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Production technology of Lavender: Frontline cash crop for Kashmir valley

Abstract

The production technology of *Lavandula angustifolia* (true English Lavender) from rooting of stem cuttings, standardizing the distance for plantation in field, yield of essential oil and economics of cultivation has been discussed. 92% rooting can be achieved in the semi hardwood cuttings of *L. angustifolia* if treated with 2000ppm IBA in the month of October. Maximum herbage yield (fresh flower) on harvesting after two years can be to the tune of 11,420kg ha-1 when planted at a spacing of 50cm X 50cm. Maximum yield of essential oil 117 kg ha-1 has been obtained from 50cm X 50cm spacing and thus showing a recovery rate of 1.02%. Actual benefits are obtained after 2nd year of plantation and production may continue up to 12-15 years. Economic analysis has shown the net results will be Rs 4.0 lakhs ha-1 year-1. Comparing the quality profile of essential oil cultivated in Kashmir with that of cultivated in Europe it has become evident that Kashmir lavender oil (linalool > 44%) is of international standards.

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Introduction

About 2000 species of plants containing essential oil belong to 60 botanical families and among them Lavender has been categorized as one of the most important essential oil yielding plants. The purple coloured flower spikes of true lavender give the best oil of high aroma value by the process of distillation. The cosmetic, perfumery and flavor industry use this oil for production of high value products. Lavender oil has been popular since centuries because of its typical lavender note. In the modern world the oil is used in aromatherapy. It has been traditionally used and now scientifically validated for its use as antibacterial, antifungal, carminative, sedative, anti-depressive and effective against burns and insect bites. The ever growing demand for lavender products viz. lavender concrete, lavender absolute, lavender water and dried flowers has widened the scope of cultivation of lavender. Lavender marc left after the distillation of oil is used in incise sticks and as organic manure. Biological activities of various lavender species have been well documented.[1] In view of its continued popularity and commercial value it was confirmed "Herb of the year 1999" in USA.[2] From the commercial point of view only four species of lavender out of 39 species and 17 hybrids have economic importance.[3] *Lavendula augustifolia* syn. *L. officinalis* commonly known as English lavender and formerly known as *L. Vera* is widely cultivated in many parts of the world because of its more oil content. It is a perennial bushy shrub 50-80 cm tall with attractive flowers borne in short compact to long interrupted spikes on a distinct and unbranched peduncle. The flowers are usually of violet – blue to purple shade. Due to its importance the present study was conducted regarding the propagation of lavender plants, quality profile of lavender oil and economics of lavender cultivation in Kashmir.

Material and methods

This study was conducted at Faculty of Forestry, S.K University of Agricultural Sciences and Technology of Kashmir at Benhama Campus, Ganderbal. The experiments comprised of propagation of true lavender by stem cuttings, planting lavender at different spacing, extraction of essential oil, study of economics of cultivation and chemical profiling of essential oil. To standardise the propagation of lavender through stem cuttings, semi hardwood cutting with terminal bud intact were taken in the month of October and treated with IBA from 200ppm to 2000ppm (Table 1) and the best treatment was established. Well rooted lavender plants were planted on the south facing slope of Lar mountain at Benhama campus of SKUAST-Kashmir at three spacing viz. 0.5m X 0.5m, 0.5m X 1m and 0.5m X 1.5m. Herbage yield and oil yield per hectare at three different spacing has been measured. To give a bushy shape and form a dome like structure the young floccules were harvested in the first year. Freed from the floccules young plants developed a strong tuft which gave a high crop during the following year and were better able to cope with adverse weather, pests and diseases. In the 2nd year flowers were harvested and immediately distilled by direct heating in a sharing distillation unit. Distillation was complete within one and a half hours. The quality profile of lavender oil cultivated in Kashmir has been done by GS/MS analysis and these constituents are compared with constituents of lavender cultivated in Europe and other parts of the world.

Table 1 Effect of IBA on rooting percentage of lavender cuttings

Treatment	Rooting%	S.E.
Control	31.08	2.033
200ppm	39.498	1.543
400ppm	46.87	2.015
600ppm	57.838	0.602
800ppm	65.955	1.397
1000ppm	71.008	1.17
1200ppm	75.158	0.67
1400ppm	79.17	0.439
1600ppm	84.33	0.408
1800ppm	87.938	0.635
2000ppm	91.995	1.097
C.D.	3.558 (RBD design in three replicates)	
SE(m)	1.231	
SE(d)	1.741	
C.V.	3.706	

The harvesting of lavender flowers started at the end of the month of June when the flowers were fully developed and its flowers in the lower half of the spike have begun to start opening. Hand tool, sickle, was used to harvest the flower spikes 15-20 cm below the flower i.e. along with some leaves.

Gas chromatography Mass spectrometry (GC/MS) analysis: *L. angustifolia* essential oils extracted from flower spikes were analysed using Gas chromatography-Mass spectrometry (GC/MS) on a Thermo Fisher TRACE GC ULTRA coupled with DSQ II Mass spectrometer instrument using a TR 50MS column (30 m x 0.25mm ID x 0.25µm, film thickness) and its chemical constituents were determined.

Economics: The economics of the cultivation of lavender has been calculated in rupees of Indian currency. All the rates quoted are as per prevailing rates in the city of Srinagar in 2019. All the inputs and out puts in the systems have been included. The data has been taken for three years and extrapolated for ten years.

Results and discussion

Rooting of stem cuttings: Rooting ability of stem cuttings of lavender is analysed in Table 1, which reveals that 92% rooting can be achieved in the semi hardwood cuttings if treated with 2000ppm IBA in the month of October. Although all the treatments show good rooting but for maximum rooting percentage and well developed roots stem cuttings need to be treated with 2000ppm IBA. Plants with well-developed roots were planted in the field at different spacing. The harvesting of flowers was done after two years of plantation. The major part of the harvest was the flower spike having some basal leaves. Table 2 reveals that maximum herbage yield (fresh flower) on harvesting after two years can be to the tune of 11,420kg/Ha. When planted at a spacing of 50cm X 50cm. Figures 1-6

Table 2 Effect of different spacing on fresh weight of Herbage yield (Kg/hac.) for cultivation of lavender

Spacing of plantation	Mean yield kg/ha.	S.E.
50m X 50m	117.5	0.764
50m X 1m	97.5	0.764
50m X 1.5m	77	2.898
C.D.	5.432	
SE(m)	1.786	
SE(d)	2.525	
C.V.	4.494	

Production cycle for Lavender oil production

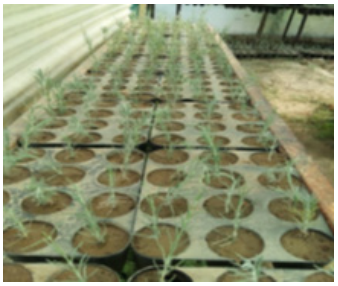

Figure 1 Planting lavender cuttings in Hikotrays.

Figure 2 Rooted plantlets ready for planting.

Figure 3 Lavender in bloom.

Harvested lavender spikes

Figure 4 Harvested lavender spikes.

Figure 5 Field distillation unit for extraction of lavender oil.

Figure 6 Lavender oil packed in bottles for sale.

Yield of essential oil: Table 3 gives the yield of essential oil obtained from the fresh herbage. The essential oil is one of the most important criteria of medicinal and aromatic plants quality. In this study, maximum yield of 11.7 kg ha^{-1} has been obtained from 50m X 50m spacing i.e. from herbage yield of 11,421 kg and thus showing a recovery rate of 1.02%. Yield with increased spacing has decreased in our study but on long term bases the yield may be similar when the crowns of the plants meet together and form a hedge. A yield of 5.57 – 14.99 ton ha^{-1} under[4] Aegean ecological conditions of Turkey which is almost equal to our yield. In this study the recovery essential oil was 1.07% but elsewhere it has been a bit more or less e.g. Wicht, 1971 and Wagner, 1980 show 1.0% recovery while Ceylan,[5] and Baytop,[6] obtained recovery of 0.5-1.0% for pharmaceutical and commercial purposes. However, Chrysargyris et al.,[7] obtained 3.01 – 4.07% of lavender essential oils under different water stress conditions. Also, Nurzynska & Zawislak,[8] reported 3.2% of essential oil in flower

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of *L. angustifolia* L. species. Our herbage yield (fresh flower) and subsequently the yield of essential oil was the modest when compared with the trials laid elsewhere in the world.

Table 3 Yield of essential oil from flower spikes of lavender per Hac. in liters) at different spacing of plantation

Spacing of plantation	Mean yield kg/ha.	S.E.
50m X 50m	11,420.950	11.084
50m X 1m	11,305.967	4.071
50m X 1.5m	11,238.800	16.042
C.D.	34.975	
SE(m)	11.498	
SE(d)	16.261	
C.V.	1.213	

Economics: In Lavender, the initial investment is the plantation and processing for the Lavender oil, which requires a steam distillation unit. Actual benefits are obtained after 2nd year of plantation and production may continue up to 12-15 years. The net results have shown that lavender can give economic return of Rs 0.4.0 Million/ ha. for a cycle of 10 years (Table 4). A farmer will take cultivation of a new crop only when it is economically feasible. In this study the cultivation and extraction of lavender has been taken on pilot scale and economics has been found out. In our study it was found that on one hectare land the returns can be to the tune of Rs 4lakh per hectare as per the prevailing rates in the city of Srinagar. Examining the studies conducted in agricultural economics one can see that the majority of these are focused on economic analysis. For instance, according to a case study conducted in Turkey by Gül et al.[9] elaborated that the relative profit in lavender was 1.65. They have obtained the average yield of lavender as 1636.70 kg/ha. The production cost of 1 kg of lavender was $0.95, and the net profit per hectare was estimated as $1018.37. They have argued in their finding that lavender cultivation at Turkey is profitable as compared to other agricultural products. Peco et al.[10] studied the economics of lavender cultivation in Bosnia and Herzegovina and calculated total profit per hectare around $1 237 and the cost of one kilogram of Maillet oil hybrids as $68 on average. In India, Singh et al.[11] found lavender cultivation was profitable in the Chamba District of Himachal Pradesh. He has observed that the lavender oil business could generate high profits for farmers providing that good agronomic management practices were adopted. Further he laments that Lavender production is important not only for its economic contribution to farmers but also for its social and environmental role in the community and ecosystem.

Quality profile of essential oil: The oil samples were analyzed by gas chromatography – mass spectrometry. Volatile compounds were identified by co-injection with reference samples. Results are shown in Table 5 in which fifty products have been listed. The main constituents of lavender oil from Kashmir are Linalool (25.27%), linalyal acetate (44.98%), -terpineol (1.49%), borneol (2.7%), camphor (1.07%), lavandulyl acetate (3.4%), β-carophyllene (1.85%), carophyllene oxide (2.08%). The by-product of distillation is the lavender water (hydrosol) which also has economic value. The volatiles obtained from lavender water were also analyzed and results are shown in Table 6. The main constituents identified were linalool (32.51%), terpineol (13.55%0, (z)-linalool oxide (7.24%) etc. The quality profile of essential oil obtained in this study are indicative of its European pharmacopeia standards which seem to be applicable for the evaluation of lavender oil because of the worldwide production today. It is well known that linalool and linalyl acetate content of lavender oil is mostly used as the criterion of quality. It is evident that Kashmir lavender oil (linalool ≥25%, linalyl acetate ≥44%) is of international standards. According to study conducted by Baydar and Kineci,[12] essential oil content ranged from 1.0-1.5% in stalked fresh flowers to 5-6% in the stalkless dry flowers, and lavender oil contains linalool between 30-45% and linalyl acetate between 20-30%. Alatrache *et al*.[13] cultivated lavender in Italy and reported the oil contains: linalool (47.8%), camphor (11.8%) and linalyl acetate (10.7%). Fakhari *et al.*[14] cultivated lavender in Iran and analyzed the chemical constituents of its oil and the results revealed as: linalool (32.8%), linalyl acetate (17.6%), lavandulyl acetate (15.9%), α-terpineol (6.7%) and geranyl acetate (5.0%). However, Sanz *et a*l.[15] analyzed the lavender oil cultivated in Spain and major components were reported as camphor and 1,8-cineole, up to 80.9 and 76.7% in leaves; 87.8 and 85.2% in flowers. In South Korea, Nam & Dong,[16] analyzed the oil of many Lavandula species and revealed that the oil contains volatiles as linalyl acetate (35.44%) and linalool (18.70%). The study conducted on essential oil of *L. angustifolia* from Australia by An and Hatfield,[17] found the principal components as: linalool (41.2%), linalyl acetate (16.1%) and terpinen-4-ol (12.1%). Lavender oil cultivated in Tunisia has been analyzed by Alatrache et al.[13] and identified forty components and the main constituents of the oil were linalool (32.3%), 1,8-cineole (11.7%), camphor (12.4%), lavandulol (8.7%), terpinen-4-ol (7.7%) and bornyl acetate (4.2%), methyl carvacrol (1.9%), linalyl acetate (1.8%), β-pinene (1.6%), α-terpineol (1.5%) and p-cymene (1.5%) . In India the lavender oil cultivated has been reported by Archana and Negi[18] that *L. angustifolia's* essential oil has major aroma constituents linalool and linalyl acetate up to 60% from India.

Table 4 Economics of cultivation of lavender from farmer's point of view

Expenditure / hectare			
Particulars	**1st year (Rs)**	**2nd year (Rs)**	**3rd year (Rs)**
Land preparation (ploughing, levelling, tilling etc.	1,00,000	---	---
Soil and bed preparation or contouring	1,00,000	---	---
Cost of planting material @Rs 10/plant for 27000	2,70,000	---	---
Transplanting @ Rs 10/plant	2,00,000	---	---
Irrigation by hand	10,000	10,000	10,000
FYM & its application	10,000	10,000	10,000
Circle hoeing (1) & weeding (2)	20,000	20,000	20,000
Harvesting	----	20,000	20,000
Cost of distillation unit 50 kg	2,00,000	----	------
Total working capital	9,10,000	8,60,000	860,000
Interest on working capital @12%	1,00,800	1,03,200	1,03,200
Cost of extraction @ Rs 10/kg	-----	25,000	70,000

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Table Continued...

Expenditure / hectare			
Particulars	**1st year (Rs)**	**2nd year (Rs)**	**3rd year (Rs)**
Total	10,10,800	1,88,200	2,33,200
Returns /Hac.			
Oil yield (Kg. /hac.)	----	25.00kg	70.0kg
Sale value @ Rs 12000/kg	----	3,00,000	8,40,000
Lavender water by product @ Rs 50 /liter	----	50,000	1,00,000
Gross earnings	NIL	3,50,000	9,40,000
Average profit/hac.	10,10,800	1,61,800	7,06,800
Average profit (over a period of 10 years) = Rs 4.0 lakhs/hac./year			

Table 5 Composition of essential oil of lavender cultivated in Kashmir

S.No.	Compound	% Composition	S.No.	Compound	% Composition
1	Methyl-n-hexyl ether	0.02	28	Borneol	2.70
2	Ethyl 2-methyl butyrate	0.02	29	Lavandulol	0.4
3	Cis 3-hexenol	0.06	30	Terpinen-4-ol	0.72
4	Hexenol formate	0.04	31	Hexyle butyrate	0.29
5	Tricyclene	0.02	32	α-Terineol	1.49
6	α- pinene	0.22	33	Verbenone	0.07
7	Camphene	0.34	34	Isobornyl formate	0.10
8	Sabinene	0.07	35	Geranoil	0.16
9	1-Octen-3-ol	0.18	36	Cumin aldehyde	0.14
10	Octanone-3	0.90	37	Carvone	0.06
11	Myrcene	0.22	38	Linalyl acetate	44.98
12	Isobutyl butyrate	0.05	39	Geranial	0.06
13	Octanol-3	0.11	40	Bornyl acetate	0.51
14	Hexyl acetate	0.28	41	Lavandulyl acetate	3.44
15	Para-cymene	0.24	42	Neryl acetate	0.44
16	Limonene	0.33	43	Geranial acetate	0.81
17	1,8- Cineole	2.10	44	E-β-Caryophyllene	1.85
18	E-β- Ocimene	0.03	45	α-Bergamotene	0.12
19	Z-β- Ocimene	0.06	46	α-Humulene	0.05
20	Thujanol	0.02	47	Z-β-Farnescene	0.67
21	Cis-Linalool oxide	0.49	48	Dimethyl-octatriene	0.51
22	Trans-Linalool oxide (furan)	0.48	49	γ- Cadinene	0.14
23	Linalool	25.27	50	Caryophyllene	2.08
24	Octen-3-yl acetate	0.66			
25	Bicyclo-heptan-3-ol	0.10			
26	Camphor	1.07			
27	Octadiene-diol	0.05			

Table 6 Composition of (%) of lavender volatiles from lavender water

S. No.	Compound	% composition
1	∝- pinene	0.107
2	B- pinene	0.58
3	Octanone-3	0.07
4	1,8 Cineole	4.94
5	Thujanol	0.09
6	Z- linalool oxide	7.24
7	E- Linalool oxide	6.04
8	Linalool	32.51
9	Bicyclo-heptane-3-ol	0.01
10	Camphor	6.04
11	Borneol	9.84
12	Lavandulol	1.0
13	1-terpinen-4-ol	3.90
14	∝-terpineol	13.55
15	Nerol	2.80
16	Linalyl acetate	2.84
17	Bornyl acetate	0.07

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Conflicts of interest

Authors declare that there is no conflicts of interest.

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