

Can Sheep Manure and Yeast Substitute Conventional N for *Lavandula angustifolia* Production in Sandy Soils?

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Abstract: This study was carried out in pots at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the two successive seasons of 2011 and 2012 to investigate the substitution potential of ammonium sulphate nitrogenous mineral fertilizer by sheep manure and active dry yeast biofertilizer, separately or in combinations. Plants received ammonium sulphate (20.5% N) at the rate of 300 or 150 kg/feddan representing full or half rate (N or 1/2N). Sheep manure (SM) was added at 30 or 15 m³/ fed representing full or half rate. Active dry yeast (Y, *Saccharomyces cerevisiae*) was used at 6 g/L. Control, as all the treatments received calcium super phosphate (15.5% P₂O₅) at the rate of 300 kg/feddan and potassium sulphate (48% K₂O) at the rate of 100 kg/ feddan. Plants received 1/2N+ 1/2SM +Y treatment gave the significantly higher values for plant height, number of branches per plant, leaves: stems fresh weight ratio, herb and roots fresh and dry weights per plant, herb air dry weight per plant, root length, oil percentage, total chlorophylls, carotenoids and total carbohydrates content followed by that received SM+Y, in most cases, with no significant difference between them. Whereas, plants received 1/2N+ 1/2SM +Y treatment gave the significantly higher values of oil yield per plant followed by that received SM+Y with significant differences between them. It is recommended to fertilize lavender plants grown in sandy soils with sheep manure at the rate of 30 m³/ feddan + 6 g/L active dry yeast, in addition to 300 kg/feddan calcium super phosphate and 100 kg/ feddan potassium sulphate for improving the vegetative growth and production of herb. For the highest essential oil production it can be recommended to apply sheep manure at the rate of 15 m³/ feddan + 6 g/L active dry yeast, in addition to 300 kg/feddan calcium super phosphate, 100 kg/ feddan potassium sulphate and ammonium sulphate at the rate of 150 kg/feddan.

Key words: Lavender (*Lavandula officinalis*) • Sheep manure • Active dry yeast • NPK • Sandy soils

INTRODUCTION

Lavender, *Lavandula officinalis*, is a shrub-like aromatic plant belongs to family Lamiaceae. The major components of lavender oil are linalool, linalyl acetate, 1,8-cineole, α -pinene, limonene, cis-and trans-ocimene, 3-octanone, camphor, caryophyllene, terpinen-4-ol and lavendulyl acetate, lavandulol, 1-octen-3-ol, 1-octen-3-ylacetate and 3-octanol [1]. The essential oil is used in manufacturing perfumes, soaps and cosmetics and as a flavor in foods. Lavender is used in aromatherapy as a carminative, spasmolytic, sedative and antispasmodic. It treats anxiety, difficulty sleeping, nervousness,

insomnia, vomiting, intestinal gas, loss of appetite and skin fungal infections. Lavender relieves migraine headaches, toothaches and joint pain. Lavender is planted as ornamental plant in gardens because of its beautiful foliage and flowers [2].

World focuses nowadays on producing organic herbs using farming strategies that achieves sustainable agriculture without relying on conventional chemical fertilizers that leach out, pollinate water basins and subsurface water and damage soil beneficial microorganisms. Organic and bio-fertilizers are eco-friendly fertilizers that increase soil organic matter content, microorganisms, physical and chemical

properties, aeration, soil moisture-holding capacity and drainage and also increases the soil exchange capacity, maximizes uptake of all essential nutrients and decreases soil pH [3]. Sheep manure contains macronutrients like nitrogen, phosphorus and potassium in addition to micronutrients as slow-release nutrients. It also maintains the organic matter content of the soil. It improves soil physico-chemical quality characteristics including soil structure, aeration, soil water holding capacity and water infiltration. It decreases soil bulk density. The addition of manure to soils positively affects soil microbes and earthworm populations which positively affect aggregate stability and porosity leading to good soil conditions for root growth. Active dry yeast (*Saccharomyces cerevisiae*) is a natural biofertilizer, it is rich in protein and B vitamins (thiamin, riboflavin and pyridoxines). Yeast contains tryptophan, a precursor of IAA which plays an important role in regulating the growth of plants and cytokinins which delay senescence of leaves by inhibiting degradation of chlorophyll and enhancing the synthesis of protein and RNA. In soil, yeast improves humus content and hence giving it a better structure, it significantly lowers soil density and increases water holding capacity resulting in better nutrient retention and lower soil degradation and it prevents soil acidification as well [4]. Therefore, combined organic and biofertilizers could be more effective in increasing the soil properties and the amount of nutrients supplied to the plant than sole application, leading to high economic production.

Nitrogenous nutrition is important in stimulating plant growth and development and plays a critical role in photosynthesis associated with the carbohydrates production. Nitrogen is essential for proteins and therefore enzymes synthesis. N is a part of the nucleic acids DNA and RNA and it is a necessary component of B vitamins such as biotin, thiamine and riboflavin. Prior researchers stated that nitrogenous fertilization affected the growth and chemical constituents of lavender [5, 6]. Despite the numerous benefits associated with organic farming, most growers still use inorganic fertilizers. Chemical fertilizer acts fast because its nutrients of inorganic form dissolve in water and plants can use them immediately. Consequently, there is an urgent need to combine use of organic and biofertilizers with chemical fertilizer to fill up soil nutrients, maintain soil organic matter and increase yield to meet the global rising food demand and the farmer income. Thereby, the present

study aimed to use sheep manure and active dry yeast individually or in mixture to substitute mineral nitrogenous fertilization (ammonium sulphate) and increase vegetative growth characteristics, yield, oil production and chemical composition of lavender (*Lavandula angustifolia*) plants.

MATERIALS AND METHODS

This study was carried out at the Experimental nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the successive seasons of 2011 and 2012, with the aim of substitution of N fertilizer by sheep manure and yeast associated with promoting vegetative characteristics, oil production and chemical composition of lavender (*Lavandula angustifolia*) plants.

Rooted cuttings of lavender (10 cm with two branchlets and well developed roots, about five cm long) were transplanted on April 1st of the two seasons in 35 cm diameter plastic pots (two cuttings per pot) filled with sandy soil obtained from sixth of October desert. The physical and chemical characteristics of the soil used are presented in Table 1. After two weeks; the seedlings were thinned to one plant per pot. Sheep manure (SM) was obtained from the animal production farm, Faculty of Agriculture, Cairo University. Chemical analysis of the sheep manure during the two seasons under study is shown in Table 2. It was added at 526 or 263 cm³/pot (30 or 15 m³/fed) representing full or half rate added in two doses, the first (60%) incorporated into the soil during soil preparation and the second one was top-dressed after the first cut. A uniform phosphorus incorporation with the potting medium before transplanting was done in all the pots, including control treatment, as calcium super phosphate (15.5% P₂O₅) at the rate of 300 kg/feddan (7 g / pot). All treatments received potassium sulphate (48% K₂O) at the rate of 100 kg/ feddan (2 g/pot) applied in two applications at four weeks intervals starting thirty days after transplanting. Plants were foliar sprayed with commercial active dry yeast (*Saccharomyces cerevisiae*) at 6g /L in two applications, four and six weeks after planting and the same spraying technique was done after the first cut. Ammonium sulphate (20.5%N) at the rate of 300 or 150 kg/feddan (5 or 2.5 g/pot) was top dressed in three equal doses with four weeks interval, the first addition was applied thirty days after transplanting.

Table 1: Physical and chemical properties of the soil used in the study (average of both seasons)

Physical analysis													
Clay %			Silt %		Fine sand%			Coarse sand%		Texture class			
2.9			1.1		9.6			86.4		Sandy			
Chemical analysis			Soluble cations and anions (meq/L)							Available elements (ppm)			
pH	ECdS/m	dS/m	O.M.%	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	K ⁺	N	P	K
7.8	12.5	0.80	0.9	101.1	53.1	39.7	20.1	92.3	3.0	25.6	1.1	44.8	

Table 2: Chemical analysis of the sheep manure applied during 2011 and 2012 seasons

Season	Density (g/cm ³)	Humidity (%)	Organic matter (%)	Total macronutrients				Total micronutrients		
				N (%)	P (%)	K (%)	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
First season	0.28	24	71.2	1.0	0.8	1.4	230	96.2	128	14
Second season	0.25	19	66.8	0.8	0.9	1.1	300	84.3	116.0	12.5

The treatments were arranged in three replicates using complete randomized block design. All common agricultural practices concern controlling weeds and managing the water supply were followed as needed. The experiment consists of ten treatments including the control (receiving only PK) as follows:

- Control (P, K)
- N
- Sheep manure
- Dry yeast
- Sheep manure + Dry yeast
- ½ Sheep manure + Dry yeast
- ½ N + Sheep manure
- ½ N + ½ Sheep manure
- ½ N + Dry yeast
- ½ N + ½ Sheep manure + Dry yeast

Two cuts harvesting were recorded on 15th of June and September in both seasons when bright purple flowers appear along the top of the plant stem. The following data were recorded: plant height (cm), number of branches per plant, leaves: stems fresh weight ratio, fresh; air dry and dry (oven dried at 70°C) weights of herb per plant (g). Root fresh and dry weights per plant (g) were estimated. Chemical analyses were made at laboratory of the Medicinal and Aromatic Plants Department, Horticulture Institute, Agriculture Research Center, Ministry of Agriculture, Dokki, Giza, Egypt. Freshly harvested plant material (100 g) was immediately subjected to hydrodistillation in a Clevenger's apparatus for three hours for the extraction of the essential oil. The oil was dried over anhydrous sodium sulphate and stored in a refrigerator at 5°C prior to analysis [7]. The essential oil percentage was determined in the fresh

herb and oil yield per plant was calculated by multiplying the percentage of the oil by weight of the fresh herb. Essential oil components obtained from the fresh herb in the second cut of the second season were identified by their gas liquid chromatographic profile using DsChrom 6200 Gas Chromatograph equipped with a flame ionization detector for separation of volatile oil constituents. The relative concentrations of the different constituents in the essential oil were calculated from the peak area [8, 9]. At harvesting, total chlorophylls and carotenoids (mg/g fresh weight) were determined in leaves [10]. Total carbohydrates, N, P and K (% of dry weight) were estimated in dry herb [11-14]. Statistical analysis was carried out according to the method of Snedecor and Cochran [15].

RESULTS AND DISCUSSION

Vegetative Growth: Data presented in Tables 3 and 4 showed that all treatments significantly increased the characteristics investigated in respect of plant height, number of branches per plant as well as leaves: stems fresh weight ratio, herb and roots fresh and dry weights per plant, herb air dry weight per plant and root length as compared to the untreated control plants, in both seasons. Few exceptions to this general trend were detected, in both cuts of both seasons, with plants sprayed with yeast which recorded insignificantly higher values than the untreated control plants. Also, in the first seasons, plants sprayed with yeast had insignificantly longer roots with insignificantly heavier dry weight as compared to the untreated control plants.

In both seasons, the plants treated with ½N+ ½SM +Y gave the significantly highest values of all vegetative growth parameters compared to other treatments, followed by plants received SM+Y and ½ SM+Y, respectively.

Table 3: Effect of ammonium sulphate, sheep manure and dry yeast plant height, number of branches per plant, leaves: stems fresh weight ratio and herb fresh, air dry and dry weights per plant of lavender plants during 2011 and 2012 seasons

Treatments	First Season		Second season		First Season		Second season		First Season		Second season	
	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
	Plant height (cm)				Number of branches per plant				Leaves: stems fresh weight ratio			
Control	17.6	18.7	17.9	18.9	12.1	12.5	11.7	12.9	1.26	1.33	1.23	1.14
N	20.5	21.4	20.9	22.5	16.3	18.1	15.2	16.1	1.69	1.84	1.68	1.51
SM	24.2	21.7	20.8	22.9	21.8	21.8	20.1	21.1	2.18	2.33	2.09	2.28
Y	19.9	19.2	19.2	19.8	17.2	18.7	16.5	17.9	1.45	1.69	1.57	1.39
SM+Y	33.7	35.9	33.9	34.3	29.9	30.6	28.7	29.8	3.34	3.53	2.69	3.54
½SM+Y	28.2	29.1	29.4	30.2	26.0	29.9	26.5	29.3	2.95	3.09	2.23	2.83
½N+ SM	25.5	24.9	25.5	29.0	25.2	26.8	23.4	24.2	2.70	2.90	2.21	2.53
½N+½SM	23.1	23.7	23.2	28.2	23.5	26.8	22.6	23.2	2.37	2.84	2.06	2.45
½N+ Y	21.6	22.5	21.5	23.7	19.6	19.9	19.4	20.4	1.98	2.06	1.98	1.66
½N+½SM+ Y	35.6	39.9	36.5	37.1	31.7	32.4	30.0	31.9	3.58	3.70	2.97	3.70
L.S.D.5%	2.4	2.5	2.8	3.1	2.3	2.5	2.2	2.3	0.26	0.28	0.29	0.22
Treatments	Herb fresh weight (g/plant)				Herb air dry weight (g/plant)				Herb dry weight (g/plant)			
	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
	Plant height (cm)				Number of branches per plant				Leaves: stems fresh weight ratio			
Control	40.40	41.81	30.80	35.41	10.07	12.10	10.84	11.52	9.50	10.10	9.90	11.02
N	53.25	56.63	47.81	49.43	17.82	17.65	18.01	19.92	11.71	11.64	11.38	12.90
SM	76.43	69.45	71.69	84.25	21.71	25.12	23.65	29.34	14.62	15.38	14.32	15.51
Y	48.21	50.49	38.23	43.66	15.74	13.47	14.72	15.67	10.46	11.48	11.26	12.65
SM+Y	139.46	141.54	137.70	142.41	39.46	36.08	39.12	40.40	26.50	28.14	24.92	25.84
½SM+Y	90.68	91.43	94.62	97.00	27.81	29.32	28.03	29.75	16.62	19.22	15.82	17.90
½N+ SM	80.87	81.82	81.80	88.81	26.90	26.14	25.70	28.81	14.32	17.50	13.16	15.92
½N+½SM	77.91	81.14	75.25	84.66	23.47	20.09	21.47	25.16	13.11	14.41	13.05	13.11
½N+ Y	60.80	62.20	59.81	64.62	19.71	18.23	20.16	24.28	11.32	12.92	12.57	12.97
½N+½SM+Y	145.25	149.62	145.12	148.20	42.70	38.99	42.63	42.50	28.03	29.10	25.47	27.10
L.S.D.5%	7.62	8.55	8.01	6.82	3.42	3.22	3.58	2.34	1.62	1.28	1.12	1.39

Control: PK full recommended rate, N: recommended rate of ammonium sulphate, SM: sheep manure, Y: active dry yeast

Table 4: Effect of ammonium sulphate, sheep manure and dry yeast on root length and root fresh and dry weights of lavender plants during 2011 and 2012 seasons

Treatments	Root length (cm)		Root fresh weight(g/ plant)		Root dry weight(g/ plant)	
	First Season	Second season	First Season	Second season	First Season	Second season
	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
Control	13.2	15.0	9.77	10.26	3.91	3.14
N	19.3	20.2	14.80	15.46	4.58	4.46
SM	28.0	21.5	16.44	17.00	5.72	5.51
Y	14.0	20.0	12.49	12.93	4.36	4.48
SM+Y	37.2	38.7	18.26	20.61	6.37	7.74
½SM+Y	34.1	39.6	16.66	18.26	5.94	7.14
½N+ SM	32.6	34.3	16.82	18.4	5.74	6.50
½N+½SM	28.5	30.4	17.00	17.91	5.86	6.06
½N+ Y	20.7	22.6	15.42	16.93	4.42	4.38
½N+ ½SM+ Y	39.1	39.9	18.53	20.93	6.48	7.96
L.S.D.5%	2.1	2.9	1.51	1.46	0.51	0.44

Control: PK full recommended rate, N: recommended rate of ammonium sulphate, SM: sheep manure, Y: active dry yeast

There was no significant difference between plants received ½N+ ½SM +Y and that received SM+Y, in most cases. The two exceptions to this general trend were recorded in the second cut of the first season with plants received SM+Y which gave significantly shortest plants than that received ½N+½SM+ Y. The second exception

was recorded in the second season with plants received SM+ Y and ½SM+ Y treatments which had insignificant shorter root length than those received ½N+½SM+ Y.

Plants received ½SM+ Y gave higher values for different vegetative characteristics studied followed by that of SM, N and yeast treatments respectively.

Table 5: Effect of ammonium sulphate, sheep manure and dry yeast on essential oil percentage and yield of lavender plants during 2011 and 2012 seasons

Treatments	First Season		Second season		First Season		Second season	
	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
	Oil percentage (%)				Oil yield (ml/plant)			
Control	0.12	0.12	0.12	0.14	4.85	5.02	3.70	4.96
N	0.13	0.15	0.15	0.19	6.92	8.49	7.17	9.39
SM	0.13	0.15	0.17	0.22	9.94	10.42	12.19	18.54
Y	0.12	0.13	0.13	0.18	5.79	6.56	4.97	7.86
SM+Y	0.18	0.21	0.21	0.27	25.10	29.72	28.92	38.45
½SM+Y	0.18	0.19	0.19	0.25	16.32	17.37	17.98	24.25
½N+ SM	0.13	0.16	0.18	0.23	10.51	13.09	14.72	20.43
½N+½SM	0.15	0.17	0.19	0.24	11.69	13.79	14.30	20.32
½N+ Y	0.13	0.15	0.16	0.21	7.90	9.33	9.57	13.57
½N+ ½SM +Y	0.19	0.21	0.22	0.30	27.60	31.42	31.93	44.46
L.S.D.5%	0.01	0.03	0.02	0.03	1.05	1.14	1.26	1.82

Control: PK full recommended rate, N: recommended rate of ammonium sulphate, SM: sheep manure, Y: active dry yeast

Generally, it is worth to mention that sheep manure and yeast substitute conventional N for *Lavandula angustifolia* production in sandy soils since ½N+ SM, ½N+½SM and ½N+ Y treatments gave higher values for different vegetative growth parameters than that recorded with plants received full dose of N.

Herb yield obtained in the second cut was higher than that of the first cut as a result of increasing branching, number of leaves and biomass production. The augmentation of plant growth and yield resulting from organic manure application was studied on some aromatic plants such as fennel [16, 17], thyme [18], peppermint [19] and marigold [20]. Previous studies found that nitrogen fertilization influenced yield of lavender plants like Biesiada *et al.* [5] who found that 100 kg N/ha gave the highest yield compared to 50 and 200 kg N/ha. On contrary to our results, Koocheki and Teimouri [21] stated that adding 50 kg/ha nitrogen fertilizer to lavender and rosemary plants gave higher yield (3930 kg/ha and 2535 kg/ha, respectively) compared to application of 20 ton/ha animal manure.

Essential Oil Percentage, Yield and Constituents: Data shown in Table 5 revealed that all treatments significantly increased essential oil percentage and yield as compared to the untreated control plants, in both seasons. Few exceptions to this general trend was detected, in both cuts of the first season and in the first cut of the second season with plants sprayed with yeast which recorded insignificantly higher oil percentage than the untreated control plants. Also, in the first cut of the first season, plants sprayed with yeast had insignificantly higher oil yield as compared to the untreated control plants.

In both seasons, the plants treated with ½N+ ½SM +Y gave the significantly highest essential oil percentage and yield compared to other treatments, followed by plants received SM+Y and ½ SM+Y, respectively. There was no significant difference between oil percentage in plants received ½N+ ½SM +Y and that received SM+Y, in both cuts of both seasons. On the other hand, there were significant differences between oil yield of plants received ½N+ ½SM +Y and that received SM+Y.

Plants received ½SM+ Y gave higher values for essential oil percentage and yield followed by that of SM, N and yeast treatments, respectively, in most cases.

Generally, It is evident from the results that sheep manure and yeast substitute conventional N for *Lavandula angustifolia* production in sandy soils since all treatments consists of ½N+ SM, ½N+½SM and ½N+ Y gave higher values for oil percentage and yield than that recorded with plants received full dose of N.

The results of analyses of the essential oil are given in Table 6. Eleven compounds were detected. The main compounds in lavender volatile oil were: 1,8 cineol (42-57.5%), linalool (14.3-20.4%), camphene (2.8-6.7%), beta-pinene (2.3-5.8%), alpha-pinene (1.3-4.1%), terpinen-4-ol (1.3-4.3%), camphor (1.3-3.3%), borneol (0.5-2.4%), beta-caryophyllene (0.2%-2.2%) and linalyl acetate (0.2-1.7%). 1,8 cineol and linalool, respectively dominated on the oil constituents. SM+Y, 1/2N+SM and SM treatments recorded the highest total component percentage (96, 92.5 and 91.8%, respectively) compared to other treatments. ½ SM+Y recorded almost the same total percentage of constituents given by N (88.5 and 85.7 %, respectively).

Table 6: Effect of ammonium sulphate, sheep manure and dry yeast on essential oil components of lavender plants in the second cut of the second season

Essential oil components	Treatments									
	Control	N	SM	Y	SM+Y	½SM+Y	½N+ SM	½N+½SM	½N+ Y	½N+ ½SM+Y
α-Pinene	1.3	4.1	2.7	1.8	1.8	1.9	1.7	3.0	1.8	2.7
Camphene	2.8	6.3	6.7	4.5	3.3	3.9	3.3	3.9	3.7	3.7
β-Pinene	2.3	5.8	5.5	3.0	3.2	3.2	3.4	3.2	3.0	3.2
1,8 Cineol	42.0	50.0	51.8	46.1	57.5	50.6	55.8	52.0	52.0	46.8
Limonene	0.3	0.8	0.9	1.1	1.0	0.8	0.9	0.7	1.7	1.6
Linalool	14.3	16.4	16.6	15.7	20.4	15.9	17.2	16.4	16.6	16.4
Terpinen-4-ol	1.3	2.3	1.4	4.3	4.0	3.9	3.8	3.8	4.2	4.1
Camphor	1.3	1.7	2.7	1.8	1.9	2.5	3.3	2.9	2.5	2.3
Borneol	0.7	0.5	2.3	0.8	1.7	1.3	1.5	2.4	1.5	1.5
Linalyl acetate	0.2	0.6	1.2	1.4	1.2	1.7	1.6	1.0	1.3	1.6
β-Caryophyllen	0.2	0.8	1.5	0.9	1.2	1.6	1.9	1.6	1.1	2.2
Total	66.5	88.5	91.8	80.5	96	85.7	92.5	89.3	88.3	83.9

Control: PK full recommended rate, N: recommended rate of ammonium sulphate, SM: sheep manure, Y: active dry yeast

Table 7: Effect of ammonium sulphate, sheep manure and dry yeast on total chlorophylls and carotenoids in leaves, total carbohydrates, N, P and K contents in dry herb of lavender plants during 2011 and 2012 seasons

Treatments	First Season		Second season		First Season		Second season		First Season		Second Season	
	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
	Total chlorophylls (mg/g fresh weight)				Carotenoids (mg/g fresh weight)				Total carbohydrates (%of dry weight)			
Control	2.35	2.90	2.85	3.60	0.85	0.65	0.90	1.05	14.60	14.40	15.80	15.20
N	3.40	4.65	3.40	4.17	1.05	0.85	1.25	1.18	19.40	20.80	21.60	31.30
SM	4.20	5.35	4.45	4.50	1.40	1.20	1.55	1.38	15.75	17.40	18.50	28.10
Y	3.05	4.30	3.00	4.15	0.95	0.70	1.10	1.08	15.80	16.60	16.70	15.40
SM+Y	5.45	6.40	5.95	6.25	1.85	1.50	1.75	1.63	20.80	25.00	25.80	32.60
½SM+Y	6.20	6.80	6.45	5.65	2.00	1.65	2.05	1.70	19.80	20.90	25.00	31.40
½N+ SM	4.55	5.75	5.00	5.95	1.50	1.20	1.60	1.48	17.90	18.92	20.70	29.10
½N+½SM	5.30	6.00	5.55	5.90	1.70	1.25	1.65	1.58	16.70	18.10	18.20	28.20
½N+ Y	3.90	5.00	3.90	4.70	1.15	1.00	1.50	1.35	15.90	17.50	17.60	27.60
½N+ ½SM+Y	6.65	8.00	7.05	7.80	2.15	1.70	2.15	1.90	25.00	27.00	27.60	33.10
L.S.D.5%	0.43	0.58	0.47	0.53	0.14	0.11	0.17	0.12	1.52	1.67	1.85	2.24
Treatments	N (%)				P (%)				K (%)			
	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut	1 st cut	2 nd cut
	Total chlorophylls (mg/g fresh weight)				Carotenoids (mg/g fresh weight)				Total carbohydrates (%of dry weight)			
Control	1.35	1.11	1.33	1.21	0.21	0.22	0.19	0.20	1.21	1.40	1.28	1.60
N	2.20	1.95	2.11	1.97	0.31	0.26	0.34	0.21	1.59	1.41	1.72	1.82
SM	2.35	2.65	2.25	2.45	0.28	0.31	0.24	0.18	1.78	1.62	1.81	1.72
Y	1.44	1.52	1.62	1.41	0.24	0.29	0.25	0.21	2.11	2.29	1.94	1.58
SM+Y	1.75	2.35	1.79	2.53	0.33	0.29	0.30	0.28	2.01	1.94	1.83	1.96
½SM+Y	2.40	2.15	2.10	2.25	0.31	0.22	0.26	0.21	1.62	1.86	1.74	1.91
½N+ SM	1.87	1.40	1.80	1.50	0.25	0.29	0.27	0.23	1.51	1.92	2.11	2.26
½N+½SM	1.85	1.75	1.95	1.70	0.22	0.27	0.24	0.21	1.68	1.77	1.59	1.83
½N+ Y	2.65	2.80	2.55	2.70	0.23	0.25	0.23	0.23	2.24	2.11	2.34	1.75
½N+ ½SM+Y	1.45	1.65	1.50	1.85	0.31	0.28	0.26	0.26	1.41	1.52	1.72	1.86
L.S.D.5%	0.16	0.18	0.15	0.21	0.03	0.02	0.02	0.02	0.17	0.19	0.21	0.23

Control: PK full recommended rate, N: recommended rate of ammonium sulphate, SM: sheep manure, Y: active dry yeast

These results are in agreement with prior studies on essential oil isolated by steam distillation from the fresh and dry flowers of *lavandula officinalis* since Ihsan [22] found that the major components in *Lavandula officinalis* oil were 1, 8 cineole (18.9% - 20.3%), linalool (34.2% - 33.0%) and borneol (12.1% - 11.0%). The essential oil content in the inflorescence of lavender (*lavandula*

angustifolia mill.) cultivated in the mid hills of Uttarakhand was found to be linalyl acetate (47.56 %), linalool (28.06 %), lavandulyl acetate (4.34 %) and alpha-terpineol (3.75 %) [23]. Hussain [24] found that the essential oil components of *Lavandula angustifolia* were linalool (25.1%), linalyl acetate (22.5%) and alloaromadendrene (5.27%). Results of other studies [25, 26]

reported that the main constituents of flowers of *Lavandula officinalis* were linalool (18.9-34.1%), 1, 8 cineole (18.5-36%), borneol (14.5%), camphor (8.0-15.0%), terpinen-4-ol (4.5%) and linalyl acetate (3.7%). Mantovana *et al.* [27] stated that the major essential oil constituents from the leaves of *Lavandula angustifolia* were borneol (22.4%), *epi*-alpha-muurolol (13.4%), alpha-bisabolol (13.1%), precocene I (13.0%) and eucalyptol (7.9%). Yuanyuan *et al.* [28] identified 17 compounds as the essential oil main components in lavender from Xinjiang, China including linalool (44.54%), geraniol (11.02%), lavandul acetate (10.78%), 3, 7-dimethyl-2, 6-octadien-1-ol (10.35%) and isoterpineol (6.75%). There are some factors must be taken into consideration when comparing the results obtained and results of previous studies on the composition of the oil produced from *Lavandula angustifolia* plants like differences in cultivation area microclimate, the average daily temperature during the blooming period, rather than the soil-type in which it is growing, availability of water and time of sowing [29]. Zheljazkov *et al.* [30] reported a change in essential oil percentage and yield due to length of oil distillation time (DT) from the same lavender flowers, the concentrations of cineole (6.4-35%) and fenchol (1.7-2.9%) decreased with increasing length of the DT. The concentration of camphor reached its maximum (6.6-9.2%) at half the time needed by linalool acetate to reach its maximum percentage (15-38%).

Chemical Composition

Total Chlorophylls and Carotenoids Contents in Leaves:

Data presented in Table 7 showed that, in both cuts of both seasons, all treatments significantly increased total chlorophylls and carotenoids contents in leaves of lavender as compared to the untreated control plants, in most cases. In both seasons, the plants treated with $\frac{1}{2}N + \frac{1}{2}SM + Y$ gave the significantly highest values of total chlorophylls and carotenoids compared to other treatments, followed by plants received $\frac{1}{2} SM + Y$ with significant differences between them in most cases.

In most cases, the highest total chlorophylls and carotenoids contents were obtained in plants treated with treatments containing combinations of yeast with sheep manure, sheep manure and ammonium sulphate, yeast and ammonium sulphate then ammonium sulphate, respectively. The detected increase in photosynthetic pigments could be attributed to the role of cytokinins produced by yeast in delaying the aging of leaves by reducing the degradation of chlorophyll and enhancing the protein and RNA synthesis [31].

Total Carbohydrates Contents in Dry Herb: Data presented in Table 7 showed that, in both cuts of both seasons, all treatments significantly increased total carbohydrates content in dry herb of lavender as compared to the untreated control plants in most cases. In both seasons, the plants treated with $\frac{1}{2}N + \frac{1}{2}SM + Y$ gave the significantly highest values of total carbohydrates content compared to other treatments, followed by plants received $SM + Y$ with no significant difference between them in both cuts of the second season. In most cases, the highest total carbohydrates content were obtained in plants treated with treatments containing combinations of yeast with sheep manure, sheep manure and ammonium sulphate.

N, P and K% in Dry Herb: Data presented in Table 7 clearly showed that the N, P and K% in dry herb of lavender were significantly increased as a result of all fertilization treatments as compared to the untreated control plants, in most cases. The plants treated with $\frac{1}{2}N + Y$ resulted in the highest N% as compared to the other treatments. There was no specific trend appeared as a result of the effect of different treatments on P and K%.

The low N, P and K% were recorded with the plants treated with $\frac{1}{2}N + \frac{1}{2}SM + Y$ and $SM + Y$ treatments, which resulted in the highest vegetative growth characteristics and yield, attributed to the dilution effect. The highest vegetative growth caused by $\frac{1}{2}N + \frac{1}{2}SM + Y$ and $SM + Y$ treatments resulted in an increase in the uptake of N, P and K, which can be confirmed by calculating the total amount of N, P and K in the dry herb by multiplying the herb dry weight by the N, P and K percentages, recording the highest uptaken values with $\frac{1}{2}N + \frac{1}{2}SM + Y$ followed by $SM + Y$ treatments. However, the N, P and K percentages were reduced because the uptaken N, P and K were diluted in a high dry weight of herb as explained by Marschner [32]. These results are in agreement with results obtained by Hussein *et al.* [33] on calendula, showing that there was insignificant difference between N, P and K% of dry matter in herb of plants receiving either mineral N or sheep manure. Mhlontlo *et al.* [34] found that 2.5 t/ha sheep manure increased growth, nutrient uptake and yield of amaranthus comparable to 150 kg/ha NPK. Several investigators studied the response of medicinal and aromatic plants to application of dry yeast that enhances vegetative growth, plant pigments, photosynthesis, accumulation of carbohydrates and mineral nutrients and oil yield like El-Sayed *et al.* [35] on coriander, Naguib and Khalil [36] on black cumin,

Heikal [18] on thyme, Ahmed *et al.* [37] on roselle and Ezz El-Din and Hendawy [38] on borago and El-Lethy *et al.* [39] on geranium and Abd EL-Latif [40] on sage.

DISCUSSION

Manure have a positive impact on soil pH, soil texture, cation exchange capacity, drainage and salinity which are major factors affecting yield. Manure adds organic matter to the soil, which increases activity of microorganisms. Microorganisms produce polysaccharides that form chemical bonds between cations and soil particles to form aggregates. Soil aggregation and porosity increases soil moisture, nutrient concentrations, water holding capacity and decreases bulk density, compaction and runoff [41]. Manure biocontrols plant pathogens. It supplies species of bacteria or fungi, or parasites that feed on pathogens, causing increasing the yield [42].

Saccharomyces cerevisiae, commercial baker's yeast has an influencing effect on plants as a natural biofertilizer. It is characterized by its richness in protein 47-51. 53%, carbohydrates 30- 33%, nucleic acid 8%, lipids 4%, dry matter 17. 95 % and different minerals 8% such as Na, Fe, Mg, K, P, S, Zn, Mn, Cu, Si, Cr, Ni, Va and Li, in addition to thiamin, riboflavin, pyridoxine, biotin, B12 and folic acid [43]. Previous researchers investigated its inducing of auxins, gibberellins and cytokinin like compounds of zeatin riboside and zeatin which promote cell division, cell enlargement and cell elongation causing increment in leaf area and photosynthesis, in addition to increasing the accumulation of carbohydrates [44- 47].

Yeast generates carbon dioxide which lowers soil pH, leading to converting nutrient elements from unavailable form to available form which the plant can uptake. The yeast excretes phytase enzyme to convert inorganic phosphorus from insoluble tri-calcium phosphate into available form suitable for the plant to uptake [48]. Yeast enhances plant growth through spermidine, spermine, putrecine polyamines production required in enhancement of plant root growth resulting in increasing the absorptive surface area. Yeast produces ACC deaminase which degrades ACC the precursor of the plant hormone ethylene leading to lowering plant ethylene [49-51]. *In vitro*, *Saccharomyces* nitrifies ammonium to nitrate and oxidizes elemental sulfur to produce phosphate, tetrathionate and sulfate [52]. Active yeast

extract affects the anatomical structure of vegetative growth by increasing stem diameter through increasing the thickness of epidermis, cortex, phloem tissue, xylem tissue and parenchymatous area of the pith [53]. Prior studies showed that inoculation of the cultivated soil with yeast increased the thickness of the leaf blade and midvein by increasing length and width of the vascular bundles, the average diameter of the vessels and average number of vessels per bundle [54]. *Saccharomyces cerevisiae* needs nitrogen supplementation for its cell growth and biomass production, in addition to carbon, hydrogen and oxygen from the rhizosphere [55]. Organic nitrogen supplementation stimulates yeast production [56]. Therefore, the increase of plant growth and production influenced by yeast is attributed with addition of organic nitrogen supplied by sheep manure.

Nitrogenous fertilization increases plant growth and development. Nitrogen converts to amino acids, the building units of proteins. Amino acids are used in formation of protoplasm, used in cell division. Enzymes of the plant are derived from amino acids. Nitrogen is a main constituent in chlorophyll pigment responsible for photosynthesis in the leaves of the plant resulting in carbohydrate accumulation and nutrient uptake leading to excessive plant growth and development.

Manure and yeast enhance the growth and production of plants, representing a promise bio-organic system through increasing the availability of macro and micronutrients, producing growth hormones and suppressing the growth of pathogens. In addition, they could improve the physical and chemical properties of soil that increase water holding capacity, prevent nutrient leaching and increase organic matter content and soil aggregation.

CONCLUSION

We recommend to fertilize lavender plants grown in sandy soils with sheep manure at the rate of 30 m³/ feddan + 6 g/L active dry yeast, in addition to 300 kg/feddan calcium super phosphate and 100 kg/ feddan potassium sulphate for improving the vegetative growth and production of herb. For the highest essential oil production it can be recommended to apply sheep manure at the rate of 15 m³/ feddan + 6 g/L active dry yeast, in addition to 300 kg/feddan calcium super phosphate, 100 kg/ feddan potassium sulphate and ammonium sulphate at the rate of 150 kg/feddan.

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