REVITALIZATION OF OLD ROSE (*Rosa damascena* Mill.) GARDEN FOR AGUMENTING GROWTH, FLOWER YIELD AND ESSENTIAL OIL QUALITY BY PRUNING AND FERTILIZER APPLICATION

ABSTRACT

The flower quality and essential oil concentration plays a critical role in marketing in local and international market. To unfold yield potential of the plants in old garden, cultural practices and nutrition remain the only feasible option as a part of management to the farmer to provide congenial environment to the plant. The impact of pruning and fertilizer application on growth, flower yield, volatile oil composition, physiological and biochemical processes are still poorly investigated on damask rose. Hence, the field experiment was led-out with nine treatment conditions encompassing three pruning systems and three fertilizer dosages to standardize the best practice to rejuvenate the old rose garden. The results showed that the pruning at 60 cm from ground level and application of 200:100:100 N, P_2O_5 and K_2O kg ha^{-1}exhibited maximum increase in growth parameters and flowering parameters like bud length (13.17 cm), diameter (5.52 cm), number of flowers per plant (273.41), flower yield (66.54 q ha^{-1}) and vase life (9.37 days) followed by pruning at 45 cm from ground level and application of 150:75:75 N, P_2O_5 and K_2O kg ha^{-1}. Essential oil characters like volatile oil percentage (0.051 %) and volatile oil productivity (0.973 l $plant^{-1}$) were highest in treatments of pruning at 60 cm from ground level and application of 200:100:100 N, P_2O_5 and K_2O kg ha^{-1}. From the experiment it is suggested that the old rose gardens can be rejuvenated by pruning and fertilizer application for better growth, flower production and increase in essential oil.

Keywords: Rose, Pruning, Nutrient management, Flower Yield and Essential oil.

1. INTRODUCTION

Damask rose (*Rosa damascena* Mill.) is a perennial shrub belongs to the Rosaceae family with a distinct scent. It is a significant oil rose species that is cultivated for rose oil, rose water, rose concrete, and rose absolute. “Rose flower extracts contain cooling, calming, astringent, anti-inflammatory, and antidepressant effects, which allow them to be employed in the pharmaceutical, food, and cosmetic sectors" (Abdel-Hameed, Bazaid, and Shohayeb 2012; Dolati, Rakhshandeh, and Shafei 2011; Kovatcheva-Apostolova *et al*. 2008; Kumar *et al.* 2009; Nikbakht and Kafi 2008). Interestingly, environmental conditions and cultural practices, particularly the pruning method, have a significant impact on flower yield and quality (Shawl & Adams, 2009; Pal, 2013; Pal & Singh, 2013). Pruning is an important productive technique which regulate crop growth by stimulating branching, and increasing floral yield (Sarkka & Erikson, 2003). Damask rose requires seasonal partial or total pruning to maximize flower and oil yield (Gibson, 1984).

In Damask rose production, pruning has a direct impact on flower production since it reflects on the number of final flowers with greater oil quality. To ensure the effectiveness of the pruning operation, "watering must be discontinued one month before and after the pruning process. Pruning intensity is a climacteric factor that improves flower production in rose" (Malhotra & Kumar, 2000). "The new auxiliary buds in the pruned stems will be initiated by facilitating physiological processes, and flower initiation occurs faster in comparison to non-pruned stems" (Chimonidou *et al.*, 2000). In the rose cultivation along with pruning intensity, nutrient management plays a crucial role in production of quality flowers and improving the essential oil composition. During crop regulation the improper nutrition management and lack of technical knowledge is one of the major causes for poor flower quality. Nutrition management plays important role in quality production in roses, especially macro nutrients which play major role in plant metabolism. "Nitrogen application not only enhances the vegetative growth but also assists the plant during blooming period to mobilize the processes of flower opening. Nitrogen enhances the vegetative growth" (Gurav *et al.*, 2005) and increases flower buds (Lovatt *et al.*, 1988). Nitrogen application increases plant height, number of leaves, plant spread and maximum flower number and weight. "Phosphorus has a critical role in cellular structure components and has a remarkable role in several metabolic pathways because it is required as a structural ingredient in biomolecules as part of DNA, RNA, phospholipids in plasma membranes, inositol triphosphate and ATP" (Loera-Quezadaa *et al.*, 2015). "P application maximizes flowers yield and content of volatile oil in damask rose under field conditions" (Ali *et al*., 2021). Potassium application plays an essential role in the production of plant components via several enzymes. "K fertilization increase oil production in aromatic plants by enhancing the amount of biomass yield unit, land area, leaf area development and photosynthetic rate" (Meneghini *et al.* 1998; Ram, Ram, and Singh 1995; Rao 2001; Sangwan *et al.* 2001). "Traditional pruning operation and fertilizer application of damask rose is done during winter in India" (Pal *et al.*, 2014). However, the scientific information on the rehabilitation of overaged damask rose garden through pruning and nutrient management is lacking. This lack of scientific knowledge hinders the improvement of flower yield from the old plantation of damask rose. Thus, this variability insisted to investigate the effects of ground-level pruning and fertilizer application on flower production and chemical profiling of essential oil of *Rosa damascena.* Therefore, the aims of this investigation were to (1) Study the effect of ground-level pruning on the flower yield of overaged bushes of damask rose; (2) To understand the combined effects of the pruning system and fertilizer application on flower yield, essential oil concentration, and quality.

2. MATERIALS AND METHODS

The experiment was conducted at floriculture experimental block of Sri Krishnadevaraya College of Horticultural Sciences, Ananthapuramu, affiliated to Dr. Y.S.R. Horticultural University, Andhra Pradesh during 2023-24 to standardize the effect of different pruning levels and Fertilizer dosages on the growth and productivity of damask rose (*Rosa damascena* Mill. var. trigentipetala) for attaining higher flowers production and quality of the volatile oil. The experimental site is located at the altitude of 335 m from mean sea level (14°37'42.7" N;77°31'43.7" E), where the average maximum and minimum temperature were 32.72 ±2˚C and 22.34 ±2˚C respectively. The average maximum and minimum relative humidity were 82.61 and 41.07 per cent. A total rainfall of 543.67 mm was received in 21 rainy days. The soil was sandy clay loam having pH of 7.3 and organic carbon of 0.43 per cent. The available nitrogen, phosphorus and potassium contents of experimental site were 269.32, 18.29, and 313.74 kg ha^{-1} respectively.

The experiment was laid out in the uniform bushes of two-year-old Damask rose garden, in which plants were planted at 2m between plants and within rows (2500 hills/ha). The plots of 16m × 16m were demarcated comprising 64 plants in each plot performed in 2^2 factorial randomized block design comprising of 9 treatments replicated thrice. The nine treatments were formed by considering each three levels of pruning and fertilizer dosages. The first factor includes pruning at 30cm from ground level (P_1), pruning at 45cm from ground level (P_2), and pruning at 60cm from ground level (P_3) whereas fertilizer dosages factor includes 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} (F_1), 150 kg N, 75 kg P_2O_5 and 75 kg K_2O ha^{-1} (F_2) and 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (F_3). Rose plants were pruned at first week of October-2023 as per the treatment specifications. Following pruning, half of the N, full P, and K were applied. Two divided doses of the remaining half dosage of N were administered into five splits with three weeks interval. The crop was grown under rainfed conditions; thus, the irrigation water was applied on need based with drip during the investigation. Other cultural practices like weeding, plant protection measures etc. were followed as per standard recommendation for *Rose damascena* for the semi-arid conditions.

The data was recorded on five randomly selected plants, five plants were randomly chosen from all the treatments from all the replications. The chosen plants were marked for the collection of day-to-day data. The data regarding plant height (cm), number of leaves branch^{-}, leaf area (cm^2), leaf total chlorophyll content (mg g^{-1}), days to flower bud emergence, bud diameter (cm), number of flowers plant^{-1}, peduncle length (cm), flower diameter (cm), fresh weight of a flower (g), flower yield (q ha^{-1}) and vase life (days) were collected using standard procedures at appropriate time. The flower harvesting was started on the march of 2024 and it was continued up to 57 days. To prevent the losses of volatile compounds, flowers were harvested in the early morning (6:00 to 7:30 AM) by manual hand picking.

"Manually picked fresh flowers of damask rose were used for essential oil extraction. The oil was extracted by the method of hydro distillation by a Clevenger-type apparatus for 4 h. For distillation, the proportion of flower to water was 1:2 (w/v) (Pal and Mahajan, 2017). For extraction of oil, 1 kg of fresh flowers was used for each sample and passed through anhydrous sodium sulfate to get water-free, the quantity of oil extracted from fresh rose petals was recorded and collected in a glass vial from different treatments was expressed as a percentage based on a fresh weight basis. The collected oil samples were kept at 4^0C in a dark place for further qualitative analysis. The identification of the oil constituents was assayed by gas chromatographic and mass spectroscopic (GC-MS) analysis of the rose oil extracted from fresh petals of *Rosa damascena* using Varian GC CP-3800 and MS Saturn 2200 equipped with a capillary column (VF-5ms 30 × 0.25mm ID and film thickness 0.25µm). The ionization energy of the electron system was 70 eV for the detection of GC-MS. The retention indices of volatile oil constituent peaks were compared with the standards and the NIST library of the GC-MS system to identify the components".

"The applicable data collected from the experiment were subjected to the analysis of variance (ANOVA) by Statistica 7 software to test the effects of the treatment. A two-factorial RBD was adopted in this experiment. The treatment means were differentiated with the help of LSD (least significant difference) value at $p = 0.05$ (Steel & Torrie, 1960). Statistica 7 software was further used to develop a correlation matrix to establish the relationships among the yield and its attributes and different compounds of essential oil".

3. RESULTS

3.1. Growth parameters

The flower yield of rose is affected by appropriate growth which put forth for a greater number of flowers per bush increase in yield. The results (Table. 1) rose shows that the growth parameters were influenced by pruning levels and fertilizer dosages of crop. The data from pruning levels revealed that the higher plant height (137.24cm), number of branches plant^{-1} (25.89), plant spread (56.59 cm^2), number of leaves branch^{-1} (42.56), leaf area (66.99 cm^2) and chlorophyll content (4.18) was recorded in plants pruned at 60cm from ground level (P_3) and lowest was observed in plants pruned at 30cm from ground level (P_1). The main effect of fertilizer dosages was noted that the application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (F_3) produced highest plant height (143.76 cm), number of branches plant^{-1} (28.24), plant spread (59.56 cm^2), number of leaves branch^{-1} (45.14), leaf area (68.14 cm^2) and accumulated more chlorophyll content (4.41) than the other two fertilizer dosages and lower growth parameters was observed with application of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} (F_1). The interaction effect of pruning levels and fertilizer dosages was significant and the plots of rose plants pruned at 60cm from ground level and combination with fertilizer application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (P_3F_3) produced maximum plant height (149.27cm), number of branches plant^{-1} (31.34), number of leaves branch^{-1} (49.17) and leaf area (72.05 cm^2) in while the data on plant spread and chlorophyll content was non-significant. The lower growth parameters were recorded in rose plants pruned at 30cm from ground level and combination with fertilizer application of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} (P_1F_1).

3.2. Flowering and flower bud characters

The flowering and flower bud characters is mainly governing by the genetic composition and environmental factor however some intercultural operations may also improve for some extent. The individual and interaction effects of pruning and fertilizer dosages influenced the flowering characters (Table.2). The individual effect of pruning and fertilizer dosages revealed that the rose plants pruned at 60cm from ground level and plants fed with 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} fertilizer dosage respectively. The interaction of two factors showed profound effect on improvement in the flowering and flower bud characters. The rose plants pruned at 60cm from ground level and fertilizer application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (P_3F_3) registered lowest number of days for first flower bud initiation (28.23 days), days to tight bud stage (33.87 days) and days to opening of first flower (34.58 days). The same treatment registered maximum length of flower bud (5.12cm), flower bud diameter (2.28cm) and weight of the flower bud (6.43g) which is on par with treated rose plants pruned at 45cm from ground level and fertilizer application of 150 kg N, 75 kg P_2O_5 and 75 kg K_2O ha^{-1} (P_2F_3) then the lowest flowering and flower bud characters was found in P_1F_1.

3.3. Flower yield and quality parameters

The flower yield of *Rosa damascena* per unit area is largely governed by the yield attributes like number of flowers per bush, individual flower weight which mainly depends on the flower bud characters. The significant difference was observed in yield and yield attributes in both main and interaction effects (Table. 3) of pruning and fertilizer dosages. The data from main effects of pruning and fertilizer dosages revealed that the rose plants pruned at 60 cm from ground level (P_3) and fertilizer dosage of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (F_3) produced highest number of flowers plant^{-1} (233.45 and 245.25 respectively), maximum flower yield plant^{-1} (1.57 and 1.69 kg respectively) and flower yield ha^{-1} (53.06 and 56.54 q ha^{-1} respectively). The lowest yield and yield attributes was observed in rose plants pruned at 30 cm from ground level (P_1) and fertilizer dosage of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} (F_1). The interaction effects of pruning levels and fertilizer dosages showed significant difference between the treatments, the rose plants pruned at 60cm from ground level and fertilizer application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (P_3F_3) registered more number of flowers $plant^{-1}$(273.81), highest flower yield $plant^{-1}$ (2.00 kg) and maximum flower yield ha^{-1} (66.54 q ha^{-1}) which is comparable with P_2F_3 and lower was found in P_1F_1.

Flower quality was mainly depended on the vegetative growth and flowering characters which ultimately controlled by intercultural operations. The main intercultural operations that influence the quality of the flower are pruning, fertilizer application, irrigation and weeding. Among all the intercultural operations the pruning and fertilizer application plays an crucial role in developing flower quality. Within the selected pruning levels and fertilizer dosages the main effects noted a profound improvement in quality. The effects of pruning levels revealed that the rose plants pruned at 60cm from ground level (P_3) registered longest peduncle for flowers (10.10cm), widest flowers (flower diameter) (5.25cm), maximum flower individual weight (6.73g), highest anthocyanin content (1.95g) and have more vase life (8.63 days) (Table. 4). On the other hand, the main effects of fertilizer dosages clarified that the rose plants with application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} fertilizers (F_3) recorded longest peduncle for flowers (11.24cm), widest flowers (5.38cm), maximum flower individual weight (6.87g), highest anthocyanin content (1.99g) and have more vase life (9.04 days). The lowest flower quality parameters were observed in flowers from plants pruned at 30cm from ground level (P_1) and fertilizer dosage of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1} (F_1) respectively. The interaction effect on flower quality was non-significant. However, the better flower quality was observed in rose plants pruned at 60cm from ground level and fertilizer application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (P_3F_3).

3.3. Essential oil quantification and composition

Essential oil quantity and composition was depended on the flower harvesting time, moisture content, flower quality and distillation method. For the oil extraction the flowers are picked in early hours of morning in the day (6:00 to 7:30 Am) to reduce the loss of moisture content from the flowers. The composition of extracted oil was analyzed in GC-MS. The observed data (Table. 5) from the extracted oil from distillation shown that the main effect of pruning was significant on the volatile oil parameters. The rose plants pruned at 60 cm from ground level (P_3) registered highest volatile oil percentage (0.045%), volatile oil yield (0.366) and volatile oil productivity (0.859) compared to remaining two pruning levels. While the fertilizer dosage not shown much significant difference in the volatile oil quantity except volatile oil percentage (0.047%). The interaction effect of pruning levels and fertilizer dosages does not show significant effect on volatile oil percentage and volatile oil yield. However, the oil productivity was recorded highest in rose plants pruned at 60cm from ground level and fertilizer application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (P_3F_3).

The essential oil analysis showed the presence of total of 29 constituents which contributed to about 89.72 to 97.16 % of the total volume. All treatments gave a similar profile with quantitative differences. The different oil constituents in response to pruning levels and fertilizer dosages are reported in Table 4. The volatile oil profile showed that the main components of the volatile oil were Citronellol (22.12-18.22%) and Geraniol (21.13-18.01%). The other important components were Heneicosane (5.02-4.62%), Linalool (7.77-4.61%), Nonadecane (7.03-7.68%), α-Pinene (4.02-3.62%), Geranial (3.32-2.87%), Phenyl ethyl alcohol (3.11-2.72%) and Myrcene (201-1.80%). Among all the constituents the Nonadecane, Caryophyllene oxide, Tricosane, Neral, 4-Terpenol and α-Pinene shown the significant difference with in treatments which was highest in the oil extracted from the flowers of rose plants pruned at 60cm from ground level and fertilizer application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1} (P_3F_3) and other compounds are non-significant within the treatments.

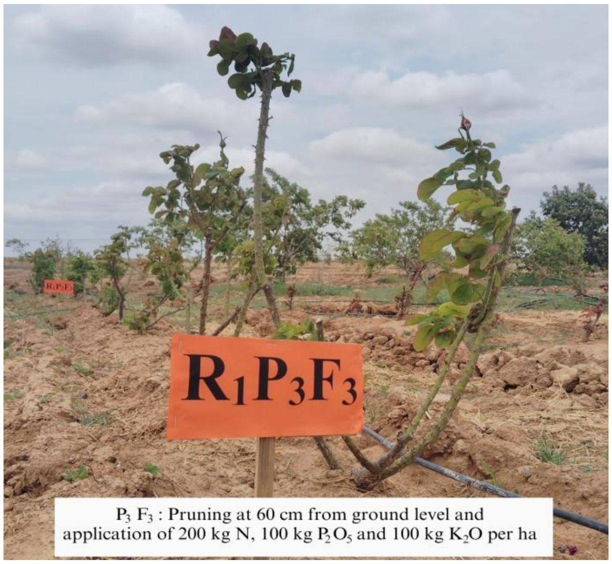

Fig. 1. Rose plants with P_3F_3 treatment

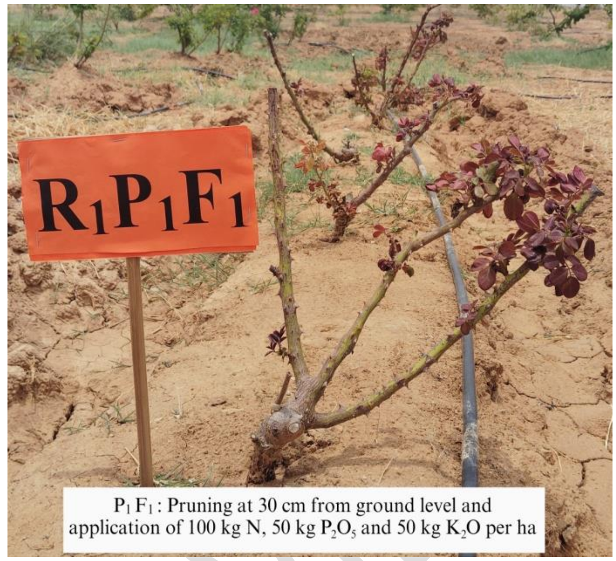

Fig. 2. Rose plants with P_1F_1 treatment

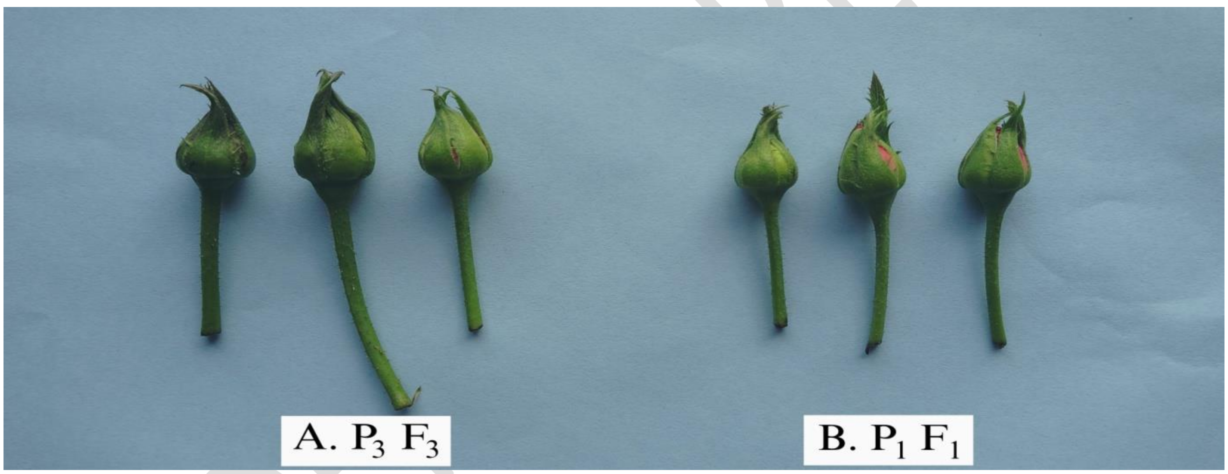

Fig. 3. Morphological difference of rose buds with P_3F_3 and P_1F_1 treatment

Fig. 4. Morphological difference of rose flowers with P_3F_3 and P_1F_1 treatment

Table 1: Effect of levels of pruning and fertilizer dosages on growth parameters of *Rosa damascena* Mill.

Treatments	Plant Height (cm)	Number of branches per plant	Plant spread (cm)	Number of leaves per branch	Leaf area (cm^2)	Chlorophyll content (mg/g)
Pruning levels:						
P_1	121.43	22.96	44.51	31.87	51.83	3.15
P_2	129.56	22.96	51.31	37.64	52.98	3.71
P_3	137.24	25.89	56.59	42.56	66.99	4.18
S Ed	2.99	0.83	1.39	1.4	4.56	0.14
CD (P = 0.05)	9.07	2.91	4.26	4.27	13.77	0.71
Fertilizer dosages:						
F_1	115.39	16.64	41.20	28.9	45.59	2.91
F_2	129.08	22.78	51.65	38.03	58.18	3.73
F_3	143.76	28.24	59.56	45.14	68.14	4.4
S Ed	2.53	1.89	2.55	2.08	2.99	0.21
CD (P = 0.05)	6.92	5.72	7.81	6.32	9.17	0.71
Interaction:						
$P_1 F_1$	107.32	12.44	36.14	21.23	31.`26	2.41
$P_1 F_2$	119.27	19.72	44.27	32.46	44.23	3.12
$P_1 F_3$	137.69	24.26	53.12	41.92	59.43	3.91
$P_2 F_1$	116.12	17.36	41.23	29.14	40.28	2.84
$P_2 F_2$	128.23	22.42	51.37	39.45	54.44	3.82
$P_2 F_3$	144.32	29.11	61.34	44.32	64.23	4.47
$P_3 F_1$	122.73	20.13	46.23	36.32	50.89	3.47
$P_3 F_2$	139.73	26.19	59.3	42.19	61.92	4.24
$P_3 F_3$	149.27	31.34	64.23	49.17	72.05	4.82
S Ed	3.13	1.27	2.01	2.01	1.41	0.19
CD (P = 0.05)	9.82	2.81	NS	5.01	4.32	NS

Table 2: Effect of levels of pruning and fertilizer dosages on flower bud developmental parameters of *Rosa damascena* Mill.

Treatments	Initiation of first flower bud (Days)	Days taken for tight bud stage	Days to opening of first flower	Length of flower bud (cm)	Diameter of flower bud (cm)	Weight of flower bud (g)
Pruning levels:						
P_1	43.60	46.87	48.06	3.85	1.44	4.95
P_2	40.23	43.28	44.03	4.18	1.74	5.42
P_3	36.13	39.73	39.30	4.59	1.99	5.87
S Ed	1.34	1.19	1.59	0.16	0.11	0.15
CD (P = 0.05)	4.21	3.68	6.01	0.52	0.31	0.49
Fertilizer dosages:						
F_1	45.31	49.4	49.73	3.61	1.37	4.72
F_2	40.23	43.36	43.81	4.25	1.72	5.45
F_3	34.42	37.11	37.86	4.77	2.08	6.06
S Ed	1.85	2.13	1.96	0.19	0.13	0.21
CD (P = 0.05)	5.67	6.54	6.01	0.61	0.42	0.68
Interaction:						
$P_1 F_1$	47.93	51.18	54.82	3.37	1.09	4.21
$P_1 F_2$	43.14	49.18	48.14	3.94	1.42	4.91
$P_1 F_3$	39.73	40.24	41.23	4.24	1.82	5.72
$P_2 F_1$	45.26	49.87	50.46	3.43	1.37	4.72
$P_2 F_2$	40.14	42.73	43.47	4.17	1.71	5.52
$P_2 F_3$	35.29	37.23	38.17	4.94	2.13	6.02
$P_3 F_1$	42.73	47.14	43.92	4.02	1.64	5.24
$P_3 F_2$	37.42	38.17	39.82	4.63	2.04	5.93
$P_3 F_3$	28.23	33.87	34.58	5.12	2.28	6.43
S Ed	1.23	1.11	1.29	0.08	0.05	0.14
CD (P = 0.05)	NS	NS	4.01	0.22	0.19	0.43

Table 3: Effect of levels of pruning and fertilizer dosages on flower yield and yield parameters of *Rosa damascena* Mill.

Treatments	Length of the peduncle (cm)	Diameter of the flower (cm)	Weight of the flower (g)	Number of flowers per plant	Flower yield (kg/plant)	Flower yield (q/ha)
Pruning levels:						
P_1	7.62	3.96	4.98	174.44	0.87	29.93
P_2	8.44	4.65	5.79	204.07	1.18	40.80
P_3	10.1	5.25	6.73	233.45	1.57	53.06
S Ed	0.56	0.23	0.32	8.99	0.13	3.52
CD (P = 0.05)	1.72	0.71	0.99	27.13	0.41	11.09
Fertilizer dosages:						
F_1	6.87	3.75	4.68	161.43	0.76	25.72
F_2	8.05	4.73	5.94	205.28	1.22	41.52
F_3	11.24	5.38	6.87	245.25	1.69	56.54
S Ed	1.03	0.19	0.29	12.45	0.11	4.81
CD (P = 0.05)	NS	0.67	1.01	40.27	0.39	14.61
Interaction:						
$P_1 F_1$	6.68	2.91	3.83	141.28	0.54	18.04
$P_1 F_2$	6.91	3.72	4.78	170.32	0.81	27.14
$P_1 F_3$	9.27	5.26	6.32	211.73	1.34	44.6
$P_2 F_1$	6.82	3.41	4.24	159.26	0.68	22.51
$P_2 F_2$	7.23	5.17	6.13	202.74	1.24	41.43
$P_2 F_3$	11.28	5.37	7.01	250.21	1.75	58.47
$P_3 F_1$	7.11	4.93	5.98	183.76	1.10	36.63
$P_3 F_2$	10.01	5.29	6.92	242.78	1.68	56.00
$P_3 F_3$	13.17	5.52	7.29	273.81	2.00	66.54
S Ed	0.62	0.09	0.11	8.07	0.08	2.73
CD (P = 0.05)	NS	NS	0.37	24.65	0.29	8.36

Table: 4 Effect of levels of pruning and fertilizer dosages on flower quality and essential oil parameters of *Rosa damascena* Mill.

Treatments	Anthocyanin pigment (mg/g)	Vase life (days)	Volatile oil percentage (%)	Volatile oil yield (ml/plant)	Volatile oil productivity (l/ha)
Pruning levels:					
P_1	1.63	7.52	0.039	0.298	0.766
P_2	1.77	8.09	0.042	0.328	0.804
P_3	1.95	8.63	0.045	0.366	0.859
S Ed	0.06	0.19	0.001	0.011	0.02
CD (P = 0.05)	0.22	0.61	0.004	0.039	0.059
Fertilizer dosages:					
F_1	1.6	6.95	0.038	0.286	0.747
F_2	1.77	8.24	0.041	0.332	0.795
F_3	1.99	9.04	0.047	0.374	0.887
S Ed	0.09	0.31	0.002	0.013	0.031
CD (P = 0.05)	0.26	0.82	0.007	NS	NS
Interaction:					
$P_1 F_1$	1.53	6.42	0.036	0.267	0.732
$P_1 F_2$	1.64	7.41	0.039	0.304	0.751
$P_1 F_3$	1.72	8.72	0.042	0.323	0.816
$P_2 F_1$	1.59	6.82	0.038	0.279	0.746
$P_2 F_2$	1.70	8.42	0.040	0.324	0.793
$P_2 F_3$	2.01	9.04	0.047	0.381	0.882
$P_3 F_1$	1.67	7.62	0.040	0.313	0.762
$P_3 F_2$	1.96	8.89	0.044	0.367	0.842
$P_3 F_3$	2.23	9.37	0.051	0.418	0.973
S Ed	0.07	0.16	0.002	0.01	0.03
CD (P = 0.05)	NS	NS	NS	NS	0.099

Table: 5 Effect of levels of pruning and fertilizer dosages on composition of essential oil of *Rosa damascena* Mill

Essential oil	$P_1 F_1$	$P_1 F_2$	$P_1 F_3$	$P_2 F_1$	$P_2 F_2$	$P_2 F_3$	$P_3 F_1$	$P_3 F_2$	$P_3 F_3$	S Ed	CD (P = 0.05)
Geraniol	18.01	18.11	18.72	18.27	19.01	19.19	19.18	20.09	21.13	1.23	NS
Linalool	4.61	4.68	4.70	4.69	5.62	5.75	6.70	7.71	7.77	0.16	NS
Citronellol	18.22	18.69	18.76	18.54	19.24	19.99	19.01	19.61	20.12	0.43	NS
α-Pinene	3.69	3.72	3.80	3.72	3.92	3.96	3.81	3.95	4.02	0.23	0.71
Geranyl acetate	0.76	0.82	0.84	0.79	0.87	0.91	0.86	0.90	0.94	0.14	NS
Nonadecene	2.24	2.32	2.48	2.29	2.51	2.65	2.43	2.61	2.71	0.11	NS
Heptadecane	1.38	1.40	1.42	1.40	1.49	1.51	1.46	1.49	1.53	0.09	NS
Tricosane	0.21	0.27	0.28	0.23	0.32	0.39	0.31	0.38	0.45	0.07	NS
Methyl eugenol	1.11	1.16	1.20	1.15	1.25	1.29	1.21	1.28	1.32	0.04	NS
Germacrene-D	0.56	0.64	0.69	0.61	0.72	0.79	0.71	0.77	0.84	0.08	NS
Geranial	2.87	2.99	3.07	2.91	3.18	3.27	3.16	3.21	3.32	0.12	NS
Myrcene	1.80	1.88	1.89	1.83	1.94	1.98	1.93	1.94	2.01	0.09	NS
Sabinene	0.06	0.08	0.09	0.08	0.12	0.15	0.11	0.15	0.17	0.03	NS
Geranylformate	0.22	0.25	0.26	0.25	0.29	0.34	0.28	0.32	0.36	0.04	NS
cis-Rose oxide	0.33	0.37	0.40	0.34	0.44	0.48	0.43	0.47	0.52	0.02	NS
Trans-Rose oxide	0.47	0.54	0.56	0.49	0.59	0.64	0.59	0.62	0.66	0.04	NS
4-Terpineol	0.28	0.33	0.34	0.29	0.40	0.45	0.36	0.42	0.52	0.04	0.13
Citronellylformate	0.14	0.19	0.21	0.17	0.25	0.26	0.22	0.25	0.29	0.09	NS
Neral	0.58	0.65	0.66	0.61	0.73	0.76	0.69	0.74	0.81	0.01	0.04
α-Humulene	0.41	0.47	0.49	0.44	0.53	0.58	0.52	0.55	0.59	0.07	NS
Eicosane	1.17	1.22	1.25	1.19	1.28	1.39	1.27	1.33	1.42	0.19	NS
Tricosane	1.19	1.24	1.27	1.23	1.30	1.34	1.29	1.33	1.38	0.01	0.03
Nonadecane	8.41	8.61	8.74	8.52	8.89	9.10	8.81	8.91	9.57	1.14	0.39
Heneicosane	4.62	4.71	4.77	4.68	4.84	4.96	4.79	4.91	5.02	0.21	NS
Phenyl ethyl alcohol	2.72	2.81	2.85	2.79	2.91	3.01	2.89	2.99	3.11	0.19	NS
Limonene	0.14	0.21	0.25	0.18	0.29	0.33	0.28	0.32	0.36	0.04	NS
Octadecene	0.15	0.23	0.25	0.19	0.29	0.39	0.28	0.33	0.42	0.06	NS
α-Guaiene	0.98	1.04	1.04	1.01	1.09	1.17	1.08	1.11	1.21	0.02	NS
Caryophyllene oxide	0.37	0.42	0.42	0.39	0.46	0.49	0.44	0.48	0.53	0.01	0.04
Farnesol	1.29	1.36	1.38	1.33	1.41	1.45	1.39	1.44	1.49	0.09	NS
α-Cadinol	1.18	1.24	1.28	1.23	1.30	1.31	1.29	1.33	1.39	0.02	NS

4. DISCUSSION

The vegetative growth parameters of rose, such as plant height, number of branches, plant spread, number of leaves per branch, leaf area and chlorophyll content have a substantial influence on plant growth. Maximum vegetative growth was reported when plants were pruned at 60 cm from ground level as compared to other treatments by boosting the plant's metabolic activity. The findings of the current investigation are consistent with the findings given by Mendhe *et al*. 2011, who discovered that "when the plant was pruned at 60 cm, the greatest vegetative growth". "Nitrogen is a structural element of chlorophyll and protein molecules, and thereby affects formation of chloroplasts and accumulation of chlorophyll in plants" (Tucker, 2004). "Application of higher nitrogen favored the optimum plant growth and extensive root system resulting in higher feeding power and nutrient absorption by the plant" (Wood & Roger, 2000). "This was also reflected in form of given higher dose of nitrogen higher chlorophyll content (Cabrera, 2004) found in the leaves, a greater number of leaves and plant spread in the treatment. Increase in Phosphorus and potassium content in leaf could be a result of synergistic effect of nitrogen availability on leaf nutritional status which putforth for better vegetative growth". Similar results have also been reported previously by Singh (2000) and (Saifuddin *et al.*, 2010).

"The treatment of pruning at 60 cm from ground level with high-rate application of fertilizers, resulted in the shortest number of days to the start of the first flower bud. It is likely that the early strong growth and pruning aided these plants in producing more cytokinin. Similarly, greater bud length and diameter may have facilitated in the transmission of these synthesized cytokinins, allowing plants to enter the reproductive phase earlier. The current study is supported by the findings of Nanjan *et al*. (1974) and Mendhe *et al*. (2011) in which pruning at 60 cm from ground level resulted in the shortest time to tight bud stage and the longest time to first flower opening. The significantly maximum stalk length was recorded in treatments of pruning at 60 cm from ground level with high-rate application of fertilizers. The results are inconformity with the findings of Patil *et al.* (2021) and Meshram *et al*. (2022)".

"Increase in the flower yield due to pruning could be ascribed to the improvement of new shoots initiation that bear more flower number. Enhancing the flower yield due to increasing the branching has been previously reported by Ali *et al.* (2014). Improving the flower yield due to pruning at 60cm could be ascribed to the outgrowth of a higher number of new shoots, which caused a temporary depletion of stored metabolic sinks from older shoots. Moreover, flowers yield depends on branches number on which flowering buds are produced" (Younis *et al.,* 2013). "Akhtar *et al.* (2016) proved that pruning is effective for increasing flowers yield. Our results are in harmony with the report of Pal & Mahajan (2017) and Kamble *et al.*, (2023) who reported that the proper pruning system could increase the flowers yield by improving the levels of both photosynthetic pigment and N content. Phosphorous has a pivotal role in genetic inheritance, membrane structure, signaling pathways, and metabolism, and therefore it is considered essential for all plants (Ashley *et al*., 2011; Butusov & Jernelöv, 2013; Kaur *et al*., 2024) which may explain the enhanced flower yield due to its application. Further, increasing the shoot number as a result of applying P-fertilizer might reflect in enhancing the flowers number and thus increases the yield and productivity".

In the present study, the volatile oil content was enhanced due to pruning and fertilizer treatments. Further, both factors were improved the oil constituents and oil yield. The main components detected in the volatile oil of the all treatments were Citronellol, Geraniol, heptadecane, nonadecane, Caryophyllene oxide, Tricosane, Neral, 4-Terpenol, Phenyl ethyl alcohol, α-Pinene, eicosane, and heneicosane which in agreement with the results of Mohamadi *et al.* (2011) and Shivani *et al.* (2022). In this study, we observed an increase in volatile oil content due to fertilizer application. Moreover, these main components were affected by pruning processes which is in accordance with the report of Pal & Mahajan (2017) and Ali *et al.* (2021) who found that the volatile oil content of damask rose was enhanced due to the pruning system and the oil main components were also improved. It has been proven that the nutrients have a positive role in secondary metabolites accumulation including volatile oils in several aromatic plants (Hassan *et al*., 2012; Hassan & Ali, 2013; Heidari *et al*., 2014).

5. CONCLUSION

The most significant finding of this field experiment is that pruning at 60 cm above ground-level with 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1}fertilizer application can significantly increase flower yield without losing the quantity and quality of essential oil from the old garden of *Rosa damascena.* The flower yield was significantly increased with the ground level pruning by about 26-32% compared with remaining pruning levels and fertilizer levels by increasing plant height, number of branches, number of leaves per branch, leaf area, plant spread, stalk length, bud length, diameter of bud, diameter of flower, number of flowers per plant, weight of flower, yield of flower per plant and yield of flower per hectare.

Based on the outcomes of this study, finally it is concluded that the old rose garden can rejuvenated by pruning at a height of 60 cm from the ground level and application of 200 kg N, 100 kg P_2O_5 and 100 kg K_2O $ha^{-1}$is efficient for enhancing growth, blooming, production, quality and vase life of the flowers which directly augmented the quantity and quality of the essential oils from the rose flowers.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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