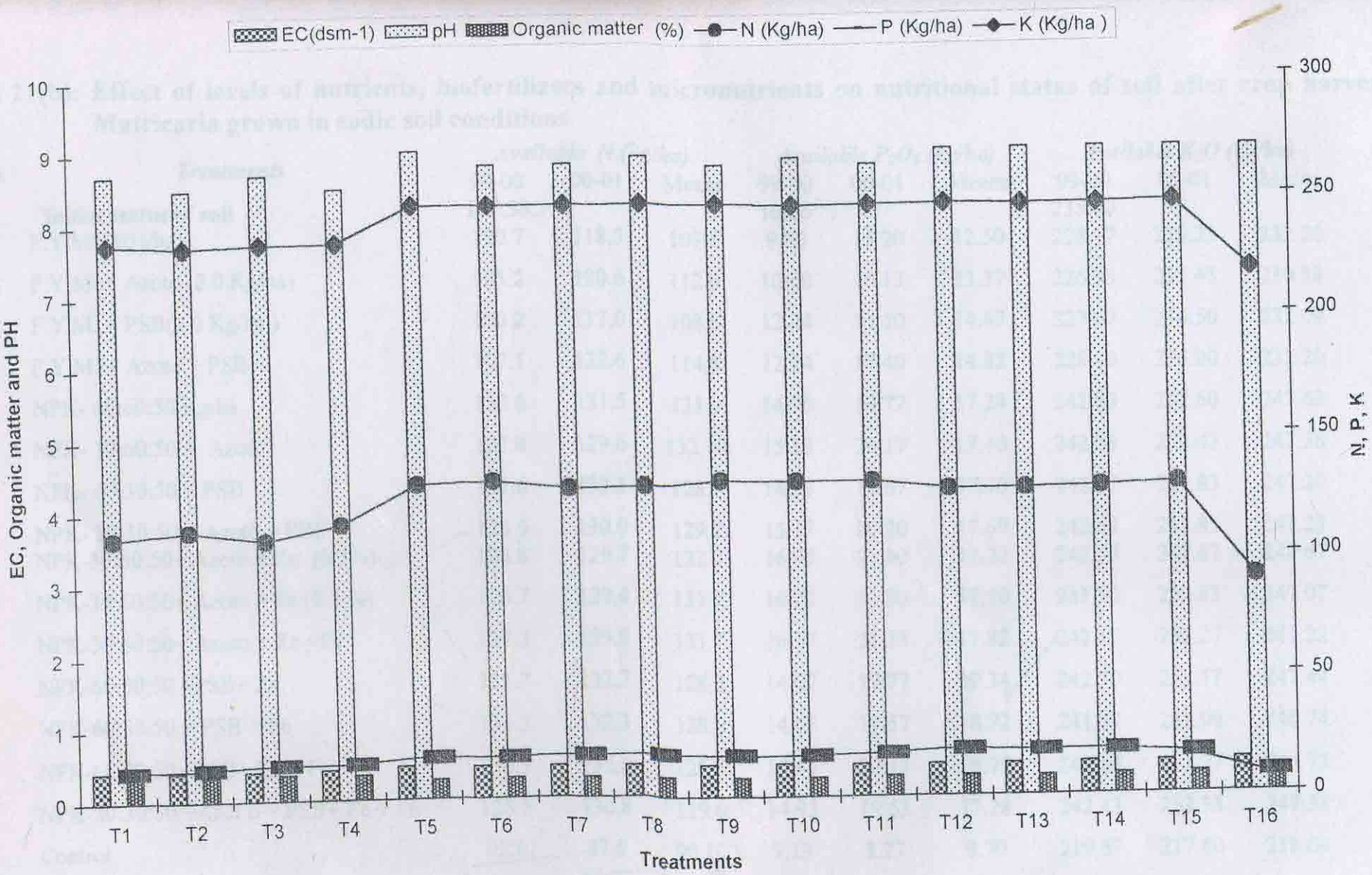

Fig.8: Effect of levels of nutrients, biofertilizers and micronutrients on nutritional status of soil after crop harvest of *Matricaria*

Table 21(b): Effect of levels of nutrients, biofertilizers and micronutrients on nutritional status of soil after crop harvest of Matricaria grown in sodic soil conditions

S.No.	Treatments	*Available N (kg/ha)*			*Available P_2O_5 (kg/ha)*			*Available K_2O (kg/ha)*		
		99-00	00-01	Means	99-00	00-01	Means	99-00	00-01	Means
	Initial status of soil	117.50			10.26			235.00		
T_1	F.Y.M. (10 t/ha)	100.7	118.5	109.6	9.80	15.20	12.50	228.17	236.23	232.20
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	105.2	120.6	112.9	10.60	16.13	13.37	226.33	235.43	230.88
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	100.2	117.0	108.6	12.24	17.10	14.67	227.67	236.50	232.09
T_4	F.Y.M. + Azoto + PSB	107.1	122.6	114.8	12.24	17.40	14.82	228.40	236.00	232.20
T_5	NPK- 60:60:50 Kg/ha	130.6	131.5	131.0	14.70	19.77	17.24	242.63	252.60	247.62
T_6	NPK- 30:60:50 + Azoto	127.8	129.6	132.10	15.23	20.17	17.10	242.33	252.43	247.38
T_7	NPK- 60:30:50 + PSB	131.6	132.5	128.7	14.53	19.67	17.70	242.57	251.83	247.20
T_8	NPK- 30:30:50 + Azoto + PBS	128.5	130.0	129.2	15.17	20.20	17.69	242.63	251.83	247.23
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	126.8	129.7	132.2	16.77	21.90	17.22	242.67	252.67	247.67
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	126.7	129.4	131.7	16.23	21.20	17.10	241.50	252.63	247.07
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	127.2	129.8	131.7	16.17	21.33	17.82	242.17	252.27	247.22
T_{12}	NPK-60:30:50 +PSB+ Zn	131.7	132.7	128.2	14.67	19.77	19.34	242.30	252.57	247.44
T_{13}	NPK-60:30:50 + PSB + Fe	131.2	132.3	128.0	14.63	19.57	18.72	241.57	251.90	246.74
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	130.9	132.6	128.5	15.47	20.17	18.75	241.67	251.77	246.72
T_{15}	NPK-30:30:50 +Azot o + PSB+ Zn + Fe	128.5	130.8	129.6	14.93	19.63	17.28	242.43	252.33	247.38
T_{16}	Control	92.6	87.6	90.10	9.13	8.27	8.70	219.67	217.60	218.64
SEm ±		1.33	1.30		0.83	0.91		0.94	0.99	
C.D.= (P=0.05)		3.84	3.76		2.39	2.63		2.71	2.87	

maximum organic matter content (0.33%) was found in plot with placement of F.Y.M. 10 t/ha (T_1) and F.Y.M. 10 t/ha +PSB (T_3) and followed by T_2 (0.32%) and T_4 (0.32%). Whereas, minimum organic matter content (0.24 and 0.23%) was obtained in control plot.

(iii) Available nitrogen (Kg/ha):

Data recorded in respect to available nitrogen in soil after harvest of crop under various treatments have been presented in Table 21. It is apparent from the data that the available nitrogen (Kg/ha) in soil ranged from 92.6 to 131.7 and 132.7 Kg/ha during 1999-2000 and 2000-2001, respectively. The maximum available nitrogen (131.7 and 132.7 Kg/ha) was observed in treatment of NPK-30: 60:50 Kg/ha + Azotobacter +Zinc (T_9), which was followed by T_6 (131.6 and 132.5), T_{10} (131.2 and 132.3), T_{11} (130.9 and 132.6) and T_5 (130.6 and 131.6) during both the years. Whereas, minimum available nitrogen (92.6 and 87.6) was found in control plot.

(v) Available phosphorus (Kg/ha):

Data shown in Table- 21 indicated that the available phosphorus (Kg/ha) in soil was also significantly affected by various treatments, which varied from 9.13 to 16.77 and 8.27 to 21.20 Kg/ha during 1999-2000 and 2000-2001, respectively. The maximum available phosphorus in soil after crop harvest (16.77 and 21.90 Kg/ha) was observed due to application of NPK- 60:30:50 Kg/ha +PSB+ Zinc (T_{12}) and followed by T_5, T_6,T_7, T_8, T_9, T_{10}, T_{13} , T_{14}, and T_{15}. It is apparent from data shown in Table-21 the availability of phosphors significantly entranced with the use of PSB incombination of different doses of NPK as compared with other treatments during both the years.

(iv) Available potassium (Kg/ha):

A perusal of data presented in Table-21 indicated a significant variation on available potassium content in soil due to different levels of nutrients, biofertilizers and micronutrients, which ranged from 219.67 to 242.67 and 217.60 to 252.67 Kg/ha during 1999-2000 and 2000-2001, respectively. The maximum availability of potassium (242.67 and 252.67 Kg/ha) in soil was

obtained by application of NPK- 30:60:50 Kg/ha +Azotobacter +Zinc (T90 and followed by T_5, T_6, T_7, T_8, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}, and T_{15} during both the years. However, minimum available potassium in soil was obtained in control.

4.7 Economic analysis of Matricaria production:

The economic analysis includes the cost of production, gross return, and net return per hectare and cost/ benefit ratio. These were worked out on the basis of current market rate of each commodities and charges paid to farm labours, farm machinery's, manure and fertilizers, biofertilizers, micronutrients, irrigation, plant production, distillation and fixed cost etc. involved in production of flowers and oil during the years 1999-2000 and 2000-2001. The details of estimated cost incurred in each field operation and distillation charge are presented in Appendix -I and the economics a return of different treatments is presented in Table- 22. The total cost involved in production of Matricaria flowers and oil per hectare varied from Rs.26109.81 to Rs.48938.27 and Rs.41509.31 to Rs.64338.09, respectively due to application of various treatments during both the years. It is obvious from the data that the maximum cost of production of flowers and oil (Rs.48938.27 and Rs.64338.27) was obtained with T_{11} treatments (NPK-30: 60:50 Kg/ha + Azotobacter +Zinc +Iron), while rather minimum cost of production of flower (Rs.26109.31) and oil (Rs.41509.31) was estimated in control (T_{16}).

The maximum net profit per hectare from flower Rs.37762.61 and oil Rs.172110.11production was obtained from treatment T_6 (NPK- 30:60:50 Kg/ha +Azotobacter) against the total cost of production flowers Rs.28364.90 and oil Rs.4374.90. The maximum cost/benefit ratio was estimated in flower production (1:2.33) and oil production (1:5.02). In other wards, with investment of Rs.1.00, the net profit was more than 4.02 times with the application of 30Kg N + 60Kg P_2O_5 + 50Kg K_2O + Azotobacter @ 2.0Kg/ha.

Table 22: Estimated of cost/benefit ratio under various treatments of Matricaria grown in sodic soil conditions

S.No.	Treatments	Total cost of cultivation (Rs/ha)		Gross return (Rs/ha)		Net return (Rs/ha)		Cost/Benefit Ratio	
		flowers	Blue oil	flowers	Blue oil	flowers	Blue oil	flowers	Blue oil
T_1	F.Y.M. (10 t/ha)	26801.28	42201.28	38465.00	101750.00	11663.72	59548.72	1: 1.44	1:2.41
T_2	F.Y.M. + Azoto (2.0 Kg/ha)	26963.50	42363.50	40455.00	112500.00	13491.50	70136.50	1:1.50	1:2.66
T_3	F.Y.M. + PSB(2.0 Kg/ha.)	26963.50	42363.50	40532.50	105875.00	13569.50	63526.50	1:1.50	1:2.50
T_4	F.Y.M. + Azoto + PSB	27125.71	42525.61	44245.00	144250.00	17119.30	101724.39	1:1.63	1:3.39
T_5	NPK- 60:60:50 Kg/ha	28397.75	43797.75	60790.00	206750.00	32392.25	162952.25	1:2.14	1:4.72
T_6	NPK- 30:60:50 + Azoto	28364.90	43764.90	66127.50	219500.00	37762.61	172110.11	1:2.33	1:5.02
T_7	NPK- 60:30:50 + PSB	28125.17	43525.17	63180.00	207750.00	35214.83	164724.83	1:2.25	1:4.77
T_8	NPK- 30:30:50 + Azoto + PBS	27954.75	43354.75	64442.50	212125.00	36487.76	170520.26	1:2.31	1:4.89
T_9	NPK-30:60:50+ Azoto + Zn (0.3%)	36765.09	52165.09	66312.50	219375.00	29547.42	175709.92	1:1.80	1:4.21
T_{10}	NPK-30:60:50+ Azoto + Fe (0.3 %)	40538.09	55938.09	65172.50	221750.00	24634.42	165811.92	1:1.61	1:3.96
T_{11}	NPK-30:60:50+ Azoto + Zn +Fe	48938.27	64338.27	69150.00	241625.00	20211.73	177286.77	1:1.41	1:3.76
T_{12}	NPK-60:30:50 +PSB+ Zn	36525.36	51925.36	64367.50	221250.00	27842.15	169324.65	1:1.76	1:4.26
T_{13}	NPK-60:30:50 + PSB + Fe	40298.36	55698.36	62815.00	214000.00	22516.62	158301.65	1:1.56	1:3.84
T_{14}	NPK-60:30:50 +PSB+ Zn + Fe	48698.52	64098.55	63637.50	222375.00	14938.98	158276.46	1:1.31	1:3.47
T_{15}	NPK-30:30:50 +Azoto + PSB+ Zn + Fe	48528.12	63928.12	68135.00	238000.00	13071.26	174071.89	1:1.40	1:3.72
T_{16}	Control	26109.31	41509.31	29305.00	68875.00	3195.70	27365.69	1:1.20	1:1.66

DISCUSSION

Chapter-V

DISCUSSION

Chamomile (*Matricaria chamomilla* Linn) is one of important essential oil bearing aromatic herbs, which has high medicinal and perfumery values. The most economical part of Matricaria plant is its flower heads, which are commercially used in most of European countries for large number of drugs and cosmetic preparations (Vergosova and Vergos, 1988). The production of high quality of chamomile oil from flower heads is depend upon the number of factors suc as ecological, soil conditions, fertility levels, growing seasons, harvesting time and methods, genetic material and post-harvest processing methods. Chamomile has a vast potential to grow under diverse soils and climatic conditions because of its high degree of tolerance to saline – alkaline soil conditions (Ram *et al,* 1999). Flowers yields and quality of essential oils is varied according to variable soil fertility and levels of NPK and micronutrients. However, no detail information is available in literatures on their yield and quality attributing factors. Thus, keeping in view the medicinal and aromatic importance and vast potential of its cultivation, the present investigation entitled "Studies on bio-chemical fertilizers and micro-nutrients on flowers yield and oil quality of *Matricaria chamomilla* Linn in sodic soil conditions" was planed and conducted during the years 1999-2000 and 2000-2001.

The experimental findings obtained due to influence of different graded doses of NPK, biofertilizers (Azotobacter and PSB) and micronutrients (Zinc and Iron) on growth, flowering, yield and quality of blue oil of Matricaria during both the years (1999-2000 and 2000-2001) are discussed herewith in following heads with support of scientific explanations and available literatures.

5.1 Plant growth characters.

5.2 Flower characteristics.

5.3 Flower and oil yields.

5.4 Quality of blue oil.

5.6 Nutrients status of Plant.

5.6 Nutrients status of soil.

5.7 Economics analysis.

5.1 Plant growth characters:

A perusal of observations recorded on plant growth parameter viz., plant height, plant spread and number of primary and secondary branches per plant after completion of vegetative growth i.e. at flowering stage (120 DAP) due to influence of different treatments during both the years (1999-2000 and 2000-2001) revealed that maximum ——— plant height (51.96 cm) and plant spread (31.88 cm) were observed with combined treatment of NPK- 30: 60: 50 Kg/ha + Azotobacter + 0.3% Zinc (T_9). The better plant growth recorded due to basal application of NPK with inoculation of biofertilizer (Azotobacter) and foliar spray of 0.3% EDTA Zn. The results clearly indicated that inoculation of Azotobacter proved to be beneficial to fix the atmospheric nitrogen and also showed synergetic effects on synthesing the biologically active plant growth substances in presence of zinc. Similar observations have been recorded in a number of crops by earlier workers (Shende and Kokorina, 1964, Bishop *et al.*, 1980 and 1988, Subba Roa, 1993, Chandrikapure *et al.*, 1999 and Ram Shuk Jat and Sharma, 2000). It has also been confirmed with the experimental findings of Pahwa (1988), Hazra (1988 & 1994) that the positive interaction of N-fertilization and zinc with bio-inoculants might be exhibited the favourable response to increase the plant growth in Matricaria. It is now well demonstrated the role and stimulatory effects of non-symbiotic N-fixing bacteria (Azotobacter) in combination with N-fertilization and foliar feeding of micronutrient (Zn), because these nutrients are essential far increasing the microbial activity in soils.

The data recorded on number of branches per plant at flowering stage due to the effects of different treatments indicated that the number of

branches per plant is on important growth parameters for improving the flower yield in Matricaria. It is evident from the observations recorded in Table-8 that the maximum average number of primary branches per plant (15.28) was recorded in treatment of NPK (30 : 30 : 50 Kg/ha)+ Azotobacter + 0.3% Zn (T_9) followed by T_{12} (14.65), T5 (14.58), T_{15} (14.04) and T_{13} (14.01). Whereas, maximum average number of secondary branches per plant (32.81) was observed in T_{15} (NPK-30: 30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron) followed by T_{11} (31.37), T_{14} (31.24) and T_{13} (30.96). The significant variation in number of branches per plant was noticed due to these treatments in comparison to other treatments, which clearly showed that the application of graded dose of NPK and inoculation of biofertilizers as well as foliar spray of Zinc and Iron have proved to be beneficial in increasing the number of effective branches per plant as compared to NPK doses alone and control. The increase in number of branches per plant due to N-fertilization in combination of bio-inoculants and micronutrients might be stimulated the plant metabolic activities, which resulted to more photosynthetic efficiency and also favoured to initiation and extension of effective branches per plant. Similar observations have been recorded by Bhattacharjee and Diwakar, 1983, Shukla and Prasad (1998), Chandrikapure *et al.,* (1999) and Gupta *et al.,* (1999).

5.2 Flower characteristics:

During the different phases of growth and development of plant system, the changes of reproductive phase is depend upon phyiso-biochemical changes and development of morphological characters responsible for changing of vegetative primodia to reproductive primodia. This phenomena are highly influenced through soil and environmental factors. The observations recorded on days taken to first flowering, 50% flowering, duration of flowering and number of flower pickings influence due to application of different levels of NPK, biofertilizers and micronutrients, clearly indicated that there was significant reduction in average days taken to emergence of first flowering (58.72) and 50% flowering (73.00) with application of (NPK-30:30:50 Kg/ha)

+ Azotobacter + PSB+ Zinc + Iron (T_{15}) as compared to other treatments. Whereas, crop grow under control and F.Y.M. alone without supplementing nutrients and bio-inoculants required more number of days for emergence of first flowering (62.57 and 62.49) and 50% flowering (79.56 and 76.50) respectively. It is evident from present findings that the earlier flowering can be induced by optimum levels of nutrients and inoculation of biofertilizers (Azotobacter and PSB) and foliar feeding of micronutrients (Zinc + Iron). The early flowering in Matricaria might be due to completion of earliar vegetative growth and changing of vegetative primodia to flower primodia, because of these bioagents have been reported to fix the atmospheric nitrogen and improved the nutrients status of soil and plant by fixing the additional nitrogen and their more mobilization and utilization to the plant system, which promoted the faster vegetative growth and induction the early flowering (Chandrikapure *et al,* 1999 and Gupta *et al.,* 1999 in marigold). The present findings is not conformity with observation recorded by Shukla and Prasad (1998) who found that graded doses of NPK did not show significant variation days taken to emergence of first flower buds and 50% flowering in Matricaria. The possible explanation of present findings may be due to the application of biofertilizers and micronutrients with basal dose of NPK showed beneficial role for advancing the vegetative growth by increasing photosynthetic activities and synthesing biological auxins gibberline and other plant hormones in the plants (Hardy *et al.,* 1971 and Subba Rao, 1993). It is very clear the role of Azotobacter and PSB under lower fertile soils, which have bean, found very effective with N-fertilization for improving the growth and flowering.

A perusal of data recorded on duration of flowering and total number of flower pickings shown in Table 9 and 10, clearly indicated that the maximum duration (45.63 days) of flowering was observed in T_1 (F.Y.M. 10 t/ha), Whereas, the minimum duration (37.76 days) of flowering noticed in control. However, other treatments combination of NPK, biofertilizers and micronutrients has taken more flowering duration (41.88 to 41.40 days) which

clearly indicated that there was not much significant variation in duration of flowering (T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13} and T_{14}), which might be attributed to emergence of uniform flower buds within optimum duration of flowering as influenced by optimum doses of nutrients through interaction of bio-inoculants with NPK nutrients. Whereas, in case of prolonged flowering duration might have been due to poor uptake of nutrients during flowering period. Similar observation was also recorded by Shukla and Prasad, 1998 in Matricaria.

It is obvious from the results that the number of flower pickings is associated with duration of flowering span, which clearly indicted that no significant difference was noticed due to use of various treatments. It is apparent from data the average maximum number of flower pickings in F.Y.M. alone (5.20), which was found at par other treatments (4.82 to 5.10). The number of flower pickings was done by manually during of peak period of flowering for picking the effective flower buds to be opened. It clearly showed that the number of flower pickings were influenced by the flowering duration and maturation of flower buds. Similar results were reported by Shukla and Prasad (1998) in Matricaria.

5.3 Flower and oil yields:

The data pertaining to recovery of essential oil (blue oil) in Maticaria is associated with the various yield attributing characteristics such as, number of flower buds per plant, fresh and dry weight flowers, moisture content in fresh flower, oil content and flower yields. These yield attributing characters were influenced due to various treatments which have been presented in Table 11, 12 13, 14 and 15. It is indicated that the application of NPK-30: 30: 50 Kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}) have shown significant response to increase the average number of flowers (221.00) per plant followed by T_{11} (217.96), T_{14} (217.76) and T_9 (215.86). The maximum number of flowers was recorded with graded dose of NPK in combination of bio-noculants and foliar feeding of micronutrients. The increasing number of flowers per plant might be due to increase in number of secondary branches per plant, which was due to

more number of secondary branches and initiation in number of flower buds per plant. It has been observed that the increase of more number of flower buds per plant might be due to synthesis of nitrogenous compounds such as amino acid (Arginin), which is a precursor of polyamines and also function as secondary messenger in flower initiation and development of more number of flower buds as influenced by phytohormones due to interaction of bio-inoculants with the NPK. Similar results were also recorded by Wange and Patil (1994) in Tuberose and Johri *et al.*, (1994) in Matricaria.

The observations recorded on fresh and dry weight (g/1000 flowers), were found significantly affected due to influence by various treatments. The average maximum fresh weight of flower (162.15) was recorded with application of NPK-30:30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}), while dry weight of flower (46.72) was observed with use of NPK-60:30:50 Kg/ha + PSB + Zinc + Iron (T_{14}) as compared to other treatments. The differences in fresh and dry weight of flowers might be due to more moisture content in fresh flowers. The increase of fresh weight of flower is also depend upon size of flower buds and accumulation of more moisture content which was observed due to inoculation of Azoatobacter as compared to PSB incombination of NPK. Similar observations were also reported by Wani (1990) and Marwaha (1995) who found that the non-symbiotic nitrogen-fixing bacteria (Azotobacter) enhanced the uptake of nutrients and water status of plants and increase the nitrate reductase activities, which may be more beneficial increase diameter of flower and fresh weight of flower.

The observations recorded on dry weight of flower (g/1000 flowers) indicated weight increased significantly with use of various treatments, which indicated that the inoculation of PSB incombination of NPK and foliar feeding of micronutrients showed reduction in moisture content of flowers as compared to other treatments. The maximum average dry weight of flowers (46.72) was obtained with application of NPK-60:30:50 Kg/ha + PSB + Zinc + Iron (T_{14}) followed by T_{13} (45.89), T_{15} (45.84), T_{12} (45.59) and T_{10} (45.59). It is clearly from the

result that increase dry weight of flower with inoculation of PSB might be due to increase of phosphorus content which were responsible for dry matter content of flower buds with less amount of moisture content. It is also reported that phosphorus available in soil rhizosphare reduced the moisture content and help in solubility of insoluble organic acid and organic phosphorus, which showed the slow uptake of phosphorus due to low uptake of moisture. The present findings is in conformity with finding of Johri *et al.*, (1994) and Shukla and Prasad (1998). The data recorded on moisture percentage in fresh flowers indicated that the moisture content is highly associated with differences of the fresh and dry weight of flowers, which varied due to fertility levels. The lower percentage of moisture was recorded with inoculation of phosphate solubilizing bacteria (PSB) along with different doses of NPK and foliar feeding of micronutrients. However, minimum percentage of moisture content in fresh flowers was observed by application of NPK-60: 30:50) Kg/ha + PSB + Zinc + Iron (T_{14}) as compared to other treatments. It clearly indicated that crop supplemented with adequate supply of nitrogen and phosphorus had positive response to accumulation of dry matter content and biomass production. Thus, the lower dry biomass production attributed to higher moisture content in fresh flowers. Similar observations were recorded by Shukla and Prasad (1998).

The data recorded on average fresh and dry yield of flowers (q/ha) as influenced by different levels of nutrients, biofertilizers and foliar spray of micronutrients (Zinc and Iron) have been presented in Table-13. The results clearly indicated that there was significant variation in yield of flowers during different picking intervals. An increasing trend was observed in average fresh and dry yield of flowers from 1st to 4th pickings, while, it was reduced in later pickings. Maximum yield of flowers was recorded in 3rd and 4th pickings, which was recorded at peak period of flower pickings. However, maximum fresh flowers yield (56.58 q/ha) was recorded with T_{15} treatment (NPK-30: 30:50 Kg/ha +Azotobacter + PSB+ Zinc + Iron). This probably had been due to favourable response of bio-ionculants, which improved the nutrients

availability of the plants by addition of atmospheric N to the soil and promoted the more vegetative growth and yield attributing parameters through stimulation of plant growth promoting substances such as auxins, gibberelin, vitamins and organic acids. The conversion of photosynthate in to proteins resulted in more production of biomass. It also favours the induction of more flower primodia and development of flower buds, attributing to higher flowers yield. Similar results were also recorded by Wange and Patil (1994) in Tuberose, Gupta (1997), Chandrikapure *et al.,* (1998) and Gupta *et al.*, (1999) in Marigold, Shukla and Prasad (1998) and Nikolova *et al.,* (1999) in Matricaria, Bodiyala *et al.,* (1993) in Saffron and Muthumanickan *et al.*, (1999) in Gerbera.

Dry flower yield (q/ha) increased significantly with the use of treatment NPK-60: 30:50 Kg/ha + PSB+ Zinc + Iron (T_{14}) .The highest of dry flower yield was observed with inoculation of phosphate solubilizing bacteria (PSB) incombination of different doses of NPK and foliar feeding of micronutrients. This is might be due to more uptake of nutrients (phosphorus) and also favours to accumulation of more dry matter content, by reducing the moisture content. Similar observations were recorded by Johri *et al.,* 1994 and Shukla and Prasad, 1998 in Matricaria.

Data recorded on oil content (% DWB) of Matricaria and oil yield (l/ha) have been presented in Table 15 clearly indicated that the recovery of oil in chamomile was significantly varied due to influence of Various treatments and maximum recovery of chamomile blue oil was obtained in NPK-60: 30:50 Kg/ha + PSB + Zinc + Iron (T_{14}). The increment of oil content and oil yield might be due to variation in production of flower buds and their maturity, which were affected by environmental factors and nutrients status of soils and plants. The crops supplemented with balanced doses of NPK and inoculated with bio-inoculation (Azotobacter + PSB) as well as foliar feeding of micronutrients (Zinc + Iron) have shown stimulatory effect on improving the nutrients availability in plants by synthesizing the more amount of nutrients

and plant growth substances. It has also been reported that the availability of adequate amount of nitrogen also favours to availability of sulphur, which is a constituent of methionine and cysteineamino acid which activates more oil glands in flowers. It has also been reported that sulphur is one of the important constituents of oil and acts as source of co-enzyme-A in metabolism of fatty acids (Young and Man, 1958). The availability of more phosphorus and micronutrients (Zinc and Iron) also favoured to oil content in flowers which might be due to involvement of Iron in activity of forredoxin (Fe- S protein) and isoenzyme of super oxide dismutase (Fe-S protein), that paly a important Key role in oil synthsis, resulting to more oil content (%) and oil yield. Similar observations have also been recorded in chamomile by Johri *et al,* 1991,92 and 94; Datta and Singh, 1961; Shukla and Prasad, 1998 and Nikolova *et al.,* 1999 and in other essential oil bearing crops viz., *Anethum gravelens* (Singh *et al.,* 1971); Tuberose (Singh *et al.,* 1976); Basil (Gulati *et al.,* 1977 and Panday et *al.,* 1978) and Jathimalli (Natarajan and Rao, 1980).

5.4 Quality of blue oil:

The observations recorded on physical and chemical properties of blue oil of Matricaria due to various treatments indicated that the physical properties of blue oil such as colour, odour, flavour, specific gravity, acid value and solubility in alcohol were not significantly affected by treatments. The essential oil extracted from flower buds has appearance in deep blue colour with sweet herbaceous odour and strongly herbaceous and specific gravity ranged from 0.932 to 0.945, acid value 30.00 to 35.50 and percentage of solubility of soil in alcohol was 90 per cent. The observation recorded on these physical compositions of blue oil did not show any differences due to affect of different treatments. This clearly indicate that all the physical compositions of blue oil of Matricaria were not affected by the variable treatments, probably because it was genetically uniform material grown under same environmental conditions and methods of extraction which did not exhibit any major changes in physical properties of blue oil. It has been reported that the quality of determine by blue

oil is presence of chamazulines, which major chemical constituents of volatile oil of Matricaria. The chamazuline content is varied according to variable genotypes, maturity of flower buds, storage of flowers and methods of extraction (Guenther, 1952 an De Pasquale and Silvestri, 1975a). Thus, the results obtained in present studies indicated that the harvesting of uniform matured flower buds, and using same methods of oil extraction and storage did not show any significant variation in physical composition of blue oil.

On the other hand, a perusal of data recorded on determination of chemical constituents of blue oil of chamomile indicated that the major chemical constituent of blue oil in Matricaria was found bisabolol, chamazuline, bisabolon oxide-B, bisabolol oxide-B and cis-dicyloether and other in trace amount of bisabolol oxide-A, farmesene, germacene, Non-guazlene and trans-dicyloethers. Data recorded on GLC analysed on major chemical constituents of blue oil (Chamomile) indicated that there was variation in composition of chamazuline content due to various treatments, which varied from 8.000–15.783 and 8.010-16.768. The maximum concentration of chamozuline was observed in treatment of NPK-30:30:50 Kg/ha + Azotobacter + PSB+ Zinc + Iron (T_{15}) followed by T_9 and T_{11}. Similar observations on concentration of chamazuline were also recorded by Emonger and Chweya, 1992 and Salamon, 1992. Whereas, the maximum concentration of bisabol in blue oil was found with the use of NPK-30: 60:50Kg/ha + Azotobacter + Zinc + Iron (T_{11}) followed by T_5, T_6, T_8 T_9, T_{10} and T_{15}.

Chamomile oil showed that the maximum bisabolon oxide-B was found in treatment of NPK-60:30: 50 Kg/ha + PSB + Zinc + Iron (T_{14}) followed by T_7, T_{13}, T_{12} and T_{15} were found higher proportions as compared to other treatments.

GC value recorded on content of bisabolol oxide-B indicated that it was found more in treatment of NPK–30:30: 50 Kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}). The observation recorded on other chemical constituents on chamomile blue oil indicated that cis-dicyloether content was found in higher

value in treatment combination of NPK-30:30: 50 Kg/ha + Azotobacter + PSB (T_8), while, the high concentration of bisabolol oxide-A in blue oil was observed due to treatment of NPK-60:30:50 Kg/ha + PSB+ Zinc (T_{12}).

The higher GC value of farnesene and gramacene in blue oil were observed due to treatment of NPK-30: 30: 50 Kg/ha + Azotobacter + PSB+ Zinc + Iron (T_{15}), while Non-guazlene content showed negative response, which was more in control and reduced with increasing the levels of nutrients. The decrease of Non-guazlene content in blue oil might be due to more availability of nutrients. However, the effect of high levels of Non-guazlene content in lower down fertility status of soil is not clearly under stood, but it has leaser importance in Matricaria blue oil and value to performing indication.

Data recorded on GC value of trans-dicyloether (1.242 and 1.246) was also obtained more in NPK-60: 30:50 Kg/ha + PSB + Zinc + Iron (T_{14}) than other treatments. The data obtained on GC values of different chemical constituents of chamomile oil did not show any linear response to graded dose of NPK, inoculation of biofertilizers and foliar feeding of micronutrients. It is evident from the present findings that chemical compositions of blue oil showed slightly significant variation due to application of lower doses of NPK, inoculation of biofertilizers and foliar spray of micronutrients. However, the quality attributesof oil-bearing crops is governed by interaction of genetic characters and environmental factors.

The present findings is also supported by Jakovlev *et al.,* 1979; Franz and Wickel, 1979 and Nikolova *et al,* 1999, who has also reported that chamazuline content in oil is more stable chemical constituent, which is much affected by variation in nutrient levels, whereas, phosphorus and potash had shows positive response to chamazuline and bisabolol oxide-B, while N-fertilization showed better response to farnesene and bisabolol oxide-A (Ram *et al.*, 1999 and Nikolova *et al.,* 1999).

5.5 Nutrients status of plants:

Data pertaining to fresh and dry yield of biomass g/plant were increased significantly due to use of various treatments. The maximum fresh biomass yield (194.36g) was obtained with treatment of NPK- 30:60:50 Kg/ha + Azotobacter + Zinc + Iron (T_{11}). This might be due to increase availability of nutrients by inoculation of Azotobacter and foliar feeding of micronutrients, which increased the fresh biomass production by improving of more photosynthetic products. Similar observation were recorded by Prakasa Rao *et al.,* 1997, whereas, maximum dry biomass yield (60.19 g/plant) was obtained with application of NPK-60: 30:50 Kg/ha + PSB + Zinc + Iron (T_{14}). It was also observed that the total dry biomass production increased the levels of phosphorus in plants. Similar observation were also recorded by Kanaujia *et al.,* 1997 and Tippannavar *et al.*, 1992.

The increase in nitrogen content in plants recorded due to application of NPK-30: 30:50 Kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}) followed by T_9, T_8, T_{11} treatments, which clearly indicated that use of Azotobacter along with inorganic nitrogenous fertilizers helped in availability of more nitrogen in soil they fixing of atmospheric nitrogen and resulted to more uptake of nitrogen to the plants. The present finding is conformity to observation recorded by Gayathrisubramanian and Thamburaj, 2000. Similar response of phosphorus content in plant was recorded due to treatment of NPK-30: 30: 50 Kg/ha + Azotobacter + PSB + Zinc + Iron (T_{15}). It is clear from the results that phosphorus content in plant might be due to use of PBS along with inorganic phosphate fertilizers, which converted to more amount of soluble phosphorus and resulted to uptake more phosphorus to the plant. (Gayathrisubramaninan and Thamburaj, 2000), whereas, the more uptake of potassium in plant was observed in T_7 (NPK-60: 30:50 Kg/ha + PSB) followed by T_5 to T_{15} treatments, it might be due to inoculation of biofertilizers. It has been showed studies that the inoculation of biofertilizers reduced the soil pH, increased the organic acid, improved nutrients status (NPK, Fe, S and Zn). The

availability of more K to the in soil favoured to more K content in plants. This findings is also in agreement with observation recorded by Gayathrisubramanian and Thamburaj (2000).

5.6 Nutrients status of soil:

During the investigation it was observed that the integrated use of F.Y.M, inorganic fertilizers, biofertilizers and micronutrients resulted addition in organic matter and decrease in pH and EC of soil. The maximum reduction in pH and EC and increase in Organic matter content of soil were observed with treatment T_1 (F.Y.M. 1-/ha + PSB) and T_4 (F.Y.M. 10/ha + Azotobacter + Azotobacter + PSB).

The organic matter increased due to additive effect of organic matter, through F.Y.M. and Azotobacter and addition of extracellular products/ and plant deteris. It was also supported by Katyal, 1993 and Ram *et al.,* 1999. The reduction of EC and pH values of the soil may be described to the formation of weak salts as a results of reaction between weak organic acids formed during decomposition of organic matter, secretion of organic acid by biofertilizers and soluble cations present in the soil, because of the improvement in hydrolic conductivity of soil. This findings have also been supported by More (1994) and Sharma (1992).

The effect of different treatments on available nitrogen, phosphorus and potassium content of soil after harvest of crop is showed that status of available nitrogen in soil decreased in control and other treatments (T_1, T_2, T_3 and T_4). Considerably reduction in available nitrogen in soil might be ascribed by increase the ratio of ammonical nitrogen on humus complex because of additive effect of F.Y.M. at highest fertility level. The maximum availability of N found in treatment T_9 (NPK-30: 60:50 Kg/ha + Azotobacter + Zinc). The increment of nitrogen at fertility level of 30:60: 50 Kg/ha NPK alongwith Azotobacter might be due to release of extracellular nitrogen substance and addition of nitrogen due to fixation of atmospheric N by Azotobacter in soil. These results corroborate with the finding of Katyal (1993).

Phosphorus status of soil in terms of available P_2O_5 was found declined only in control and treatments T_1, T_2, T_3 and T_4, while available phosphorus content of soil improved under rest of the treatments. The availability of more phosphorus in soil was due to treatment of NPK-60: 30:50 Kg/ha + PSB + Zinc (T_{12}). The present results is also corroborates to finding of Gayathrisubramanian and Thamburaj (2000).

Further considerable reduction of available K was noted in control plot and T_1, T_2, T_3 and T_4 treatments. The more available potassium in soil over its initial status was observed with treatment NPK-30:60:50 Kg/ha + Azotobacter + Zinc (T_9), other treatments did not show significant differences in respect to available potassium in soil. The little variations in available K_2O content in soil among other treatments which corraborates with the finding of More (1994).

5.7 Economics analysis:

The cost of production is directly associated with cost of fertilizers, biofertilizers and micronutrients treatments. Gross income was found directly associated with flowers and oil yields under different treatment combinations. Application of NPK-30: 60:50 Kg/ha + Azotobacter @ 2.0 kg/ha gave higher net returns by Rs. 37762.61 for flowers production and Rs. 172110.11 for oil production per ha. The high net return per ha was due to low cost of production by 50% reduction in cost of N fertilizers by inoculation of Azotobacter. Thus, the present finding may be calculated that high cost / benefit ratio was obtained (1:2.33 for flower production and 1:5.02 for oil production) with optimal dose of NPK – 30:60:50 Kg/ha and inoculation of @ 2.0 Kg/ha Azotobacter.

SUMMARY AND CONCLUSION

Chapter-VI

SUMMARY AND CONCLUSION

The present investigation entitled " studies on bio- chemical fertilizers and micronutrients on flowers yield and oil quality of *Matricaria chamomilla* Linn in sodic soil conditions" has been carried out during the years 1999-2000 and 2000-2001 at Mains Experiment Station, Department of Horticulture, Narendra Deva University of Agriculture and Technology (Narendra Nagar), Kumarganj, Faizabad (U.P.). The salient features of the present findings have been summarized and concluded here with.

6.1 The maximum plant height, plant spread and number of primary branches per plant were recorded with application of 30N:60P:50K Kg/ha + Azotobacter +0.3% Zn EDTA, (T_9), whereas, the maximum number of secondary branches per plant was observed in 30N:30P:50K Kg/ha +2Kg/ha Azotobacter + 2Kg/ha PSB +0.3% Zn EDTA +0.3% Fe EDTA (T_{15}).

6.2 The application of 30N: 30P: 50K Kg/ha +2Kg/ha Azotobacter + 2Kg/ha PSB + 0.3% Zn EDTA +0.3 % Fe EDTA favoured to indication of early flower buds, while application of 10t/ha F.Y.M. alone or in incombination with bio-fertilizers prolonged the flowering duration as compare to other treatments.

6.3 The total number of flowers pickings did not significantly affected by various treatments, which ranged from 4 to 5 and the total number economically flower pickings (4) was obtained with inoculation of biofertilizers with different doses of NPK +0.3% Zn EDTA and Fe EDTA.

6.4 The maximum number of flowers per plant, fresh weight of 1000 flowers and fresh flower yield (q/ha) were observed due to application of lower doses of N- fertilization (NPK- 30:30:50 Kg/ha + 2.0 Kg/ha Azotobacter +2.0 Kg/ha PSB + 0.3% Zn EDTA + 0.3 % Fe EDTA).

6.5 The maximum dry weight of flower /1000 flowers, dry yield (q/ha), oil content (%) and oil yield (l/ha- DWB) were significantly observed due to application of NPK- 60:30:50 Kg/ha + 2.0Kg/ha PSB + 0.3% Zn EDTA and Fe EDTA.

6.6 The physical quality parameters of Chamomile blue oil determined for colour, odour, flavour, specific gravity, acid value and percentage of solubility in alcohol which did not significant affected by various treatments.

6.7 The chemical constituents available in chamomile oil determine by GC values of bisabolol, chamazuline, bisabolon oxide- B, bisabolol oxide –B, cis- dicyloether, bisabolol oxide- A, farnesene, germasene, Non-guazlene and trans- dicyloether and found that the highest GC value of bisabolol followed by chamazuline,, bisabolol oxide-B, farnesene and germacene were have been observed in blue oil of *Matricaria* flowers at 30N:30P:50K Kg/ha + 2.0 Kg/ha Azotobacter +2.0 Kg/ha PSB +0.3% Zn and Fe (EDTA), whereas, the high value of bisabolon oxide-B and trans-dicyloether were found with higher dose N- fertilization of (NPK – 60:30:50 Kg/ha) + 2.0 Kg/ha PSB + 0.3% Zn EDTA and Fe EDTA as compared to other treatments.

6.8 The highest percentage of bisabolol oxide- A was observed in NPK- 60:30:50 Kg/ha +2.0 Kg/ha PSB +0.3% Zn EDTA , while, the high content of cis- dicyloether in blue oil recorded in 30N 30P 50K Kg/ha + 2.0 Kg/ha Azotobacter + 2.0 Kg/ha PSB. The maximum value of Non-guazlene in blue oil was obtained in control.

6.9 The highest fresh biomass production was recorded in treatment of 30N 60P 50K Kg/ha + 2.0 Kg/ha Azotobacter + 0.3% Zn EDTA and Fe EDTA, whereas, maximum dry biomass yield was obtained with application of NPK- 60:30:50 Kg/ha + 2.0 Kg/ha PSB + 0.3%Zn EDTA and Fe EDTA .

6.10 The nutrients analysis in plant revealed that the maximum percentage of N and P were observed by application of NPK- 30:30:50 Kg/ha +2.0Kg/ha Azotobacter + 0.3% Zn EDTA and Fe EDTA, whereas, the maximum

percentage of potassium was observed in NPK- 60:30:50 Kg/ha +2.0 Kg /ha PSB as compared to other treatments.

6.11 The chemical analysis of soil after crop harvest indicated that the maximum reduction in pH and EC, and high amount of organic matter content were observed due to basal placement of 10 tonnes FYM per ha alone and also combination of 2.0 Kg/ha Azotobacter and PSB.

6.12 The highest value of nitrogen and potassium content were observed due to application of 30N:60P:50K Kg/ha +2.0 Kg/ha Azotobacter + 0.3% Zn EDTA, whereas, the highest amount of available phosphorus was estimated in 60N: 30P: 50K Kg/ha + 2.0Kg/ha PSB as compared to other treatments.

6.13 The highest net return (Rs. 37762.61 and Rs. 172110.11) and cost /benefit ratio (1:2.33and 1:5.02) were estimated respectively for production of flowers and essential oil of *Matricaria* with application of 30N:60P: 50K Kg/ha +2.0 Kg/ha Azotobacter, which was found to be most economical viable and optimal dose of fertilization for commercial production of *Matricaria* in sodic land conditions.

Conclusion:

The overall review of above highlighted experimental findings revealed that the application of 30Kg N +60 Kg P +50Kg/ha +2.0 Kg/ha Azotobacter +0.3 % Zn EDTA have been found optimal dose for better plant growth, while the application of 30Kg N +30Kg P +50Kg K /ha +2.0 Kg/ha Azotobacter +PSB + 0.3% Zn and Fe (EDTA) advanced the flowering and prolonged the flowering duration. The maximum production of fresh flowers (56.58q/ha) was obtained with application of NPK-30:30:50Kg /ha +Azotobacter +PSB + 0.3 % Zn and Fe (EDTA). The maximum recovery of blue oil content (0.60%) and oil yield (9.62 l/ha) were also recorded due to treatment of NPK-60:30:50 Kg/ha +2.0 g/ha PSB +0.3% Zn +Fe (EDTA). The physical properties of *Matricaria* oil i.e. colour, odour, flavour, specific gravity, acid value and percentage of solubility in alcohol did not show any variation with treatments. However, among the chemical constituents of blue oil of

major constituents viz., bisabolol, chamazuline, bisabolol oxide-B, bisabolol-B were observed in highest percentage, while cis- dicyloether, bisabolol oxide-A, farmesene, germcene, Non-guazlene and trans-dicyloether were observed as miner constituents of blue oil as influenced by application of NPK, inoculation of bio-inoculates and folair spray of micronutrients (Zinc +Iron). The nutritional status of plant and soil have also been improved with application of optimal doses of NPK, biofertilizer and micronutrients. The highest net return (Rs. 37762.61 and Rs. 172110.11) and cost/ benefit ratio (1:2.33 and 1: 5.02) were estimated for production of flowers and oil at optimal dose of nutrients (NPK-30:60:50Kg/ha +2.0 Kg/ha Azotobacter).

Thus, it is concluded from the present experimental results that the highest yield and economic return per ha was obtained with application of optimal dose of NPK- 30:60:50 Kg/ha +2.0 Kg/ha Azotobacter for commercial cultivation of Matricaria under sodic soil condition. The application of bio-inoculates with lower dose of N- fertilization have also been found to be more beneficial in minimizing the requirement of chemical fertilizer and also improved the yield and quality of blue oil, which has been found more economical for improving the soil fertility of sodic soil having low fertility levels.

Keeping in view the value of chamomile oil to pharmaceutical and perfumery industries. It has vast potential to grow under sodic land condition for better suitability and economic feasibility to the cultivation. There is further need to evaluate the other potential genetic materials having high yield and quality attributes to grow under variable soil and agro- climatic conditions. The emphasis would also be focussed on cultivation of *Matricaria* under different cropping system. The research priority would also be initiated for improving the superior genotype having desirable traits and highest recovery and quality of oil from the chamomile flowers.

BIBLOGRAPHY

Chapter-VII

BIBLIOGRAPHY

Anuradha, Pampathy; K.K. and Narayan; N. (1990). Effect of nitrogen and phosphorus on flower, yield and quality of marigold. *Indian J. Hort.* **47** (3): 363-367.

Asokan, R.; Sukhada Mohandas and Lalitha Anand (2000) Biofertilizers and biopesticides for Horticultural crops. Indian Horti. Vol. **45** (1): 44-47.

Badiyala, D.; Saroch, K. and Panwar, K.D. (1993). Fertilizers management in saffron (*Crocus sativus* L.) under high hill temperature conditions of Himachal Pradesh. *Indian Perfumer*, V. **37** (3): p. 253-255.

Bhattacharjee, S.K. and Diwakar, N.G. (1983). Flower yield and essential oil content of *J. grandiflorum* L. as influenced by nitrogen, phosphorus and potash fertilization. IX International Congress of essential oil, *Singapur. Book*-1. pp . 121-25.

Bishop, P.E.; Jarlenski, D.M.L. and Hetherington, D.R. (1980). Evidence of alternative nitrogen fixation system in *Azotobacter vinelandii* Proc. Natl. Acad. Sci. 77, 7342-7346.

Bishop, P.E.; Premkumar, R.; Joerger, R.D.; Jacobson, M.R.; Dalton, D.A.; Chisnell, J.R. and Wolfinger, E.D. (1988). Alternative nitrogen fixation system in *Azotobacter vinelandii*, pp. 71-79. Nitrogen Fixation, Hundred years After. Eds. H. Bothe, E.J. de Bruijn and W.E. Newton, Gustav Fischer, Stuttgart.

Bopaiah, B.M. and Khader, K.B.A. (1989). Effect of biofertilizers on growth of black pepper. *J. Agric. Sci.* **59** (10): 682-683.

Chand, S.; Kaul, P.N.; Bhattacharya, A.K.; Singh, K.; Singh, C.P. and Rajeshwara Rao, B.R. (1996). Response of Jamrosa

(*Cymbopogan species*) to spacing, FYM, nitrogen, phosphorus and Zinc. *Indian Perfumer*, **40** (2): 41-46.

Chandra, V.; Singh, A. and Kapoor, L.D. (1968). Experimental cultivation of some essential oil bearing plants in saline soil. *M. chamomilla* Linn. *Perfum. Essent. Oil Rec.*, **59** (12): 871.

Chandrikapure, K.R.; Sadawrte, K.T.; Panchbhai, B.D. and Shelke, B.D. (1999). Effect of bio-inoculants and graded doses of nitrogen on growth and flower yield of marigold (*Tagetes erecta* L.). *The Orissa J. Hort.* V. **27** (2): 31-34.

Cimco, N. (1983). Int. Jr. Of crude days research, **21**(4): 145-151.

Datta, P.K. and Singh, A. (1964). Effect of different spacing on fresh flower and oil yields of *M. chamomilla* L. *Indian J. Agron.*, **9** (1): 11-12.

De Pasquale, A. and Silvestri, R. (1975a). Atti-Conv. Naz. Olli. Essenz. Sui. Devv. Agvum. **6** (7): 130-36.

Datta, P.K. and Singh, A. (1961). Effect of NPK singly and in combination on the oil content of *M. chamomilla* L. Abstract of paper presented at the symposium on " Production and Utilization of Medicinal and Aromatic Plants in India" held at RRL Jammu on Nov. 27-29, pp.11.

El- Hamidii, A; Salesh, M. and Hamidii, H. (1965). The effect of fertilizers level on growth, yield and oil production of *M. chamomilla* L. *Lloydia,* **28** (3): 245-251.

Emonger, V.E.; Chweya, J.A.; Keya, S.O. and Munaavu, R.M. (1989). The effect of N and P on growth and flower yield of Chamomile. *East African Agril. &* Forestry Journal, **55** (2): 63-67.

Emongor; V.E. and Chweya; J.A. (1992). Effect of nitrogen and variety on essential oil yield and composition from chamomile flowers. *Trop. Agri.*, **69**:3, 290-292.

F.F.D.C. (2000). Cultivation and distillation technologies of chamomile. Tech. bulletin No.5, Fragrance and flavour Development Centre. G.T. Road, Kannauj-209726 (U.P.) India.

Fisher, R.D. and Yates, F. (1949). Statistical table for biological and medical research Oliver and Boyd. Edberg (London): 3rd edi. (1949).

Franz, Ch. and Wickel, I. (1979). The composition of essential oil in crossing and Selfing progenies of *Matricaria chamomilla* L. *Planta med.*, **36** (3): 281-282.

Gayathrisubramanian and Thamburaj (2000). Influence of biofertilizers on growth, flowering and yield of carnation cv. Pamir. Deptt. of Horticulture, TNAU, Coimbatore -600003.

Gould, L. Reddy, C.V.; Gomprocht, R.F. (1974). Cardiac effect of chamomile *Tea. J. Chemical Pharmacology*, **13** (11/12): 475-479.

Gowda, T.N. V., Farooqi, A.A.; Subbiah, T. and Raju, B. (1991). Influence of plant density, N and P on growth, yield and essential oil content of Chamomile. Indian Perfumer, **35** (3):168-172.

Guenther, E. (1952). The Essential oils, Vol V (D. Van Nostrand company, Inc., New York), 438-445.

Gulati, B.C.; Duhan, S.P.; Gupta, R. and Bhattacharya, A.K. (1977). Introduction of French basil (*Ocimum basillium* L.) in Tarai of National, U.P. (India). *Perfumeric and Kosmetics*, **58**:165-69.

Gupta, N.S. (1997). Performance of marigold (*Tagetes erecta* L.) at graded levels of nitrogen and bio-inoculants. M.Sc. Thesis submitted to Dr. PDKV, Akola (Unpublished).

Gupta, N.S.; Sadavarte, K.T.; Mahorkar, V.KL.; Jad hao, B.J. and Dorak, S.V. (1999). Effect of graded levels of nitrogen and bio-inoculants on growth and yield of Marigold (*Tagets erecta* L.) J. soil and crops. **9** (1): 80-83.

Hardy, R.W.F.; Burns, R.C. and Parshall, G.W. (1971). The biochemistry of nitrogen fixation. In *Advances in chemistry* series No. 100. *Bioinorganic chemistry.* pp. 218-247, American chemical society.

Hazra, C.R. (1988) T.S.I.-F.A.I. Symposium, sulphur in Indian Agriculture, FAI, New Delhi, pp. SII/4 (1-13).

Hazra, C.R. (1994). In Non-Traditional sources for fertilizer use (H.L.S. Tandon, Ed.), FDCO, New Delhi, pp. 30-47.

Jackson, M.L. (1973). Soil chemical Analysis. Prentice Hall, New Delhi.

Jagat Aroma Oil Distillery (2002). Publication of annual progressive report on aromatic crops, at Jagat Aroma Oil Distillery, Kannauj (U.P.).

Jakovelv, V.; Isaac, O.; Thiemer, K. and Kunde, R. (1979). *Planata Medica,* **35** (2): 125-140.

JMAPS (2002). A publication of Central Institute of Medicinal and Aromatic Plants, Lucknow- 226016. **19** (1): 99-104.

Johri, A.K.; Rana, R.C. and Srivastva, L.J. (1994). To study the effect of irrigation and nitrogen levels on flower, oil yield and oil content of *M. chamomilla* Linn. Paper presented in × All India Workshops on Medicinal and Aromatic Plants, held at Kerala Agriculture University, Trichur on 17-20 Jan., pp. 238-245.

Johri, A.K.; Srivastava, L.G.; Singh, J.M. and Rana, R.C. (1991). Effect of row spacing and nitrogen levels on flower and essential oil yield in German chamomile (*Matricaria chamomilla* L.). *Indian J. Agrom.,* **37** (2): 302: 304.

Johri, A.K.; Srivastava, L.J.; Singh., J.M.; Chand, R. and Malhotra, R. (1992). Rate, source and time of appliocation of nitrogen in *M. Chamomilla* Linn. Indian Perfumer, **36** (4): 284-288.

Kanaujia, S.P.; Rastogi, K.B. and Sharma, S.K. (1997). Effect of phosphorus, potassium and Rhizobium inoculation on growth, yield and quality of pea cv. Lincoln. *Vegetable Science.* **24** (2): 91-94.

Katyal, J.C. (1993). Integrated nutrient management and supply an overview. Proceedings of Indian National Sci. Academy Part- B. Biological Sci. **59**: 3-4, 161-172.

Khan, F.U. (2000). Effect of micronutrients on Dahlia. J. Ornamental Hort.; New series Vol. **3** (2):122-123.

Letchamo, W. (1990). A comparative study of chamomile yield, essential oil and flavonoids content under two sowing seasons and nitrogen levels. XXIII International Horticultural Congress, Florence, Italy, 27 Aug. –1 Sep.

Marwaha, B.C. (1995). Biofertilizers a supplementary source of plant nutrients. Fertilizer New Vol. 40 (7). 39-50.

More, S.D. (1994). Effect of farm wastes and organic manures on soil properties, nutrient availability and yield of rice-wheat grown on vertisol. *J. Indian Soc. soil Sci.* **42** (2) 253 256.

Motl, O.; Repcak, M.; Budesinsky, M. and Ubik, K. (1983). Further components of chamomile oils. Parts-3. Archiv- der- Pharmaczie, **316** (11): 908-912.

Muthumanickan; D, Rajamani; K. and Jawaharlal; M. (1999). Effect of micronutrients on flower production in Gerber. J. Ornamental Hort., New seines Vol. **2**(2): 131-132.

Natrajan, S. and Madhava Rao, V.N. (1980). Effect of frequency of fertilizers application in Jathimalli (*Jasminum grandiflorum*). Madras Agric. J. **67** (3): 207-220.

Nikolova, A.; Kohuharova, K.; Zheljazkov, V.D.; Craker, L.E.; Giberti, G.; Lorenz, M.; Mathe, A. and Giulietti, A. (1999). Mineral nutrition of chamomile (*Chamomilla recutita* L.). Proceedings of the second world congress on Medicinal and Aromatic plant for Human welfare, WOCMAP-2. Post-harvest techniques and biotechnology, Mendoza, Argentina, 10-15 Nov., 1997. Acta-Hort, 1999, No. 502, 203-208.

Olsen, S.R.; Cole, C.V.; Watanable, F.S. and Dean, L.A. (1954). Estimation of available phosphorus in soils by extration with sodium bicrbonat. U.S. Department of Agriculture Circular 339.

Pahwa, M.R. (1988). Annual Report, IGFRI, Jhansi.

Panday, M.B.; Sharama, M.L. and Austhana, J.R. (1978). Indian perfumes **22** (2): 100-03.

Pasechnic, L. Kh. (1966). Cholagogic action of extracts prepared from wild chamomile. Biological Abstract, **48**:106916.

Prakasa Rao, E.V.S.; Narayana, M.R. and Rajeswara Rao, B.R. (1997). The effect of nitrogen and farm yard manure on yield and nutrient uptake in davana (*Artemisia pallen* wall ex. D.C.). Journal of Herbs, Spices & Medicinal plants, V. **5** (2): p. 39-48.

Ram Sukh Jat and Sharma, O.P. (2000). Effect of fertility levels and biofertilizers on growth, yield and quality of fenugreek (*Trigonella foenum- graceum*). Acta Ecologica, V. **22** (1): p 56-61.

Ram, Balak; Misra, P.N.; Sharma, N.L.; Katiyar, R.S. and Ram, B.(1999). Effect of different levels of sodicity and fertility on the performance of German chamomile (*Chamomilla recutita* L.) under sub- tropical conditions. I. growth and yield. J. Med. Arom. Plant Sci., **21**:3, 692-694.

Ram, Balak; Misra, P.N.; Sharma, N.L.; Naqvi, A.A.; Katiyar, R.S. and Ram, B. (1999). Effect of different levels of sodicity and fertility on the performance of German chamomile (*Chamomilla recutita* L.) under sub- tropical condition. II oil content and composition of essential oil. J. Med. Aroma. Plant Sci. **21**:4, 969-971.

Rastogi, J.M.S.; Sood, M.; Srivastava, L.J. and Romesh Chand (1997). Reponse of clary sage (*Salvia sclorea* L.) to nitrogen levels and row spacings. Indian Perfumer, V. **41** (3): p. 113-116.

Salaman, Ivan (1992). Production of chamomile *Chamomilla recutita* L. Rauschert, in Slovakia. J. of Herbs, Spices & Medicinal Plants, Vol. **1** (1/2): 37-45.

Sharma, A.; Kumar, A. and Virmani, O.P. (1983). Cultivation of German chamomile: A review. Curr. Res. Med. Arom. Pl., **5**: 269-278.

Sharma, R.A. (1992). Efficient water used and sustainable production of rainfed soybean and sunflower through conjunctive use of organic and fertilizer. *Crop Res.* (Hisar). **5** (2): 181-194.

Shende, S.T. and Kokorina, L.M. (1964). Efficiency of the Azotobacter administered conjointly with mineral fertilizers for the rice crop. *Mikrobiologiya,* **33** 467-471.

Singh, R.S.; Motial, V.S. and Singh, L.B. (1976). Effect on nitrogen, phosphorus and potash fertilization on tuberose (*Polianthes tuberosa* Linn). Indian J. Horti., **33**: 289-94.

Singh, R.S.; Singh, L.B. and Singh, C.P. (1971). Response of nitrogen and phosphorus on the yield and essential oil content of in non-saline alkali soil. Ferti. News, **16** (20): 48.

Subba Rao, N.S. (1993). Biofertilizers in Agriculture and forestry, 3rd Ed. Oxford and IBH Publishing Co., New Delhi.

Subbiah, B.V. and Asijia, G.L. (1956). A rapid procedure for the determination of available nitrogen in soil. *Curr. Sci.* **25**: 259-260.

Sudheendra, S.; Farooqi, A.A.; Thailak, K.S. and Bhat, B.V. (1993). Influence of nitrogen, phosphorus and potassium on growth, seed yield and essential oil content in Celery (*Apium graveolens* L.). Indian Perfumer, V. **37** (4): p. 315-377.

Shukla, P. and Prasad, J. (1998). Effect of different levels of nitrogen and phosphors on flower and oil yield of Garman Chamomile (*Matricaria chamomilla* Linn). M.Sc. Thesis submitted to NDUAT, Faizabad (U.P.).

Szelenyi, T.; Issac, O. and Thiemer, K. (1979). Pharmacological experiments with compounds of chamomile III. Experimental studies of the ulcer protective effect of chamomile. Planta Medica, **35** (3): 218-227.

Tippannavar, C.M.; Desai, S.A.; Krishnamurthy, K. and Patil, S.B. (1992). Peformance of biofertilizers in Northern dry zone of Karnataka. *J. Maharastra Agril. Univ.* **17** (3): 494-495.

Tuşi, C. (1948). The role of Zinc in auxin synthesis in the tomato plant. Amarican J. Bot., **35**:172.

Vergosova, M. and S. Vergos. (1988). Our Medicinal Plants (in slovak). State Pendagogical Publisher, Bratislava, Czecho-slovakia. 384 p.

Walkley, A and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.***34**: 29-38.

Wange, S.S. and Patil, S.S. (1994). Response of Tuberose to biofertilizers and nitrogen. J. Maha. Agric. Univ.,**19** (3): 484-485.

W ani, S.P. (1990). Indian J. Microbiol. **30**: 363-397.

Young, L. and Man, G.A. (1958). The metabolism of sulpher compounds. Methuen, London. In Soil Biochemistry by Mc taren, A.D. and Peterson, H.G. Marcel Dekken, INC. New york pp. 253.

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APPENDIX

Appendix-I

Calculation for the cost of production of flowers and oil yield/ha on the basis of rates prevailed during the years 1999-2000 and 2000-2001

S.No.	Particulars of operation	Quantity	Value Rs.	Total value (Average of two years) Rs.
A. Variable cost				
1.0 Raising of nursery				
1.1	Seed	2.0Kg/ha	250/Kg	500
1.2	Required lab. For preparation of nursery and seed sowing	4lab.,2 days	58/lab.	232
2.0 Land preparation				
2.1	One ploughing by soil turning plough by tractor	4 hrs.	140/hrs.	560
2.2	Two ploughing by tractor drawn cultivator	4 hrs.	140/hrs.	560
2.3	Two planking by tractor	2 hrs.	140/hrs.	280
2.4	Labour for planking	2 lab.,2 days	58/lab.	116
3.0 Manure and fertilizers				
3.1	F .Y .M	10t/ha	100/t	1000
3.2	Urea	80Kg/ha	5/Kg	400
3.3	DAP	130Kg/ha	10/Kg	1300
3.4	MOP	84Kg/ha	5/Kg	420
3.5	Application of fertilizers	6 lab.	58/lab.	348
4.0 Biofertilizers				
4.1	Azotobactor	2.0 Kg/ha	50/Kg	100
4.2	PSB	2.0/Kg	50/Kg	100
4.3	Application of biofertilizers	1 lab.	58/lab.	58
5.0 Transplanting of seedlings				
5.1	Lifting of seeding	21 lab.,2 days	58/lab.	2436
5.2	Transplanting of seedling in field	20 lab.,2 days	58/lab.	2320
6.0	**Irrigation**	6	300/Irri.	1800
6.1	Labour required per irrigation	12	58/lab.	696
7.0 Spray of micronutrients				
7.1	Zinc(0.3%), Zn EDTA(12%)	15 Kg/ha	560/Kg	8400
7.2	Iron (0.3%), Fe EDTA(12%)	15Kg/ha	800/Kg	1200
7.3	Labour required for spraying	2 lab.	58/lab.	116
8.0	Weeding and hoeing (two)	20 lab.,2 days	58/lab.	2320
9.0	Plant protection	-	-	500
10.0	Pickings of flowers (five)	40 lab./pick.	58/lab.	11600
11.0	Processing of flower(drying and storage)	10 lab.	58/lab.	580

12.0	Distillation of dry flowers	-	-	15000
13.0	Miscellaneous	-	-	500
		Sub total Cost of flower production = 49242		
		Sub total Cost of oil production = 64242		
B Fixed cost				
14.0	Intrest on working capital(16%)per annum for one year of the period crop in the field	-	-	For flower = 3939.36 For oil = 5139.36
	* Dried flowers rate = 45 Rs./ Kg. * Blue oil rate = 25000Rs./ Liter			