



Assessment of date of planting, land configuration and plant spacing in geranium under sub-mountainous region of Punjab

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ABSTRACT

A field experiment was conducted at PAU Regional Research Station, Gurdaspur during 2013-14 and 2014-15 to assess the effect of date of planting, land configuration and plant spacing on the fresh herbage yield and essential oil yield of geranium under sub-mountainous region of Punjab. The experiment was laid out in split-split plot design having three replications with date of planting of geranium in main plots and land configuration in sub-plots and plant spacing in sub-sub plots. It consists of three planting dates of geranium plot viz. D₁: November 15, D₂: November 30, D₃: December 15, two land configurations (Bed and Flat planting) in sub-plots and three plant spacing viz. S₁: 90cm×30cm, S₂: 90cm×45cm, S₃: 90cm×60cm in sub-sub plots. The results indicated that the date of planting, land configuration and plant spacing did not show any significant effect on plant height of geranium at both harvests during both the years of study. The maximum plant spread was observed at D₁: November 15, which was statistically at par with D₂: November 30 and both these levels significantly higher than that of D₃: December 15. Geranium 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 plant spacing of S₃: 90cm×60cm, which was statistically at par with S₂: 90cm×45cm and these two plant spacing treatments resulted in significantly higher values of plant spread than 90cm×30cm. Significantly the highest herbage yield and essential oil yield were recorded in D₁: November 15 which was statistically at par with D₂: November 30 and these treatments obtained higher herbage yield and essential oil yield than D₃: December 15 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 geranium. Among plant spacing, the highest fresh herbage yield and essential oil yield was observed in both the harvest in plant spacing S₁: 90cm×30cm, proved significantly superior to S₂: 90cm×45cm and S₃: 90cm×60cm. The date of planting, land configuration and plant spacing resulted in statistically similar values of oil content of geranium at both harvests during both the years of study.

Key words: *Pelargonium graveolens*, essential oil, herbage yield.

INTRODUCTION

Geranium (*Pelargonium graveolens* L.) is a perennial bushy plant belongs to the family Geraniaceae is growing in China, Egypt, Algeria, Morocco and Reunion Island for the production of essential oil. Geranium is a native of dry rocky slopes of Cape Province (South Africa) and has spread to various parts of the world. It was introduced to India during early parts of 20th century and gained commercial importance in high altitude regions of Southern India (Tamilnadu, Karnataka, Andhra Pradesh) and some pockets of Himachal Pradesh, Uttaranchal and Uttar Pradesh. The current international demand of about 500-750 tonnes of geranium oil is being met largely by China, Egypt, Morocco, Reunion Island and South Africa (Anonymous, 2). In India, about 20 tonnes of geranium oil is produced annually but its own requirement is 200 tonnes approximately per year and fulfil its requirement by import (Ram *et al.*, 19). Geranium is propagated through rooted

terminal stem cuttings under favourable growing conditions. The essential oil of geranium obtained by steam or hydro-distillation of the aerial parts, (leaves, tender shoots and flowers). Such geranium oil is extensively used in the perfumery, cosmetic, food and pharmaceutical industries (Rajeswara Rao, 17). The geranium oils are characterized by presence of citronellol, geraniol, iso-menthone, linalool and wide range of esters, such as geranyl formate, citronellyl formate, geranyl acetate, geranyl propionate, citronellyl butyrate, 2-phenylethyl, citronellyl and geranyl tiglates (Chauhan and Verma, 5). It is one of the best skin care oil because it is good for opening skin pores and cleaning oily complexions. Geranium oil is useful for mite control, eczema, athlete foot problems and treatment of dysentery, haemorrhoids, inflammation, cancer, diabetes, diarrhea, gallbladder problems, gastric ulcers, jaundice, liver problems and useful in reducing pain due to post-herpetic neuralgia followed by shingles. The leaves are used as a form of herbal tea to de-stress, fight anxiety, ease tension, improve circulation and to cure tonsillitis (Peterson *et al.*, 14).

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Date of planting, land configuration and plant spacing 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. Higher water use efficiency was recorded with the planting techniques of seed spreading augmented with furrows and that of bed planting as compared to the flat planting technique (Aggarwal and Goswami, 1). In addition, 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 final crop yield in irrigation under seed spreading augmented with furrows planting method as compared to the flat planting (Nasrullah *et al.*, 13). Research work on these factors under Punjab conditions is meagre. Therefore, in dearth of such valuable information, the present investigation was undertaken to assess the effect of date of planting, land configuration and plant spacing on the fresh herbage yield and essential oil yield of geranium.

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-mountainous region of Punjab which is situated between 32°02' N Latitude, 75°22' E Longitude and has an altitude of about 265.17 m from msl to assess the effect of date of planting, land configuration and plant spacing on the fresh herbage yield and essential oil yield of geranium under sub-mountainous region of Punjab. The experimental site was clayey loam in texture, medium in organic carbon (0.53%), low in available phosphorus (12.38 kg/ha) and low in potassium (78.75 kg/ha) at 0-15 cm soil depth. The soil was neutral in reaction (pH - 7.1) with normal electric conductivity (0.28 ds/m). The experiment was laid out in split-split plot design having three replications with date of planting of geranium in main plots, land configuration in sub-plots and plant spacing in sub-sub plots. It consists of three planting dates of geranium plot viz. D₁: November 15, D₂: November 30, D₃: December 15, two land configurations (Bed and Flat planting) in sub-plots and three plant spacing (S₁:90cm × 30cm, S₂:90cm×45cm, S₃: 90 cm×60 cm) in sub-sub plots during both the years of study.

The planting material was raised through rooted terminal stem cuttings of geranium cultivar China. 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. D₁: November 15, D₂: November 30, D₃: December 15 during both the years with different plant spacing treatments (S₁:90cm×30cm S₂:90cm×45cm, S₃: 90 cm×60 cm). In flat planting, 90 cm row to row spacing was maintained with different plant to plant spacing according to treatment. In bed planting, 90 cm wide beds with 30 cm deep furrow were made. One row of geranium was planted in the centre of bed in which different plant to plant spacings were adjusted according to the treatment. The geranium crop was fertilized with 100 kg N/ha, 80 kg P₂O₅/ha) and 60 kg K₂O /ha 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 (Kaushik *et al.*, 10). The whole quantity of phosphorous and potassium were applied at the time of planting (Singh, 21).

The crop was irrigated immediately after transplanting, 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 regular weeding for 1-2 months since crop growth is very slow initially and thereafter at about 45 days interval. After harvest, a hoeing is done followed by irrigation. The crop was harvested twice after six months of transplanting in the month June and October during both the years. The entire shoot portion of geranium crop was harvested by clipping 20 cm above the ground level.

Data on plant height, plant canopy and fresh herbage yield above the ground level were recorded at the time of each harvest. Oil concentration (%) in fresh herbage was estimated by hydro distillation method using Clevenger's apparatus (Clevenger, 6). 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 yield was computed by multiplying the oil concentration (%) with that of herbage yield and expressed in kg/ha (Singh, 21).

The data was analysed using analysis of variance (ANOVA) for the qualitative and quantitative characters (Cocharan and Cox, 7).

RESULTS AND DISCUSSION

Plant growth

The date of planting, land configuration and plant spacing did not any show significant effect on plant height of geranium at both harvests during both the years of study (Table 1). Plant height at maturity was not affected significantly by different sowing methods viz. line sowing, ridge sowing and bed sowing (Ayub *et al.*, 4). In contrary to it, inter and intra-row space and possible competition for sunlight resulted in significantly taller plants compared with 90 cm and 120 cm row spacings. The plants were 17.7% lengthier in 60 cm than 120 cm row spacing (Rajeshwra Rao, 17).

Date of planting, land configuration and plant spacing influenced plant spread of geranium at both harvests during both the years of study (Table 1). The maximum plant spread (0.64, 0.57 m²/plant, respectively in both the harvest) were observed at D₁: November 15, which was statistically at par with D₂: November 30 and both these levels were significantly higher than that of D₃: December 15.

Geranium planted on beds attained more plant spread (0.61, 0.51 m²/plant, respectively in both the harvest) which was significantly higher than that of flat planted plots (0.49, 0.40 m²/plant, respectively in 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. There are several reports of reduced irrigation amounts or time, more plant spread, similar or higher yields, for vegetable crops on beds compared with conventional tilled vegetable crops, from farmer participatory trials and researcher plots across the IGP (Naresh *et al.*, 12). Sowing of sesame on beds and also on ridges produce higher spread, number of capsules per plant and more seed weight than flat sowing, because plants on beds have suitable spacing for light penetration and this arrangement may also reduce competition among the plants (El-Serogy *et al.*, 8). The results coincide with the findings of Qasim *et al.* (16) who reported that maximum plant spread (45.5 cm) after 60 days of planting of potato tubers was more in bed and ridge planting than flat planting. One reason may be due to the favourable environment that this method provided to the plants leading to good emergence and healthier plants.

The maximum values of plant spread were produced by plant spacing of S₃: 90cm×60cm (0.64, 0.54 m²/plant, respectively in both the harvest), which was statistically at par with S₂:90cm×45cm and these two plant spacing resulted in significantly higher values of plant spread than S₁: 90cm×30cm. The lowest value of plant spread in S₁: 90cm×30cm (0.40, 0.31 m²/plant, respectively in both the harvest) may be attributed to the fact that there was more number of plants under

Table 1. Plant height (cm) and plant spread (m²/ plant) of geranium as influenced by date of planting, land configurations and plant spacing during the years 2013-14 and 2014-15.

Treatments	Plant height (cm)						Plant spread (m ² /plant)					
	1 st harvest			2 nd harvest			1 st harvest			2 nd harvest		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Date of planting												
D ₁ : Nov 15	89.65	87.3	88.5	87.05	86.4	86.8	0.66	0.62	0.64	0.59	0.54	0.57
D ₂ : Nov 30	86.57	83.6	85.1	86.54	86.0	86.3	0.62	0.59	0.60	0.50	0.48	0.49
D ₃ : Dec 15	84.83	82.0	83.4	84.43	83.9	84.2	0.43	0.38	0.41	0.31	0.28	0.30
CD (p=0.05)	NS	NS	NS	NS	NS	NS	0.16	0.17	0.16	0.15	0.19	0.17
Land configuration												
Flat planting	86.28	83.6	84.9	85.20	84.4	84.8	0.51	0.46	0.49	0.41	0.38	0.40
Bed planting	87.75	85.1	86.4	86.82	86.5	86.7	0.63	0.59	0.61	0.52	0.49	0.51
CD (p=0.05)	NS	NS	NS	NS	NS	NS	0.10	0.11	0.10	0.09	0.10	0.09
Plant spacing												
S ₁ : 90cm×30cm	84.53	81.8	83.2	82.59	82.1	82.4	0.43	0.37	0.40	0.35	0.29	0.32
S ₂ : 90cm×45cm	86.63	83.9	85.3	86.70	86.1	86.4	0.62	0.59	0.61	0.51	0.48	0.50
S ₃ : 90cm×60cm	89.89	87.2	88.6	88.73	88.0	88.5	0.66	0.62	0.64	0.55	0.52	0.54
CD (p=0.05)	NS	NS	NS	NS	NS	NS	0.17	0.20	0.18	0.14	0.18	0.16

this treatment. Availability of abundant space between the rows encouraged horizontal growth of rose-scented geranium plants in wider row spacings of 90 cm and 120 cm leading to plants with significantly larger spread in these spacings (Rajeshwra Rao, 17). A greater plant spread in wider rows was earlier reported in rose-scented geranium (Prakasa Rao *et al.*, 15).

Herbage yield, oil content and essential oil yield

Significant variations in date of planting, land configuration and plant spacing 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 (11.31, 9.41 t/ha, respectively in both the harvest) and essential oil yield (22.63, 20.59 kg/ha, respectively in both the harvest) were recorded in D₁: November 15 which was statistically at par with D₂: November 30 and these treatments obtained significantly higher herbage yield and essential oil yield than D₃: December 15 at both harvests during both the years of study. The different cultivars of planting of geranium in October-November allowed the maximum production of essential oil (Ram *et al.*, 18). But Singh *et al.* (22) reported that cuttings planted in mid December recorded significantly higher survival (93.5%), fresh biomass (539.7 q/ha) and essential oil yield (54.9 kg/ha) than earlier or later planted cuttings. A delay in planting time from December to April resulted in a significant decreased in biomass and oil yield (Kaushik *et al.*, 10).

Significantly higher fresh herbage yield (10.76, 8.77 t/ha, respectively in both the harvest) and essential oil yield (21.92, 18.59 kg/ha, respectively in both the harvest) were recorded in bed planting than in flat planting among both the harvests of geranium. Ridge sown fennel crop produce higher seed yield than flat sown (Ashiq and Shah, 3). Higher grain yield was reported in bed and ridge sowing than flat sowing (Aggarwal and Goswami, 1). Also, Majeed *et al.* (11) reported that wheat planting on beds produced 15.06% higher grain yield than flat planting. Similarly, Qasim *et al.* (16) found that planting of potato on plain wide beds in lines produced maximum tuber yield per hectare (12.4 t/ha). It may be due to the reasons of good emergence, excellent plant spread. Due to good plant spread, more area was exposed to sunlight. It increased photosynthesis and thus increased starch accumulation, which led to high yield.

Among plant spacing, the highest fresh herbage yield (11.30, 9.12 t/ha, respectively in both the harvest) and essential oil yield (22.73, 19.59 kg/ha, respectively in both the harvest) were observed in plant spacing S₁: 90cm×30cm, proved significantly superior to S₂: 90cm×45cm and S₃: 90cm×60cm. This was due to the reason that the number of plants in S₁: 90cm×30cm were more than other spacing treatments S₂: 90cm×45cm and S₃: 90cm×60cm. In contrary to this study by Rajeseswara Rao (17) revealed that the row spacing of 60 cm×30 cm (60 cm between rows and 30 cm between plants within the rows) was superior

Table 2. Effect of date of planting, land configurations and plant spacing on herbage yield (t/ha) in geranium during the years 2013-14 and 2014-15.

Treatments	Fresh Herbage yield (t/ha)					
	1 st harvest			2 nd harvest		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
	Date of planting					
D ₁ : Nov 15	11.91	10.70	11.31	9.88	8.94	9.41
D ₂ : Nov 30	10.59	9.30	9.95	8.55	7.46	8.01
D ₃ : Dec 15	7.88	6.58	7.24	5.95	4.62	5.28
CD (p=0.05)	2.65	2.58	2.59	2.37	2.72	2.49
	Land configuration					
Flat planting	8.92	7.55	8.24	6.89	5.83	6.36
Bed planting	11.34	10.17	10.76	9.36	8.18	8.77
CD (p=0.05)	2.15	2.17	2.13	2.30	2.27	2.26
	Plant spacing					
S ₁ : 90cm×30cm	11.83	10.79	11.30	9.61	8.63	9.12
S ₂ : 90cm×45cm	9.84	8.46	9.15	7.96	6.67	7.31
S ₃ : 90cm×60cm	8.72	7.33	8.03	6.81	5.72	6.27
CD (p=0.05)	1.85	2.04	1.89	1.45	1.77	1.57

Table 3. Effect of date of planting, land configurations and plant spacing on oil content (%) and essential oil yield (kg/ha) in geranium during the years 2013-14 and 2014-15.

Treatments	Oil content (%)						Essential oil yield (Kg/ha)					
	1 st harvest			2 nd harvest			1 st harvest			2 nd harvest		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Date of planting												
D ₁ : Nov 15	0.20	0.20	0.21	0.22	0.21	0.22	23.55	21.12	22.63	21.65	18.63	20.59
D ₂ : Nov 30	0.21	0.19	0.20	0.23	0.21	0.22	22.53	17.67	20.13	18.88	14.92	16.85
D ₃ : Dec 15	0.20	0.19	0.19	0.21	0.20	0.21	15.74	12.27	14.26	12.56	9.39	11.28
CD (p=0.05)	NS	NS	NS	NS	NS	NS	4.15	4.33	4.13	4.09	5.49	4.83
Land configuration												
Flat planting	0.20	0.19	0.19	0.22	0.21	0.22	17.87	14.17	16.09	15.30	12.14	13.89
Bed planting	0.21	0.20	0.21	0.22	0.21	0.22	23.34	19.87	21.92	20.19	16.48	18.59
CD (p=0.05)	NS	NS	NS	NS	NS	NS	3.94	4.19	4.10	2.66	3.02	2.77
Plant spacing												
S ₁ : 90cm×30cm	0.21	0.19	0.20	0.22	0.21	0.22	24.55	20.41	22.73	21.00	17.65	19.59
S ₂ : 90cm×45cm	0.20	0.20	0.20	0.22	0.21	0.22	19.48	16.44	18.23	17.32	13.67	15.69
S ₃ : 90cm×60cm	0.20	0.19	0.20	0.23	0.22	0.23	17.79	14.22	16.07	14.92	11.62	13.44
CD (p=0.05)	NS	NS	NS	NS	NS	NS	3.50	3.28	3.18	2.43	3.12	2.73

to other row spacings and produced 57.4 t/ha total (total of four harvests) biomass yield (132.4% higher than 120 cm×30 cm spacing) and 52.7 kg/ha total essential oil yield (98.9% greater than 120 cm×30 cm spacing). A paired row arrangement (40/80 cm) of geranium planting significantly increased the herb and essential oil yield over the conventional single row planting method (60 cm×30cm) (Singh, 23). Singh (20) reported that the spacing of 60 cm×45 cm was superior to 75 cm× 45 cm and produced 12.1% higher herbage yield of patchouli than that of 75 cm×45 cm spacing and 10.9% greater total essential oil yield than that of 75 cm×45 cm. The date of planting, land configuration and plant spacing resulted in non-significant values of oil content of geranium at both harvests during both the years of study (Table 2). Planting methods did not vary statistically with respect to oil content (%) in Japanese mint (Kaur *et al.*, 9). Quality of oil was not influenced by plant spacing and intercropping systems (Singh, 20).

CONCLUSION

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 D₁: November 15 which was statistically at par with D₂: November 30 and these treatments obtained higher herbage yield and essential oil yield than D₃: December 15 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 geranium. Among plant spacing, the highest fresh herbage yield and essential oil yield was observed in plant spacing S₁: 90 cm×30cm, proved significantly superior to S₂:90cm×45cm and S₃: 90cm×60cm.

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