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Impact of nutrient management strategies on growth and propagation potential of rose rootstocks (*Rosa multiflora* & Natal Briar) and scion varieties

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ABSTRACT

Quality planting material plays a pivotal role in attaining maximum productivity and quality of any flower crop. Considering this, an experiment to study the effect of nutrient management in rose rootstock (Rosa multiflora& Natal Briar) and scion (Arka Savi & Arka Swadesh) mother plants for propagation was carried out in the research block of the Division of Flower and Medicinal Crops, ICAR-IIHR, Bengaluru during the year 2022-23 and 2023-24. The experiment was laid out according to Factorial Randomized Block Design (FRBD) with two rootstocks (Rosa multiflora& Natal Briar), four different nutrient combinations (400:200:200 kg (control), 600:200:700 kg, 450:150:525 kg, and 300:100:350 kg NPK/ha/year) in five replications. Among the rootstocks, Natal Briar recorded the maximum plant height (185.81 cm) and maximum number of secondary branches per plant (15.95). Among different nutrient combinations tried, the application of 450:150:525 kg NPK/ha/year to the mother plants recorded maximum plant height (183.23 cm). Among the interaction effects, application of 600:200:700 kg NPK/ha/year to the Natal Briar rootstocks recorded maximum plant height (215.78 cm), and Rosa multiflora rootstock supplied with 450:150:525 kg NPK/ha/year recorded the maximum number of primary branches per plant (12.74). Among the different types of scion highest plant height was noticed in scion variety Arka Swadesh (107.37 cm); however, Arka Savi recorded the maximum number of primary branches/plant (4.48) and maximum number of secondary branches/plant (28.91). Among different types of nutrient concentrations, the nutrient 450:150:525 kg NPK/ha/year recorded the significantly maximum plant height (109.18 cm). However, the nutrient combination 600:200:700 kg NPK/ha/year recorded the maximum number of primary branches/plant (4.61). These findings could be used for the large-scale production of healthy and vigor rootstock and scion bud for the steady production of quality planting materials in roses. A major challenge was managing uniform nutrient application across seasons. The study contributes valuable insights for producing vigorous, healthy rose planting material at scale.

Keywords: *Rose, rootstock, scion, nutrients, plant growth parameters, mother plants, propagation, branching pattern, NPK fertilizer*

INTRODUCTION

The *Rosa × hybrid L.*, also referred to as the "Queen of Flowers," is a well-known member of the Rosaceae family and is a top cut flower on the international market because of its many different shapes, vivid colours, and delightful scent. In India, roses are cultivated over an area of 40.21 million hectares, yielding approximately 180.73 metric tonnes of loose flowers and 184.66 metric tonnes of cut flowers [3].

Roses are generally propagated through vegetative methods such as grafting, budding, stem cutting, cutting-grafting (stenting), root grafting, and tissue culture. The success of rooting in stem cuttings depends on factors such as the species and cultivar, growth season, vigour of the mother plant, age, and the portion of the branch, growing media, moisture level, nutrient status, temperature and type of cuttings (hardwood, semi-hardwood and softwood cuttings [8]. The vigour of the propagules depends upon the vigour of the mother plant, and nutrition plays an important role in promoting the initial growth and improving the quality of rootstock [5]. The growth and quality of roses are greatly influenced by nutrient management, which affects phytohormone balance and the source-sink relationship through the transport of photo assimilates. Nitrogen, phosphorus, and potassium are major and essential nutrients for plant growth and development, and their adequate levels enhance plant growth and development [6]. Raising and maintaining the rootstock and scion mother block of roses is crucial, as cuttings and budwood are frequently taken from the rootstock and scion, respectively. Therefore, replenishing the nutrients absorbed by these mother plants is essential to ensure the production of healthy, high-quality planting material. However, there is limited information on the effects of application of different doses of nutrients, mainly N, P and K, on the initial growth, development and vigor of rose rootstock and scion mother plants. Hence, this study investigated the effect of nutrient management in rose rootstock (*Rosa multiflora*& Natal Briar) and scion (Arka Savi & Arka Swadesh) mother plants for further propagation by cuttings and budding.

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MATERIALS AND METHODS

Description of the study area

The investigation was carried out at the Division of Flower and Medicinal Crops, ICAR-IIHR, Bengaluru, over a period of two years (2023-2024). The weather parameters for the experimental period are shown in Figure 1. The experimental field is located at 13°7′ N latitude and 77°29′ E longitude, 890 m above MSL. The climate of the experimental site is semi-arid, and the soil is red sandy loam. During the experimental period during year 2023-2024, the monthly average temperatures ranged from a maximum of 27.84 to 33.51 °C and a minimum of 20.58 to 22.81°C. The relative humidity varied from 80.80 to 91.14 % in the morning and 51.26 to 73.62 % in the afternoon.

Establishment of rootstock mother block

Rootstocks (*Rosa multiflora*& Natal Briar) were raised in the nursery using hardwood stem cuttings sourced from mother plants maintained in the field gene bank of ICAR-IIHR, Bengaluru. The one-and-a-half-month-old rooted cuttings were planted in the main field at a spacing of 1 m x 1 m. The experiment was conducted using a Factorial Randomized Block Design (FRBD) with five replications. The nutrient application to the mother plants was done as per the treatments: N_1 - 400:200:200 kg NPK/ha/year (control), N_2 - 600:200:700 kg NPK/ha/year, N_3 - 450:150:525 kg NPK/ha/year, and N_4 - 300:100:350 kg NPK/ha/year. As a basal dose, 25 t/ha FYM, 1/4th of N and K and half the amount of phosphorus were incorporated for all treatments along with Arka Microbial Consortium (AMC) @ 12.5 kg/ha. The remaining dose of NPK was applied in three equal splits at quarterly intervals.

Establishment of scion mother block

Leading loose flower and cut flower varieties of ICAR-IIHR were taken as scion varieties (Arka Savi& Arka Swadesh, respectively). The three-month-old budded plants of were planted in the main field at a spacing of 1 m x 1 m. The design followed in this experiment was Factorial Randomized Block Design (FRBD), replicated five times. The nutrient application was done as per the treatments: N_1 - 400:200:200 kg NPK/ha/year (control), N_2- 600:200:700 kg NPK/ha/year, N_3 - 450:150:525 kg NPK/ha/year, and N_4 - 300:100:350 kg NPK/ha/year. The dose and timing of nutrient application were similar to those used in the rootstock experiment.

Data collection

The data on plant height (cm), number of primary branches per plant, number of secondary branches per plant, plant spread N-S (cm), plant spread E-W (cm) and plant spread area (cm^2) were recorded on five randomly selected plants of the rootstocks (V_1-*Rosa multiflora* & V_2-Natal Briar) and scion varieties (V_1-Arka Savi & V_2-Arka Swadesh) at regular intervals. The pooled mean of each year was used for the tabulation and interpretation of the two years.

Statistical analysis

Since analysis of variance (ANOVA) indicated a significant difference between the two years of the study 2022-2023). Data for the two seasons were pooled for the rest of the analyses. The data were subjected to analysis of variance (ANOVA) using SAS software, version 9.3. Mean comparisons were performed using the least significant difference test (LSD) at the 5% significance level.

RESULTS AND DISCUSSION

Effect of nutrients on the growth &vigor of rose rootstock mother plants

The analysis of data on plant height, the number of primary branches per plant, and the number of secondary branches per plant in rose rootstock mother plants revealed significant differences between the two seasons as well as in the pooled mean (Table 1). Natal Briar rootstock recorded the maximum plant height during years I, II and pooled mean (186.46, 185.16 and 185.81 cm, respectively) and maximum number of secondary branches per plant during season II and pooled mean (15.84 and 15.95). Whereas, *Rosamultiflora* rootstock recorded the maximum number of primary branches per plant during year I and pooled mean (10.81 and 10.63, respectively). For different nutrient combinations, the nutrient level 450:150:525 kg NPK/ha/year recorded maximum plant height during year I, and the pooled mean (189.72 and 183.23 cm). According to [13], the translocation of N from the root to the aerial parts is facilitated by the ideal concentrations of K^+ and NO_3^-, with K^+ acting as a counter-ion in the xylem sap, favouring the loading of NO_3^- to the aerial part. On the other hand, concentrations above and below the plant's need, the transport of both nutrients, inducing accumulation in the root system. The maximum number of primary branches per plant during year I (11.18) however, the nutrient level 600:200:700 kg NPK/ha/year recorded the maximum plant height during year II (79.18 cm) and the maximum number of primary branches per plant during year II and pooled mean (11.72 and 11.30, respectively). Nitrogen is the principal mineral element responsible for rapid vegetative growth in plants [10]. The nutrient level 400:200:200 kg NPK/ha/year recorded the maximum number of secondary branches per plant during years I, II, and pooled mean (19.20, 17.14 and 18.17, respectively). Nitrogen is one of the principal nutrients responsible for plant growth, and its restriction directly influences the production of proteins, amino acids, and enzymes, indispensable for the production of non-structural carbohydrates, including starch and soluble sugars (sucrose, glucose, fructose and sorbitol). These molecules play an essential role in vegetative growth, providing structural components for the formation of new cells and, consequently, the maximum production of biomass [7]. Among the interaction effects, Natal Briar rootstock supplied with 600:200:700 kg NPK/ha/year (V_2N_2) recorded greatest plant height during year I, II and pooled mean (216.20, 215.36 and 215.78 cm, respectively) and *Rosa multiflora* rootstock applied with 450:150:525 kg NPK/ha/year (V_1N_3) recorded the maximum number primary branches per plant during year I, II and pooled mean (12.88, 12.60 and 12.74, respectively), however V_2N_1 (V_2-Natal Briar, N_1-400:200:200 kg NPK/ha/year) recorded maximum number of secondary branches per plant during year I, II and pooled mean (25.08, 22.16 and 23.62, respectively). [18] reported that phosphorus is not a limiting factor to the growth of peach rootstocks, however, despite being a nutrient that is only required in small amounts, adequate levels of the nutrient are essential for maintaining plant metabolism, for example, in the formation and integrity of cell membranes, in the production and transfer of cellular energy involving ATP, as well as in the metabolism of carbohydrates.

The perusal of data exemplified the significant impact of different nutrient levels on plant spread (N-S and E-W) and plant spread area (cm^2) of rose rootstock mother plants (Table 2).

Maximum plant spread (N-S) was recorded in rootstock *Rosa multiflora* during year I (245.78 cm); however, rootstock Natal Briar recorded maximum plant spread during season II and pooled mean (223.80 and 226.91 cm, respectively). For the different nutrient levels, maximum plant spread (N-S) during year I (245.76 cm) and plant spread area during year I and pooled mean (59473.54 and 54734.03 cm^2, respectively), however was recorded at the nutrient concentration 450:150:525 kg NPK/ha/year during year I, however application of 300:100:350 kg NPK/ha/year was recorded maximum plant spread during year II and pooled mean (219.30 and 232.06 cm, respectively) and plant spread area during year II (51343.70 cm^2). Among the interaction effect, V_1N_3 (V_1- *Rosa multiflora*, N_3-450:150:525 kg NPK/ha/year) was recorded maximum plant spread (N-S) during year I (276.76 cm) and maximum plant spread area during year I (66034.32 cm^2), however the combination V_2N_2 (V_2-Natal Briar, N_2-600:200:700 kg NPK/ha/year) was recorded maximum plant spread (N-S) during year II and pooled mean (251.52 and 247.04 cm, respectively), however maximum plant spread (E-W) during year I, II and pooled mean (269.96, 275.88 and 272.92 cm, respectively). Similarly, [2] observed that application of macro nutrients such as NPK at 25:20:15 g $plant^{-1}$ influenced best vegetative growth in rose plants in terms of plant spread, total leaf area, shoot diameter, and plant height.

Effect of varieties and nutrients on the growth and vigor of rose scion mother plants

Table 1 illustrates that the data pertaining to plant height, number of primary branches per plant and number of secondary branches of rose scion mother plants were significantly influenced by different nutrient levels. Significantly maximum plant height was noticed in scion Arka Swadesh during year I, II and pooled mean (107.25, 107.49 and 107.37 cm, respectively), however Arka Savi recorded the maximum number of primary branches per plant during year I, II and pooled mean (4.34, 4.62 and 4.48, respectively) and maximum number of secondary branches per plant during year I, II and pooled mean (28.88, 28.93 and 28.91, respectively). Nitrogen, phosphorus, and potassium, being the major and essential nutrients for plant growth and development, resulted in enhancing the vegetative growth with increased levels of the nutrients. The studies conducted on pomegranate with different doses of N, P, K, and FYM proved very useful in boosting the overall growth of the plants [15]. Among the different nutrient levels tried, the treatment 450:150:525 kg NPK/ha/year recorded significantly highest plant height during years I, II and pooled mean (107.60, 110.76 and 109.18 cm, respectively). This may be because FYM provided nutrients that were directly accessible to the plants, enhancing the soil's biological and physical characteristics. Additionally, Azotobacter influenced the uptake of micronutrients. Since nitrogen is a component of chlorophyll molecules and is used extensively in protein synthesis, higher concentrations of nitrogen resulted in much higher plant height in roses [17]. Earlier, [12] obtained that potassium at 200 kg ha^{-1} influences both primary and secondary branches in marigold. The 300:100:350 kg NPK/ha/year treatment consistently produced the maximum number of secondary branches per plant during year I and pooled mean (27.50 and 26.46), however, during year II (25.62) was noticed for 400:200:200 kg NPK/ha/year. The application of the optimum dose of NPK required for the plants can help increase and accelerate plant growth.

Nitrogen is needed by plants in large quantities, and its deficiencies make plants stunted and slow to grow. The contribution of nitrogen to plant growth is 40-50 %, the function of nitrogen in plants is as an important component of protein, nucleic acids, chlorophyll, enzymes, several growth hormones, affects the use of carbohydrates, and stimulates the uptake of other nutrients and has an important influence on the rate of growth of plants [19]. Earlier, [16] studied the effects of high phosphorus application on jasmine, which improved plant height and branch count. This might be because the soil is in better physical condition and there are more microorganisms, which likely led to the creation of second-order lateral shoots, which are more productive. Among interaction effect, V_2N_1 (V_2-Arka Swadesh, N_1- 400:200:200 kg NPK/ha/year) recorded the maximum plant height during season I (108.72 cm), however during year II and pooled mean (113.92 and 110.70 cm, respectively) was recorded highest plant height by V_2N_3 (V2-Arka Swadesh, N_3- 450:150:525 kg NPK/ha/year), however the maximum number of primary branches/plant observed in V_1N_2 (V_1- Arka Savi, N_2-600:200:700 kg NPK/ha/year) during year I, II and pooled mean (5.48, 5.28 and 5.38, respectively) and the combination V_1N_4 (V_2- Arka Savi, N_4-300:100:350 kg NPK/ha/year) recorded maximum number of secondary branches/plant during year I and pooled mean (37.36 and 33.88), however during year II (31.44) it was recorded by V_1N_1 (V_2-Arka Savi, N_1-400:200:200 kg NPK/ha/year) treatment combination. It is well established that K affects the metabolic processes linked to the incorporation of mineral nitrogen in the form of nitrate by either signalling for the transcription and expression of genes linked to the nitrate transporters that are in charge of N uptake or by activating the nitrate reductase enzyme [9].

Data with respect to plant spread (N-S), (E-W), and plant spread area (cm^2) of rose scion mother plants were significantly influenced by different nutrient levels (Table 2). Scion variety Arka Savi recorded the maximum plant spread N-S (67.90 and 65.74 cm, respectively), E-W (75.26, 72.66, and 73.96 cm, respectively) during year I and pooled mean compared to Arka Swadesh. Among the nutrient levels, treatment 600:200:700 kg NPK/ha/year recorded the maximum plant spread (N-S) during year I, II and pooled mean (71.48, 70.06 and 70.77 cm, respectively), and the nutrient 600:200:700 kg NPK/ha/year was recorded maximum plant spread area during year I, II and pooled mean (5067.46, 4701.82 and 4884.64 cm^2, respectively). This might be due to the fact that nitrogen is a key component of many of the most significant compounds found in plants, and its administration boosted the number of stems [11]. Because the Arka Savi variety has better growth and canopy spread. According to [14], the utilization of K, or plant growth, is closely linked to the total amount of this nutrient in the tissues because the cytoplasm must contain sufficient levels of K to support a number of nitrogen metabolism-related processes. Among the interaction effects, the combination V_1N_4 (V_1-Arka Savi, N_4-300:100:350 kg NPK/ha/year) recorded maximum plant spread (N-S) during year I (76.84 cm), however maximum plant spread (E-W) (84.11, 84.00 and 84.06 cm, respectively) were recorded during year I, II and pooled mean. The presence of a sufficient amount of NPK nutrients in the soil supports both functional traits and vigorous plant growth. Potash is essential for several physio-biochemical processes in plant cells, including the activation of many enzymes and nutrient uptake that promote rapid plant development [4].

CONCLUSION

The study concludes that NPK fertilization has a significant impact on the growth parameters of rose rootstock and scion mother plants, including plant height, number of primary and secondary branches, and plant spread. Among the rootstocks tested, Natal Briar showed the highest root spread compared to *Rosa multiflora*. The nutrient level of 450:150:525 kg NPK per hectare per year resulted in the greatest plant spread, while the same dose also led to the highest plant height. In contrast, the highest number of primary branches was observed at 600:200:700 kg NPK per hectare per year. In terms of interaction effects, the combination of *Rosa multiflora* with 400:200:200 kg NPK resulted in the tallest plants, whereas pairing *Rosa multiflora* with 600:200:700 kg NPK gave the most primary branches. Among the scion types, Arka Swadesh produced the tallest plants, while Arka Savi showed the maximum number of both primary and secondary branches, as well as the greatest plant spread and spread area. Overall, the research highlights that using Natal Briar as rootstock, Arka Savi as scion, and applying 450:150:525 kg NPK per hectare per year is ideal for maintaining vigorous and healthy mother plants. This approach supports large-scale production of quality planting material, enhances flower yield and quality, and contributes to higher income for farmers and nurserymen.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest: The authors declare that they have no conflict of interest.

AUTHORS' CONTRIBUTIONS

Maya Priya, Smitha G. R., D. Kalaivanan, Sujatha A. Nair, G. Venugopalan, and K.S. Shivashankar were involved in the conception and design of the experiment, recording observations, acquisition of data, analysis, and interpretation of data. All the authors were involved in drafting the manuscript.

Table 1: Effect of different rootstock genotypes and nutrient combinations on vegetative growth parameters of rose mother plants

Treatment	Plant height (cm)			No. of primary branches			No. of secondary branches		
	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean
Factor -Type of rootstocks									
V_1: *Rosamultiflora*	161.22	155.27	158.25	10.81	10.46	10.63	16.85	12.69	14.77
V_2: Natal Briar	186.46	185.16	185.81	9.64	10.12	9.88	16.05	15.84	15.95
SE(m)±	0.89	0.56	0.52	0.15	0.13	0.12	0.50	0.25	0.27
CD@5%	2.59	1.64	1.52	0.45	NS	0.34	NS	0.73	0.77
Factor B-Type of nutrients concentration									
N_1: 400:200:200 kg NPK/ha/year	169.20	169.20	169.20	9.28	8.84	9.06	19.20	17.14	18.17
N_2:600:200:700 kg NPK/ha/year	180.74	179.18	179.96	10.88	11.72	11.3	16.52	14.80	15.66
N_3:450:150:525 kg NPK/ha/year	189.72	176.74	183.23	11.18	10.88	11.03	14.44	13.02	13.73
N_4:300:100:350 kg NPK/ha/year	155.70	155.74	155.72	9.56	9.72	9.64	15.64	12.10	13.87
SE(m)±	1.26	0.79	0.74	0.22	0.18	0.16	0.70	0.36	0.38
CD@5%	3.66	2.31	2.15	0.63	0.53	0.48	2.05	1.03	1.09
Interaction effect (A X B)									
V_1N_1	144.72	145.12	144.92	9.52	8.84	9.18	13.32	12.12	12.72
V_1N_2	145.28	143.00	144.14	11.16	10.96	11.06	18.40	11.24	14.82
V_1N_3	192.32	168.92	180.62	12.88	12.60	12.74	16.76	14.32	15.54
V_1N_4	162.56	164.04	163.30	9.68	9.44	9.56	18.92	13.08	16.00
V_2N_1	193.68	193.28	193.48	9.04	8.84	8.94	25.08	22.16	23.62
V_2N_2	216.20	215.36	215.78	10.60	12.48	11.54	14.64	18.36	16.50
V_2N_3	187.12	184.56	185.84	9.48	9.16	9.32	12.12	11.72	11.92
V_2N_4	148.84	147.44	148.14	9.44	10	9.72	12.36	11.12	11.74
CD@5% (V x N)	5.18	3.27	3.04	0.89	0.74	0.67	2.90	1.46	1.55
SE(m)± (V x N)	1.78	1.12	1.04	0.31	0.26	0.23	1.00	0.50	0.53

Table 2: Effect of different rootstock genotypes and nutrient combinations on vegetative growth parameters of rose mother plants

Treatment	Plant spread N-S (cm)			Plant spread E-W (cm)			Plant spread area (cm^2)		
	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean
Factor A - Type of rootstocks									
V_1: *Rosamultiflora*	245.78	191.98	218.88	226.85	215.94	221.40	55805.28	41937.72	48,871.50
V_2: Natal Briar	230.02	223.80	226.91	244.92	245.10	245.01	56425.60	55333.05	55,879.32
SE(m)±	1.75	4.09	2.40	4.05	1.53	2.25	1,142.43	1,069.53	960.47
CD@5%	5.08	11.91	6.99	11.79	4.46	6.56	NS	3,114.30	2,796.72
Factor B- Type of nutrients concentration									
N_1: 400:200:200 kg NPK/ha/year	223.90	196.94	210.42	235.46	225.88	230.67	52601.96	44486.04	48,544.00
N_2: 600:200:700 kg NPK/ha/year	237.12	198.20	217.66	234.68	233.62	234.15	55714.64	48717.28	52,215.96
N_3:450:150:525 kg NPK/ha/year	245.76	217.12	231.44	242.70	229.80	236.25	59473.54	49994.52	54,734.03
N_4:300:100:350 kg NPK/ha/year	244.82	219.30	232.06	230.70	232.78	231.74	56671.62	51343.70	54,007.66
SE(m)±	2.47	5.79	3.40	5.73	2.17	3.19	1,615.64	1,512.55	1,358.30
CD@5%	7.19	16.85	9.89	NS	NS	NS	4,704.48	4,404.29	3,955.15
Interaction effect (AXB)									
V_1N_1	226.60	171.92	199.26	228.28	216.96	222.62	51511.80	37327.64	44,419.72
V_1N_2	231.68	144.88	188.28	199.40	191.36	195.38	45762.20	27690.72	36,726.46
V_1N_3	276.76	227.32	252.04	238.36	233.04	235.70	66034.32	52593.20	59,313.76
V_1N_4	248.08	223.80	235.94	241.36	222.40	231.88	59912.80	50139.32	55,026.06

V_2N_1	221.20	221.96	221.58	242.64	234.80	238.72	53692.12	51644.45	52,668.27
V_2N_2	242.56	251.52	247.04	269.96	275.88	272.92	65667.08	69743.84	67,705.46
V_2N_3	214.76	206.92	210.84	247.04	226.56	236.80	52912.76	47395.84	50,154.30
V_2N_4	241.56	214.80	228.18	220.04	243.16	231.60	53430.44	52548.08	52,989.26
CD@5% (V x N)	10.17	23.82	13.98	23.58	8.92	13.12	6,653.14	6,228.60	5,593.43
SE(m)± (V x N)	3.49	8.18	4.80	8.10	3.07	4.51	2,284.86	2,139.07	1,920.93

Table 3: Effect of different scion varieties and nutrient combinations on vegetative growth parameters of rose mother plants

Treatment	Plant height (cm)			No. of primary branches			No. of secondary branches		
	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean
Factor A - Type of variety									
V_1: Arka Savi	102.40	104.60	103.50	4.34	4.62	4.48	28.88	28.93	28.91
V_2: Arka Swadesh	107.25	107.49	107.37	3.74	3.72	3.73	19.94	20.16	20.05
SE(m)±	0.63	0.50	0.44	0.08	0.06	0.05	0.44	0.41	0.31
CD@5%	1.84	1.47	1.29	0.24	0.17	0.14	1.28	1.19	0.91
Factor B- Type of nutrient concentrations									
N_1: 400:200:200 kg NPK/ha/year	107.34	105.76	106.55	3.58	4.30	3.94	22.24	25.62	23.93
N_2:600:200:700 kg NPK/ha/year	99.36	101.30	100.33	4.60	4.62	4.61	23.22	22.60	22.91
N_3:450:150:525 kg NPK/ha/year	107.60	110.76	109.18	4.37	4.14	4.26	24.68	24.54	24.61
N_4:300:100:350 kg NPK/ha/year	105.00	106.36	105.68	3.60	3.61	3.61	27.50	25.42	26.46
SE(m)±	0.89	0.71	0.63	0.12	0.08	0.07	0.62	0.58	0.44
CD@5%	2.60	2.08	1.82	0.34	0.24	0.20	1.81	1.68	1.29
Interaction effect (A X B)									
V_1N_1	105.96	107.56	106.76	3.76	4.76	4.26	24.68	31.44	28.06
V_1N_2	93.40	97.84	95.62	5.48	5.28	5.38	28.92	27.68	28.30
V_1N_3	107.72	107.60	107.66	4.40	4.52	4.46	24.56	26.20	25.38
V_1N_4	102.52	105.40	103.96	3.72	3.92	3.82	37.36	30.40	33.88
V_2N_1	108.72	103.96	106.34	3.40	3.84	3.62	19.80	19.80	19.80
V_2N_2	105.32	104.76	105.04	3.72	3.96	3.84	17.52	17.52	17.52
V_2N_3	107.48	113.92	110.7	4.34	3.76	4.05	24.80	22.88	23.84
V_2N_4	107.48	107.32	107.4	3.48	3.30	3.39	17.64	20.44	19.04
CD@5% (V x N)	3.68	2.93	2.58	0.48	0.34	0.29	2.56	2.38	1.83
SE(m)± (V x N)	1.26	1.01	0.89	0.16	0.12	0.10	0.88	0.82	0.63

Table 4: Effect of different scion varieties and nutrient combinations on vegetative growth parameters of rose

Treatment	Plant spread N-S (cm)			Plant spread E-W (cm)			Plant spread area (cm²)		
	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean	Year I	Year II	Pooled mean
Factor A - Type of variety									
V_1: Arka Savi	67.90	63.58	65.74	75.26	72.66	73.96	5066.98	4616.28	4,841.63
V_2: Arka Swadesh	63.91	64.43	64.17	68.11	62.09	65.10	4411.97	4053.05	4,232.51
SE(m)±	0.57	0.72	0.50	0.62	0.67	0.50	74.74	79.82	69.29
CD@5%	1.65	NS	1.45	1.80	1.96	1.46	217.64	232.41	201.75
Factor B- Type of nutrients concentration									
N_1: 400:200:200 kg NPK/ha/year	57.92	62.36	60.14	73.34	68.72	71.03	4323.12	4318.28	4,320.70
N_2: 600:200:700 kg NPK/ha/year	71.48	70.06	70.77	69.82	66.48	68.15	5067.46	4701.82	4,884.64
N_3:450:150:525 kg NPK/ha/year	67.16	61.90	64.53	69.82	62.14	65.98	4586.32	3831.56	4,208.94
N_4:300:100:350 kg NPK/ha/year	67.06	61.70	64.38	73.76	72.16	72.96	4981.00	4487.00	4,734.00
SE(m)±	0.80	1.01	0.70	0.87	0.95	0.71	105.70	112.88	97.99
CD@5%	2.34	2.95	2.04	2.54	2.78	2.06	307.79	328.68	285.32
Interaction effect (A X B)									
V_1N_1	59.28	61.92	60.60	75.84	74.16	75.00	4556.64	4608.04	4,582.34
V_1N_2	67.48	66.56	67.02	67.24	68.16	67.70	4568.48	4556.88	4,562.68
V_1N_3	68.00	62.32	65.16	73.84	64.32	69.08	4870.80	3997.84	4,434.32
V_1N_4	76.84	63.52	70.18	84.11	84.00	84.06	6272.00	5302.36	5,787.18
V_2N_1	56.56	62.80	59.68	70.84	63.28	67.06	4089.60	4028.52	4,059.06
V_2N_2	75.48	73.56	74.52	72.40	64.80	68.60	5566.44	4846.76	5,206.60
V_2N_3	66.32	61.48	63.90	65.80	59.96	62.88	4301.84	3665.28	3,983.56
V_2N_4	57.28	59.88	58.58	63.40	60.32	61.86	3690.00	3671.64	3,680.82
CD@5% (V x N)	3.30	4.17	2.89	3.60	3.92	2.91	435.28	464.82	403.50
SE(m)± (V x N)	1.13	1.43	0.99	1.23	1.35	1.00	149.49	159.63	138.57

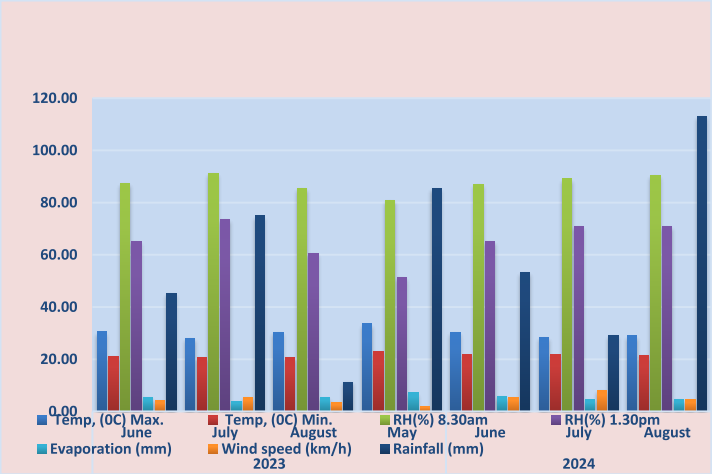

Figure 1. Meteorological parameters during the experimentation period.

Figure 2. A- General view of rootstocks mother block, B- General view of scion mother block

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