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GROWTH, BIOMASS AND OIL YIELD OF ROSE-SCENTED GERANIUM (*PELARGONIUM GRAVEOLENS* L. HERIT) AS INFLUENCED BY DIFFERENT HARVESTING STAGES

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***Abstract*: In order to investigate the effect of harvesting stage on growth, biomass and oil yield of rose-scented geranium; an experiment was conducted at the research field of Wondo Genet Agricultural Research Center in 2013/14 cropping season. Five levels of harvesting stages (90, 105, 120, 135 and 150 days after transplanting) were arranged in randomized complete block design with three replications. Plant height, number of branches/plant, number of leaves/plant, leaf area index, fresh leaf yield/ha, fresh stem yield/ha, harvest index, essential oil content(%) and essential oil yield/ha was significantly influenced by harvesting stages; however, moisture content (%) was not affected by harvesting stage. The highest essential oil yield (77.10kg/ha) was recorded at harvesting stage of 120 days after transplanting.**

***Keywords*: Rose-scented geranium; harvesting age; essential oil content (%); essential oil yield.**

I. INTRODUCTION

Rose-scented geranium (*Pelargonium graveolens* L. Herit) is an important high value perennial, aromatic shrub which belongs to the family of Geraniaceae [1]. It is originated from South Africa and it is cultivated in Egypt, India, China, and to a lesser extent in Central Africa, Madagascar, Japan, Central America, Belgium, Reunion Islands, Congo and Europe [1], [2]. There are about 700 different species in the Geraniaceae family [3], [1] out of which rose-scented geranium (*P. graveolens*) grows for production of essential oil from its leaves, tender shoots and flowers by using steam- and/or hydro-distillation [1], [4].

The essential oil of rose-scented geranium is widely used in soaps, perfumery and cosmetic industries [3], [5], [6], pharmaceutical industries [7], aromatherapy [4], flavoring agent in major food categories, alcohol and soft drinks [1]. It is used in skin care oil because it has the ability of opening skin pores and cleaning complexions [8], [9]. It is also used in the treatment of dysentery, diarrhea and colic [1], in heavy menstrual flow and menopause problems [6], hemorrhoid, inflammation, cancer, diabetes, gallbladder problems, gastric ulcers, jaundice and liver problems [10], [1], in reducing pain due to the post-herpetic neuralgia, sterility and urinary stones [11].

Traditionally rose-scented geranium is used to staunch bleeding; healing of wounds, ulcer, skin disorders, antibacterial and insecticidal properties [1], mite control, eczema and athletes foot [12], [13]. The leaves are used as a form of herbal tea to de-stress, fight anxiety, ease tension, improve circulation and to cure tonsillitis [9].

The main constituents of rose-scented geranium oil are citronellol (19.28-40.23%), geraniol (6.45-18.40%), linalool (3.96-12.90%), iso-menthone (5.20-7.20%), citronellyl formate (1.92-7.55%), Guaia-6,9-diene (0.15-4.40%) and traces of over hundred compounds [14], [15].

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The yield and quality of geranium was affected by harvesting frequency and plant shoot age [10], population density and seasonal changes [16], plant part distilled [17], temperature [10], [18], light and humidity, length of exposure to sunlight, availability of water, altitude and the presence of fungal diseases and insects [19] . The oil content and yield may also change as a result of the harvesting methods used, the isolation techniques employed, the moisture content of the plants at the time of harvest and the prevailing steam distillation conditions [20].

Despite the diverse advantages of rose-scented geranium have, research works in Ethiopia on this plant has been limited. This lack of information on appropriate agronomic practices is considered to be among the major obstruction to embark on mass production and utilization of this valuable plant in the country. Thus, it is believed necessary to assess appropriate production technologies that would enable to maximize biomass and essential oil yield in order to exploit this economically important plant as a cash crop. Therefore, the objective of this study was to assess the effects of harvesting age on growth, biomass and oil yield of rose-scented geranium.

II. MATERIALS AND METHODS

The field experiment was carried out at Wondo Genet Agricultural Research Center, Ethiopia in 2013/14 main cropping season. The experiment consisted of five levels of harvesting stages (90, 105, 120, 135 and 150 days after transplanting; which arranged in randomized complete block design (RCBD) with three replications. The experimental plot had an area of 7.2 m^2 (6 m length x 1.2 m width). The space between replications and plots was 1.5 m and 1 m respectively. Plants in the two middle rows out of the four rows per plot constituted the net plot used as the sampling unit. Five plants from the middle rows were taken for sampling and data analysis.

One year old fresh soft wood cuttings, having 10-15 cm length, were taken from the top parts of disease-free plants of rose-scented geranium cv. Shito which was released by Wondo Genet Agricultural Research Center in 2012/2013. The seedlings were grown at the nursery for about 90 days. Uniformly grown seedlings were selected, hardened and transplanted to the experimental field after 90 days of planting in the nursery site. Nitrogen (in the form of urea) at the rate of 120 kg/ha was applied uniformly in three splits, one during transplanting and the other 30 and 60 days from the date of transplanting. All appropriate agronomic practices such as weeding, watering and hoeing were conducted manually both at the nursery and experimental field uniformly.

Data on plant height, number of branches/plant, number of leaves/plant, leaf area index, fresh leaf yield/ha, fresh stem yield/ha, moisture content (%), harvest index, essential oil content (%) and essential oil yield/ha were collected randomly from the two middle rows of each plot at each harvest stages (90, 105, 120, 135 and 150 Days after transplanting (DAT)). Essential oil content was obtained by hydro-distillation, according to the procedure described by [21]. Dry leaves of rose-scented geranium having biomass of 300 g/composite sample was charged in the Clevenger apparatus along with 700 ml of water trapped for 3 h.

Data were subjected to analysis of variance (ANOVA) using General Linear Model (GLM), statistical analysis software program [22]. The Tukey's Studentized Range (HSD) Test was used to compare the mean separations at 5% probability level and for the interpretation of the correlation coefficient analysis.

III. RESULTS AND DISCUSSION

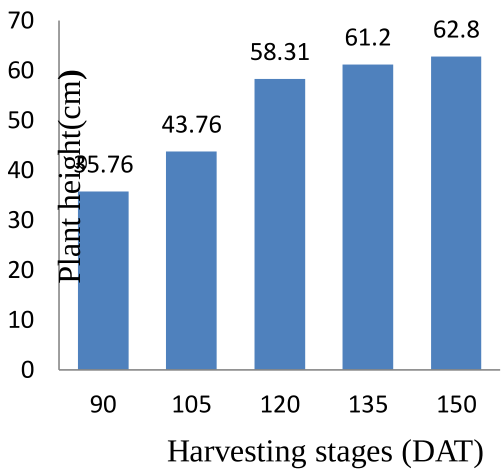
The analysis of variance table revealed that harvesting stage had been exerted significant ($P<0.001$) influence on plant height (cm), number of branches/plant, number of leaves/plant, leaf area index, fresh leaf yield (t/ha), fresh stem yield (t/ha), harvest index, essential oil content (%) and essential oil yield (kg/ha); however, moisture content (%) did not affected by the different harvesting stages (Table 1).

I. Plant Height**:** Significantly higher plant height (62.80 cm) was recorded at the harvest stage of 150 days after transplanting (DAT), whereas significantly lower plant height (35.76 cm) was recorded at 90 DAT. Delaying days to harvest stage of rose-scented geranium plants from 90 to 105, 120, 135 and 150 DAT plant height was increased by about 22, 63, 71 and 76%, respectively (Fig. A). This increase in plant height may be due to conducive growth condition and extended duration of harvest which increased plant height until it started to level off at 150 DAT. In harmony with the present result [10], [23] were reported similar results in rose-scented geranium.

TABLE 1: Analysis of variance for effect of plant spacing and harvesting age on growth, yield and yield components traits of rose-scented geranium

Source of variation	Replication	Harvesting age	Error	CV%
Degree of freedom	2	4	54	
Plant height	6.17	1716.33***	8.23	5.48
Number of branches/plant	5.91	34.63***	1.01	6.33
Number of leaves/plant	58.11	1117.93***	124.46	7.20
Leaf area index	0.001	0.060***	0.004	24.30
Moisture content (%)	9.99	16.90 ns	19.85	5.94
Fresh leaf yield/ha	16.74	450.94***	39.45	23.73
Fresh stem yield/ha	3.45	427.90***	13.45	24.14
Harvest index	0.0002	0.0369***	0.0002	2.44
Essential oil content (%)	0.00004	0.03460***	0.00044	9.85
Essential oil yield/ha	21.00	3234.55***	251.97	28.24

*ns; non-significant, and ***; significant at P< 0.001probability level.*



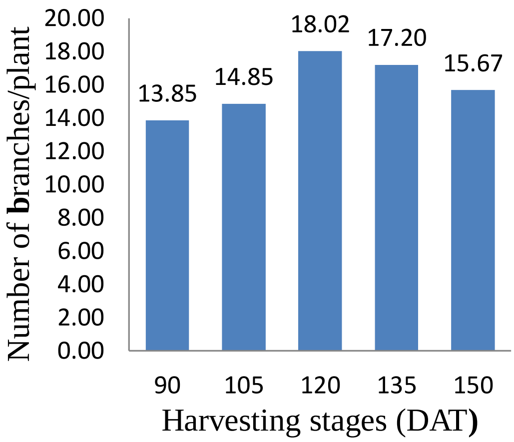


Fig. A **Fig. B**

Figure: Rose-scented geranium (Pelargonium graveolens L. Herit) field view

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II. Number Of Branches Per Plant: The highest number of branches/plant (18.02) was recorded at harvesting stage of 120 DAT followed by 135 DAT whereas the lowest value (13.85) was recorded when the plant was harvested at 90 DAT (Fig. B). Number of branches/plant at 120 DAT was increased by about of 30.22 and 15.00 than that of 90 and 150 DAT, respectively. In general, number of branches/plant increase with increased harvesting stage up to 135 DAT thereafter beyond this harvest it reduced. The increase in number of branches/plant up to 135 DAT might be due to the encouragement of commencing supplementary buds to regenerate new branches [24].

III. Number of Leaves per Plant: Significantly higher number of leaves/plant (164.87) was recorded when the plant was harvested at 135 DAT; which, however, this value was comparable with number of leaves obtained at harvesting stage of 150 DAT. On the other hand, significantly lower number of leaves/plant (142.05) was recorded when harvesting was done at 90 DAT (Fig. C). The increase in number of leaves/plant toward at the delayed harvesting stage (135 DAT) might be due to extended growth stage enabling the plant become vigorous and more branched and formation of new leaves on branches retained. These findings are in conformity with those of [25] in coleus and [26] in patchouli who reported that number of leaves/plant increased with harvesting stage. Number of leaves/plant was significantly and positively associated with number of branches/plant (r= 0.49***) (Table 2).

VI. Leaf Area Index (LAI): LAI increased with increasing harvesting stage up to 135 DAT thereafter decreased when harvesting was extended up to 150 DAT. At harvesting stage of 120 DAT the highest LAI (0.31) was recorded, however, it was equivalent with harvesting stage of 135 DAT (0.31). The lowest LAI (0.15) was obtained from the harvesting stage of 90 DAT (Fig. D). The increase in LAI at the delayed harvesting stage (135DAT) might be due to the increased in number of leaves/plant. According to the reports of [27] in cowpea and [25] in coleus reported an increase in leaf area with increasing harvest stage. Leaf area index was significantly and positively associated with fresh leaf yield/ha (r= 0.94***) (Table 2).

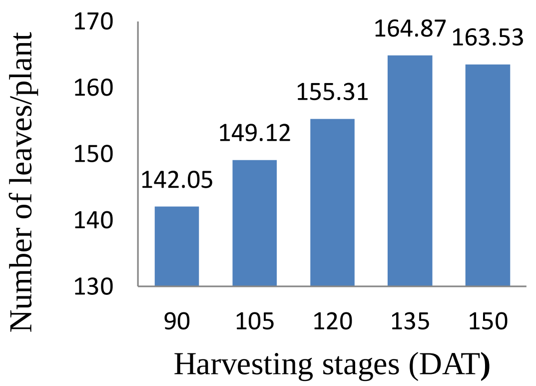

Fig. C

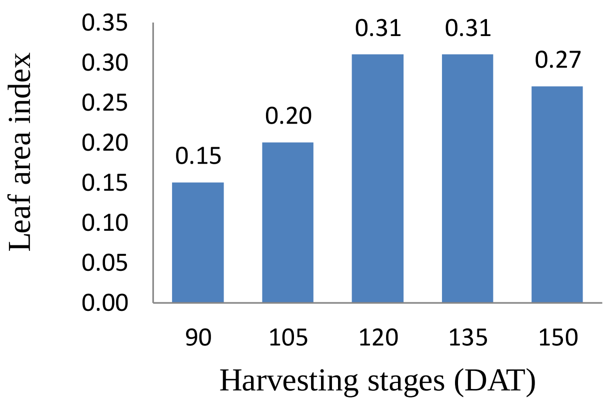

Fig. D

***V. Moisture Content (%)*:** The highest moisture content (76.17%) was recorded when harvesting was done at 135 DAT, however, this value was relatively comparable with the moisture content (75.26 and 75.87 %) at the harvesting stages of 105 and 120 DAT, respectively. The lowest moisture content (73.14%) was recorded when the plant was harvested at 150 DAT (Fig. E). Generally, the moisture content recorded in this experiment was within the range of (70-80%) reported by [7] for rose-scented geranium.

VI. Fresh Leaf Yield: Significantly higher fresh leaf yield (32.48 t/ha) was recorded when the plant was harvested at 120 DAT followed by comparable yield harvested at 135 DAT while significantly lower fresh leaf yield (17.31 t/ha) was recorded when harvesting was done at 90 DAT (Fig. F). The increase in fresh leaf yield/ha might be due to higher leaf area index at the extended harvesting age (120 DAT) whereas the decrease beyond 135 DAT might be due to senescence of older leaves as observed in the field. In agreement to this finding similar result was reported by [7], [28], [24] in rose-scented geranium. Fresh leaf yield/ha was significantly and positively associated with leaf area index (r= 0.94***) (Table 2).

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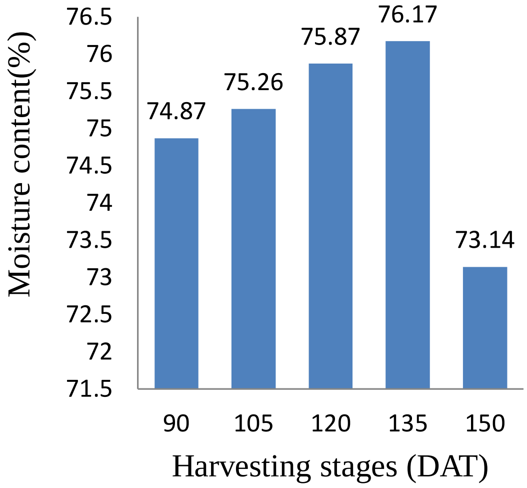

Fig. E

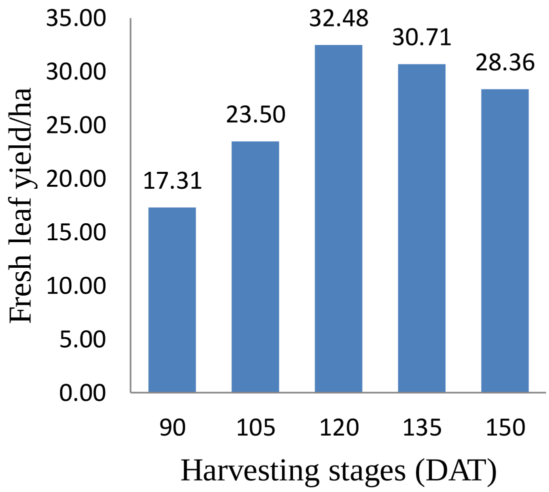

Fig. F

VII. Fresh Stem Yield: Fresh stem yield/ha increased with delaying in harvesting stage of the rose-scented geranium plant. The highest fresh stem yield (20.00 t/ha) was produced at the harvesting stage of 135 DAT while the lowest fresh stem yield (6.53 t/ha) was produced when the plant was harvested at 90 DAT (Fig. G). These findings are in conformity with those of Blank et al. (2012) in rose-scented geranium [29] in stevia and [30] in moringa. Fresh stem yield/ha was significantly and positively associated with leaf area index (r= 0.91***) and number of branches/plant (r=0.53***) (Table 2).

VIII. Harvest Index: The highest harvest index (0.73) was recorded at harvesting stage of 90 DAT whereas the lowest harvest index (0.59) was recorded when harvesting was done at 150 DAT (Fig. H). The lower harvest index at the delayed harvesting stage (150 DAT) may be due to relatively low essential oil content (%) at the same harvesting stage. In agreement with this finding [31], [32] were reported similar results in artemisia and fennel, respectively.

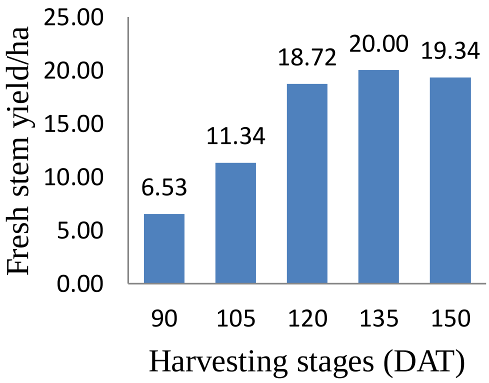

Fig. G

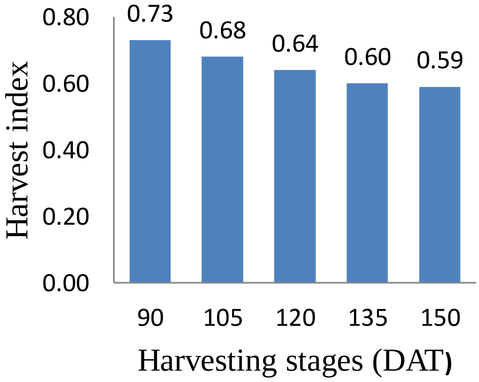

Fig. H

IX. Essential Oil Content (%): The highest essential oil content (0.26%) was recorded when harvesting was done at 90 DAT; however, the lowest essential oil content (0.13%) was recorded when the plant was harvested at 150 DAT (Fig. I). The higher essential oil content in young tissues (early harvest) could be for the plant to be competitive and achieve its primary growth and to prevent itself from stresses resulting from competition for growth factors by accumulation of these secondary metabolites.

***X. Essential Oil Yield*:** Significantly higher essential oil yield (77.10 kg/ha) was recorded at harvesting stage of 120 DAT which was comparable with essential oil yield (61.67 and 62. 88kg/ha) when the plant was harvested at 105 and 135 DAT, respectively. Significantly lower essential oil yield (36.32 kg/ha) was recorded at the harvesting stage of 150 DAT (Fig.

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J). The decrease in essential oil yield/ha at the earlier and delayed harvesting stage (90 and 150 DAT) might be due to higher leaf area index and fresh leaf yield/ha. Essential oil yield/ha at 120 DAT was superior by 78.93 and 25.02 at harvesting stages of 90 and 105 DAT and 22.62 and 112.28% when the plant was harvested at 135 and 150 DAT, respectively. These results are in line with those of [24], [29], [7] in rose-scented geranium, [33] in kalmegh who reported essential oil yield/ha increased with harvesting age. Essential oil yield/ha was significantly and positively associated with leaf area index (r= 0.67***), fresh leaf yield/ha (r=0.73***) and essential oil content(r=0.44***) (Table 2).

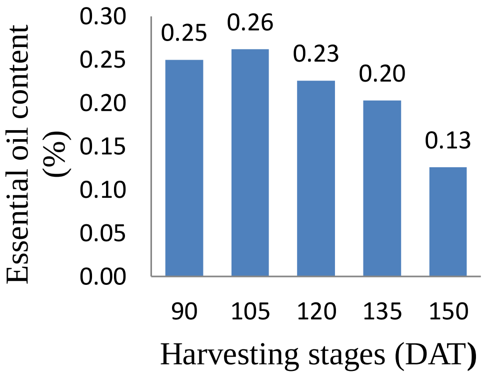

Fig. I

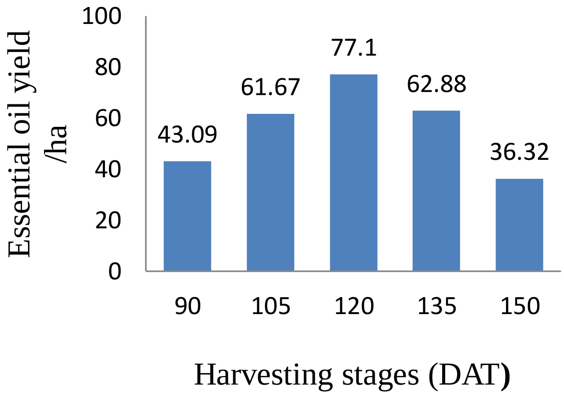

Fig. J

TABLE 2: Association among yield and yield component traits of rose-scented geranium

	PH	NBPP	NLPP	LAI	FLYPH	FSYPH	HI	EOC	EOYPH
PH	1								
NBPP	0.61***	1							
NLPP	0.50***	0.49***	1						
LAI	0.77***	0.50***	0.10^{ns}	1					
AGBPH	0.17^{ns}	-0.06^{ns}	-0.34**	0.46***					
FLYPH	0.74***	0.43**	0.01^{ns}	0.94***	1				
FSYPH	0.90***	0.53***	0.27*	0.91***	0.92***	1			
HI	-0.89***	-0.57***	-0.64***	-0.56***	-0.49***	-0.77***	1		
EOC (%)	-0.65***	-0.20**	-0.51***	-0.32*	-0.27^{ns}	-0.47***	0.70***	1	
EOYPH	0.24^{ns}	0.30*	-0.32*	0.67***	0.73***	0.50***	0.01^{ns}	0.44**	1

*ns; not significant at P< 0.05, * significant at P< 0.05; ** significant at P<0.01 and *** significant at P< 0.001probability level. PH=Plant height; NBPP=Number of branches/plant; NLPP= Number of leaves/plant; LAI=Leaf area index; FLYPH=Fresh leaf yield/ha; Fresh stem yield/ha; HI=Harvest index; EOC=Essential oil content (%); EOYPH=Essential oil yield/ha*

IV. CONCLUSION

The results of this study, harvesting stages had positive effect on higher plant, number of braches/plant, and number of leaves/plant, fresh stem yield, fresh leaf yield, harvest index, essential oil content and essential oil yield. Since higher essential oil yield (77.10kg/ha) was recorded at harvesting stage of 120 DAT, it can be recommend to use this harvesting stage for essential oil yield production in Wondo Genet area.

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