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Influence of date of planting, land configuration and planting geometries in patchouli (*Pogostemon cablin* Benth.) under sub-mountaineous region of Punjab

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ABSTRACT

To find out the influence of date of planting, land configuration and planting geometries on the fresh herbage yield and essential oil yield of patchouli under sub-mountaineous region of Punjab, three planting dates of patchouli plot viz. September 20, October 5, October 20, two land configurations (Bed and Flat planting) in sub-plots and three planting geometries viz. 90×30cm, 90×45cm, 90×60cm were evaluated during 2013-14 and 2014-15. The maximum plant spread was observed with October 20, which was statistically at par with October 5. Patchouli planted on beds attained more plant spread which was significantly higher than that of flat planted plots. The maximum values of plant spread were produced by planting geometries of 90×60cm, which was statistically at par with 90×45cm. The highest herbage yield and essential oil yield were recorded in October 20 which was statistically at par with October 5 at both harvests during both the years of study. Significantly higher fresh herbage yield and essential oil yield in both the harvest were recorded in bed planting than in flat planting among both the harvests of patchouli. Among planting geometries, the highest fresh herbage yield and essential oil yield was observed 90 cm×30cm in both the harvest and proved significantly superior to 90×45cm and 90×60cm. The date of planting, land configuration and planting geometries resulted in statistically similar values of oil content of patchouli at both harvests during both the years of study.

Keywords **:** Date of planting, essential oil, herbage yield, land configurations, patchouli, planting geometries

India has a long tradition of more than 500 years as a supplier of fragment materials to western civilization in Greece, Rome and Egypt. Today there is a huge demand for oil of plant origin in view of their biosafety and unique aroma properties. Patchouli (*Pogostemon cablin*) is one of the important aromatic crops which belong to family Lamiaceae. It is considered to be a native of tropical regions of Asia and is now extensively cultivated in China, India, Thailand, Indonesia, Malaysia, Mauritius, Philippines, West Africa and Vietnam. It was introduced to India during year 1941 in Madhya Pradesh, Tamil Nadu, Kerala and Karnatka. In India, it is cultivated coastal area of South India, West Bengal, Assam, Karnataka, Madhya Pradesh and coastal regions of Gujrat (Ramya *et al.*, 2013). Production of the patchouli herb for its essential oil is estimated to be around 1200 t in the world and majority of the market share belongs to Indonesia (1100 t year^{-1}), sharing more than 91.7 per cent of the total world production (Lawrence, 2009). Cultivation in India has been meagre but producing 20 t of oil per annum (Singh and Srinivas, 2014) and and most of its domestic requirement is met by importing patchouli oil worth of 9 million rupees annually. Since the demand for patchouli oil is increasing in domestic and international markets, there is huge scope to increase its production by increasing its area.

Patchouli possesses aromatic and medicinal properties can be grown successfully in India (Bhaskar*et al.*,1997). Patchouli is a branched, erect, perrinnial aromatic herb with quardiangular stems, propagated vegetatively through rooted terminal stem cuttings and multi-harvest aromatic crop. Patchouli is exploited for the production of natural essential oil that finds extensive use in flavour and to give a base and lasting character to fragnance in perfumery industry. Besides the oil is also used as flavour ingredients in the major food products, including alcoholic and non-alcholic beverages. Dry patchouli leaves have also been found to possess moth repellent properties and therefore are used to scent wardrobes and protecting clothes especially woollens from insect damage (Khanuja *et al.*, 2004). In Indo-Malayan region, it has been used as insecticides and leech repellent and also to soothe menstrual cramps. There is no synthetic chemical to replace the oil of patchouli which further enhances its value (Ramchandra *et al.*, 2002). It has been used in India, China and Japan for various medicinal purposes (Ramya *et al.*, 2013). Because of its primary antiseptic properties, it is used to treat athlete's foot, dandruff, wounds and scars. It gives relief from constipation and acts as an antidote against insect bites temporarily (Chakrapani *et al*., 2013). Patchouli alcohol is a fragrance ingredient used in

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decorative cosmetics, fine fragrances, shampoos, toilet soaps, non-cosmetic products such as household cleaners and detergents (Bhatia *et al.,* 2008).

A great deal of manipulation with regard to agronomic practices is necessary for enhancing the production of essential oils from this crop. Date of planting, land configuration and planting geometries are amongst the most limiting factors for crop yield of environmentally sound agriculture. Planting techniques are the most important aspects of advanced production technology which not only ensures better crop establishment but also results in efficient irrigation water utilization, especially when the crop is sown on ridges or beds. Also, Aggarwal and Goswami, 2003 reported higher water use efficiency in bed planting as compared to the flat planting technique. Also, improvement in water use efficiency is also endorsed due to better availability of plant nutrients, lower weed density in ridge sowing, and ultimately an enhanced crop yield under seed spreading augmented with furrows planting method as compared to the flat planting (Nasrullah *et al.,* 2009).

There is paucity of research work on these factors under Punjab conditions. Therefore, in dearth of such valuable information, the present investigation was undertaken to study the influence of date of planting, land configuration and planting geometries on the fresh herbage yield and essential oil yield of patchouli (*P. cablin*).

MATERIALS AND METHODS

The field experiment was conducted for two years during 2013-14 and 2014-2015 at PAU Regional Research Station, Gurdaspur in sub-mountaineous region of Punjab which is situated between $32^0 3'$ N Latitude, $75^0 22'$ E Longitude and has an altitude of about 258 m from msl to study the influence of date of planting, land configuration and planting geometries on the fresh herbage yield and essential oil yield of patchouli under sub-mountaineous region of Punjab. The soil of experimental field was clayey loam in texture, medium in nitrogen on the basis of organic carbon (0.60%), medium in available P_2O_5 (13.25 kg ha^{-1}) and low in K_2O (75 kg ha^{-1}) at 0-15 cm soil depth. The soil was neutral in reaction (pH - 7.2) with normal electric conductivity (0.23 ds m^{-1}). The experiment was laid out in split-split plot design having three replications with date of planting of patchouli in main plots, land configuration in sub-plots and planting geometries in sub-sub plots. It consists of three planting dates of patchouli plot *viz.* September 20, October 5, October 20, two land configurations (Bed and Flat planting) in sub-plots and three planting geometries (90 × 30cm, 90 × 45cm, 90 × 60 cm) in sub-sub plots during both the years of study.

The planting material was raised through rooted terminal stem cuttings of patchouli cultivar Kelkar. Terminal cuttings of about 15 cm length having about 3-5 nodes were selected. Cuttings were raised in polybags (6"×4" size) filled with sand and FYM mixture (1:1), which ensures better survival percentage in the field. A light watering by hand was also given immediately after planting in polybags. Forty five days old rooted stem cuttings were planted according to the date of planting. The field was thoroughly ploughed, levelled and laid into furrows and beds according to layout. Beds and Flat planting was done according to date of planting viz. September 20, October 5, October 20 during both the years with different planting geometries treatments 90×30cm, 90×45cm & 90 ×60 cm). In flat planting, 90 cm row to row spacing was maintained with different planting geometries according to treatment. In bed planting, 90 cm wide beds with 30 cm deep furrow were made. One row of patchouli was planted in the centre of bed in which different plant to planting geometries were adjusted according to the treatment. The patchouli crop was fertilized with 100 kg N ha^{-1}, 50 kg P_2O_5 ha^{-1} and 50 kg K_2O ha^{-1} (N:P:K; 2:1:1) through urea, single super phosphate and muriate of potash, respectively. Nitrogen was applied in the form of urea in three equal splits one as basal and the rest after each harvest. The whole quantity of phosphorous and potassium were applied at the time of planting (Singh and Srinivas, 2014).

The crop was irrigated immediately after transplanting for better establishment of the crop, subsequently once in a week and thereafter as and when required. Hand weeding was done as weeds affect the yield and quality of the oil. The crop is kept weed free by periodical weeding for 1-2 months since crop growth is very slow initially and thereafter at about 45 days interval. After harvest, a hoeing was done followed by irrigation. The crop was harvested twice after six months of transplanting in the month February and August during both the years. The entire shoot portion of patchouli crop was harvested by clipping 20 cm above the ground level. Data on plant height, plant spread and fresh herbage yield above the ground level were recorded at the time of each harvest. The plant spread along North- South and East-West directions was measured and multiplied and expressed in m^2 (Suresh, 2008). Oil concentration (%) in fresh herbage was estimated by hydro distillation method using Clevenger's apparatus (Clevenger, 1928). A sample of about 300 g of herb was harvested and hydro-distilled in a Clevenger's apparatus for 3 hours. Moisture in oil samples were removed by sodium sulphate anhydrous 2%. The oil concentration in plants was expressed as percentage on a volume basis (ml oil obtained from 100 g of fresh herbage). The essential oil

Table 1: Plant height and plant spread of patchouli as influenced by various date of planting, land configurations and planting geometries during the years 2013-14 and 2014-15

Treatments	Plant height (cm)						Plant spread (m^2 $plant^{-1}$)					
	1st harvest			2nd harvest			1st harvest			2nd harvest		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Date of planting												
September 20	73.03	71.9	72.5	72.00	72.6	72.3	0.36	0.37	0.37	0.46	0.46	0.46
October 5	72.57	71.1	71.8	72.28	71.7	72.0	0.50	0.54	0.52	0.57	0.59	0.58
October 20	72.13	69.6	70.9	71.85	71.0	71.4	0.59	0.61	0.61	0.64	0.65	0.65
SEm (±)	**1.63**	**1.60**	**1.62**	**1.02**	**1.18**	**1.09**	**0.03**	**0.04**	**0.04**	**0.02**	**0.03**	**0.02**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.12**	**0.16**	**0.14**	**0.09**	**0.11**	**0.09**
Land configuration												
Flat planting	71.50	69.5	70.5	71.06	70.5	70.8	0.43	0.45	0.45	0.49	0.50	0.50
Bed planting	73.66	72.2	72.9	73.03	73.0	73.0	0.54	0.57	0.55	0.62	0.63	0.63
SEm (±)	**1.21**	**1.19**	**1.20**	**0.87**	**0.85**	**0.86**	**0.02**	**0.03**	**0.02**	**0.02**	**0.03**	**0.03**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.08**	**0.09**	**0.08**	**0.07**	**0.10**	**0.09**
Planting geometries												
90 × 30cm	71.58	69.9	70.7	71.26	70.8	71.0	0.39	0.41	0.40	0.46	0.45	0.46
90 × 45cm	72.03	70.6	71.3	71.81	71.7	71.8	0.52	0.55	0.53	0.59	0.61	0.60
90 × 60cm	74.12	72.1	73.1	73.06	72.8	72.9	0.55	0.57	0.56	0.62	0.64	0.63
SEm (±)	**1.46**	**1.42**	**1.45**	**1.44**	**1.55**	**1.45**	**0.04**	**0.04**	**0.04**	**0.03**	**0.05**	**0.04**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.11**	**0.12**	**0.11**	**0.10**	**0.14**	**0.12**

Table 2: Effect of date of planting, land configurations and planting geometries on herbage yield in patchouli during the years 2013-14 and 2014-15

Treatments	Fresh herbage yield (t ha^{-1})					
	1st harvest			2nd harvest		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Date of planting						
September 20	2.04	1.93	1.99	2.68	2.25	2.46
October 5	3.71	3.80	3.76	4.80	4.51	4.56
October 20	4.34	4.06	4.20	5.58	5.20	5.39
SEm (±)	**0.40**	**0.43**	**0.39**	**0.52**	**0.50**	**0.51**
LSD (0.05)	**1.55**	**1.67**	**1.54**	**2.03**	**1.94**	**1.98**
Land configuration						
Flat planting	2.57	2.38	2.47	3.03	2.91	2.97
Bed planting	4.16	4.14	4.16	5.68	5.06	5.37
SEm (±)	**0.43**	**0.48**	**0.45**	**0.59**	**0.58**	**0.58**
LSD (0.05)	**1.47**	**1.66**	**1.56**	**2.02**	**1.99**	**2.00**
Planting geometries						
90 × 30cm	4.30	4.32	4.31	5.62	5.46	5.54
90 ×45cm	3.29	3.15	3.22	4.03	3.76	3.90
90 × 60cm	2.50	2.32	2.42	3.40	2.74	3.07
SEm (±)	**0.33**	**0.36**	**0.34**	**0.45**	**0.45**	**0.45**
LSD (0.05)	**0.97**	**1.06**	**0.99**	**1.31**	**1.32**	**1.31**

yield was computed by multiplying the oil concentration (%) with that of herbage yield and expressed in kg ha^{-1} (Singh and Guleria, 2012). The data was analysed using analysis of variance (ANOVA) for the qualitative and quantitative characters (Cocharan and Cox, 1957).

RESULTS AND DISCUSSION

Growth attributes

Plant height of patchouli at both harvests was not significantly influenced by different date of planting, land configuration and planting geometries during both the years of study (Table 1). Different planting geometries did not show significant effect on plant height at harvest stage of patchouli (Singh, 2008) and *kalmegh* crop (Semwal *et al.*, 2016). Also, Plant height at maturity was not affected significantly by different sowing methods *viz*. line sowing, ridge sowing and bed sowing (Ayub *et al.*, 2008).

However, the differences in plant spread of patchouli due to different date of planting, land configuration and planting geometries were influenced significantly at both harvests during both the years of study (Table 1). The maximum plant spread (0.61, 0.65 m^2 plant^{-1}, respectively in both the harvest) were observed at October 20, which was statistically at par with October 5 and both these levels were significantly higher than that of September 20. Patchouli planted on beds attained more plant spread (0.55, 0.63 m^2 plant^{-1}, respectively in both the harvest) which was significantly higher than that of flat planted plots (0.45, 0.50 m^2 plant^{-1}, respectively at both the harvest). Potential agronomic advantages of beds include reduced water logging, improved soil structure due to reduced compaction through controlled trafficking and timely machinery operations due to better surface drainage. It may be due to the favourable environment that this method provided to the plants leading to good emergence and healthier plants (Qasim *et al*., 2013).

The maximum values of plant spread were produced by planting geometries of 90×60cm (0.56, 0.63 m^2 plant^{-1}, respectively in both the harvest), which was statistically at par with 90 ×45 cm and these two planting geometries resulted in significantly higher values of plant spread than 90 ×30 cm. The lowest value of plant spread in 90 ×30 cm (0.40, 0.46 m^2 plant^{-1}, respectively in both the harvest) may be attributed to the fact that there was more number of plants under this treatment. Availability of abundant space between the rows encouraged horizontal growth of patchouli plants in wider row spacing of 75 cm leading to plants with significantly greater canopy spread (Singh, 2008). Planting geometry with more space produced significantly wider plant

Table 3: Effect of date of planting, land configurations and planting geometries on oil content and essential oil yield in patchouli during the years 2013-14 and 2014-15

Treatments	Oil content (%)						Essential oil yield (kg ha^{-1})					
	1st harvest			2nd harvest			1st harvest			2nd harvest		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Date of planting												
September 20	2.36	2.31	2.34	2.35	2.32	2.34	47.54	45.70	46.61	64.89	53.97	59.49
October 5	2.35	2.43	2.39	2.44	2.43	2.44	89.09	92.32	90.73	115.33	108.34	111.99
October 20	2.44	2.45	2.45	2.49	2.47	2.48	106.55	98.02	102.48	136.77	126.94	131.94
SEm (±)	**0.05**	**0.05**	**0.04**	**0.04**	**0.03**	**0.03**	**8.75**	**10.41**	**8.88**	**12.68**	**12.40**	**12.52**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**34.15**	**40.65**	**34.68**	**49.49**	**48.42**	**48.88**
Land configuration												
Flat planting	2.36	2.38	2.37	2.43	2.38	2.40	60.43	57.59	58.92	74.40	70.46	72.48
Bed planting	2.41	2.42	2.42	2.43	2.43	2.43	101.69	99.77	100.96	136.93	122.37	129.80
SEm (±)	**0.03**	**0.04**	**0.02**	**0.04**	**0.05**	**0.04**	**10.33**	**11.38**	**10.85**	**13.86**	**13.78**	**13.81**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**35.64**	**39.28**	**37.46**	**47.85**	**47.56**	**47.67**
Planting geometries												
90 × 30cm	2.38	2.41	2.40	2.43	2.40	2.42	104.42	104.71	104.54	137.27	132.53	135.04
90 × 45cm	2.43	2.40	2.42	2.33	2.41	2.42	79.25	76.24	77.84	97.99	91.18	94.69
90 × 60cm	2.34	2.39	2.37	2.42	2.40	2.41	59.50	55.09	57.45	81.73	65.54	73.68
SEm (±)	**0.05**	**0.05**	**0.03**	**0.05**	**0.04**	**0.05**	**7.99**	**9.14**	**8.33**	**11.12**	**11.33**	**11.18**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**23.32**	**26.70**	**24.32**	**32.47**	**33.09**	**32.64**

spread than that of all the other planting geometries in rose-scented geranium (Rajeshwra Rao, 2002) and in kalmegh crop (Semwal *et al.,* 2016).

Herbage yield, oil content and essential oil yield

Significant variations in date of planting, land configuration and planting geometries were recorded with respect to herbage yield (Table 2) and essential oil yield (Table 3) at both harvests during both the years of study. Significantly the highest herbage yield (4.20, 5.39 t ha^{-1}, respectively in both the harvest) and essential oil yield (102.48, 131.94 kg ha^{-1}, respectively in both the harvest) were recorded in October 20 which was statistically at par with October 5 and these treatments obtained significantly higher herbage yield and essential oil yield than September 20 at both harvests during both the years of study. Significantly higher yields of herb and essential oil were noticed in different dates of planting of patchouli (Sarma and Kanjilal, 2000) and of geranium (Ram *et al*., 1997).

Significantly higher fresh herbage yield (4.16, 5.37 t ha^{-1}, respectively in both the harvest) and essential oil yield (100.96, 129.80 kg ha^{-1}, respectively in both the harvest) were recorded in bed planting than in flat planting among both the harvests of patchouli. The results are similar to that of reported earlier in geranium in which significantly higher herb and essential oil under raised bed planting followed by flat and ridge planting methods (Anonymous, 2014). Similarly, Qasim *et al.* (2013) found that planting of potato on plain wide beds in lines produced maximum tuber yield per hectare.

Among different planting geometries, the highest pooled fresh herbage yield of both years of study (4.31, 5.54 t ha^{-1}, respectively at both the harvests) (Table 2) and essential oil yield of both years of study (104.54, 135.04 kg ha^{-1}, respectively at both the harvest) (Table 3) were observed in planting geometries 90 ×30 cm, proved significantly superior to 90×45 and 90×60 cm. This was due to the reason that the number of plants in 90×30cm were more than other spacing treatments *viz*. 90 ×45 cm and 90×60cm. Singh, 2008; Ramachandra *et al.,* 2002 obtained higher herbage yield and essential oil yield with closer spacing than wider spacing due to more number of plants per unit area. The date of planting, land configuration and planting geometries resulted in non-significant values of oil content of patchouli at both harvests during both the years of study (Table 3). Content and quality of essential oil of patchouli were not significantly influenced by planting geometries (Sarma and Kanjilal, 2000; Singh, 2008).

Based on two years' data, it may be concluded that the present study indicated that the highest herbage yield and essential oil yield were recorded in October 20 which was statistically at par with October 5 and these treatments obtained higher herbage yield and essential oil yield than September 20 at both harvests during both the years of study. Also, higher fresh herbage yield and essential oil yield were recorded in bed planting than in flat planting among both the harvests of patchouli. Among planting geometries, the highest fresh herbage yield and essential oil yield was observed in planting geometries 90×30cm, proved significantly superior to 90×45cm and 90×60cm.

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