HIGH NPK SOLUTION AND PGP IMPROVED EOS PROPERTIES OF ROSE GROWN IN COCOPEAT

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ABSTRACT

This research was carried out at Research Station , Department of Horticulture and Landscape Engineering , College of Agricultural Engineering Sciences , University of Baghdad during fall season of 2020, it was aimed to improve flower productivity, quantity and quality of essential oils with increasing the concentration of N, P , K elements in the nutrient solution, and foliar app `lication of Plant growth promoters (PGP) on *Rosa Damascene* grown on a soilless culture system with coco peat substrate bags. A factorial experimental design was carried out according to (RCBD)with three replication. Results indicated the superiority of a high nitrogen treatment and 1.5 g of PGP (N2S2), of the flowers number, dry matter%, flower diameter, oil quantity and all physical and the anatomical characteristics, represented by the diameter of the head diameter of the glandular capillaries. Petals number increased significantly with a high potassium nutrient solution and PGP 1 g (N4S1).The high phosphorous solution, which was not treated with growth stimulator, showed superiority in the length of glandular capillaries.

Keyword*: Rosa Damascene*, Essential Oil, Coconut husks, glandular capillaries , Nutrients.
***Part of M.Sc. Thesis of the 1st author.**

محاليل مغذية عالية NPK ومحفز نمو النبات تحسن خصائص الزيوت الاساسية في الورد السلطاني النامي في وسط الكوكوبيت

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المستخلص:

اجريت الدراسة في محطة الابحاث , قسم البستنة وهندسة الحدائق , كلية علوم الهندسة الزراعية , جامعة بغداد في الموسم الخريفي 2020، بهدف تحسين انتاجية الازهار وكمية ونوعية الزيوت العطرية في نباتات الورد الدمشقي (السلطاني) المزروعة في نظام الزراعة من دون تربة في أكياس بلاستيكية من قشور جوز الهند، مع زيادة تركيز عنصر N و P و K في المحلول المغذي، والرش الورقي بمحفز نمو النبات (PGP) ، في تجربة عاملية بتصميم القطاعات كاملة التعشية، اشارت النتائج ال تفوق نباتات معاملة عالية النيتروجين و 1.5 غم .لتر−1من محفز النمو (N2S2) في عدد الأزهار ونسبة المادة الجافة وقطر الزهرة وكمية الزيت وجميع الخصائص الفيزيائية للزيت والصفة التشريحية التي تتمثل بقطر رأس الشعيرات الغدية. بينما زاد عدد البتلات بشكل ملحوظ في معاملة المحلول المغذي عالي البوتاسيوم ومحفز النمو 1 غم.لتر−1(N4S1)، وأظهرت نباتات المعاملة عالية الفسفور والتي لم تعامل بمحفز النمو (S3S0) ، تفوقًا في طول الشعيرات الغدية .

الكلمات المفتاحية: الزيوت العطرية، قشور جوز الهند، شعيرات غدية، خصائص فيزيائية للزيت، عناصر مغذية.

*** مستل من رسالة ماجستير للباحث الاول.**

Received:28/7/2021, Accepted:21/11/2021

INTRODUCTION

Damask rose (*Rosa damascena* Mill.) considered as one of the most important aromatic plants, cultivated as cut flowers in some varieties, indoor arrangement plants and, garden design (25) . Commercially cultivated for essential oil production, It has also been used in the food, perfumes and cosmetic industries for many years. A few cultivars of Rosa are only used to produce essential oils for perfume production Among these species, R. damascena, which is characterized by its high content of high-value essential oils compared to other varieties. The name of the type (Damascene) is due to the city of Damascus in Syria, where it grows as a wild plant, and it is called in Iraq the name (all Sultani) This species has a long history in the Middle East, where high-quality of essential oil is produced, which yielded high economic returns for workers in this field, however, it is now cultivated in different countries around the world (20). Essential oils are the main active components of many essential oils raw materials it is the most numerous group of medicinal raw materials, which has a long tradition It is still applied in a wide range of therapeutic fields (1, 3, 15, 18, 24). Oily raw materials are obtained from natural materials and from the crop, essential oils generally produced from plant cells by specialized secretory structures, after formation it released into the atmosphere through specialized secreting cells, such as osmophores, conical-papillae, glandular trichomes, ducts, cavities and sometimes they are secreted from unspecialized cells (6). Genetic factors control the synthesis of essential oils through the secondary compound metabolism, but this does not hinder the influence of biotic and abiotic environmental factors in essential oils parameters, composition and production quantity (28). Essential oil biosynthesis, such as other processes taking place in the plant, and it is dependent on a number of factors, among others, such as enzymes and presence of different input substances, depending on the metabolic pathway in which a given group of compounds is formed (8, 11, 29). Macroelements and microelements as nutrients affect plant metabolism, they play a major role in the growth and development of all crop plants. In the case of medicinal plants that produce essential oils, the nutrients can increase oil production and quality (5, 13, 26, 27, 30, 31). Nitrogen is one of essential minerals, included in the synthesis of organic compounds as amino acids, proteins, enzymes and nucleic acids, Amino acids and enzymes play a major role in the biosynthesis of many compounds which are components of essential oils (16) . In *Rosa damascena*, the bud development stage, flower yield and oil production were found to be associated with NPK levels in the petals, and in many countries the yield of rose flowers has been improved with the addition of nitrogen in some plants essential oil yield increased , and its composition modified by nitrogen fertilizer and the rate of applying (21). Potassium is a second important nutrient for plants, which usually occurs in the plant at a high concentration, potassium deficiency result, disturbances in nitrogen metabolism, by accumulation of harmful amino substances (19). Soiless culture system has become popular in recent years since it could be controlled more than regular agriculture system. Even more It saves us from soil problems such as fixation and unavailability (22) The aim of this research was to improve flower productivity, essential oil's quantity and quality of rose plants grown in a soilless culture system with coco peat substrate bags, by increasing the concentration of N,P,K elements in the nutrient solution, and foliar application of plant growth promoters (PGP).

MATERIALS AND METHODS

This study was carried out at Research Station ,Department of Horticulture and Landscape Engineering , College of Agricultural Engineering Sciences , University of Baghdad during fall season of 2020, from the first week of September 2020 until the last week of January 2021. Eighteen months old of *Rosa damascena* seedlings with a fairly homogeneous growth has been selected, at the 1^{st} sept. 2020 the seedlings pruned to three main branches with symmetric height, transferred 15^{th} sept. 2020 to bags contain coco peat as an agricultural medium for cultivation soilless systems. Experimental factors in this study were as follows :

1- (N) irrigation with four types of nutrient solution
N1 Balanced Nutrient Solution
N2 High Nitrogen Nutrient Solution
N3 High phosphorous nutrient solution
N4 High Potassium Nutrient Solution
2- (S) foliar application by plant growth promoters (disper bloom) PGP with concentrations below
1- S0 Zero concentration
2- S1 1 ml. L^{-1} concentration
3- S2 1.5 ml. L^{-1} concentration

The four Nutrient solutions were prepared by calculating the concentrations of the elements in commercial fertilizers with high water solubility, fertilizers weighted required concentrations of the elements according to the treatment mentioned above. on the 4^{th} of October 2020 plants had been firtigated with the four types of nutrient solutions twice a week, feeding started with 200 ml nutrient solution for each plant early growth stages while continuing to gradually increase the volume of the solutions, until reaching 350 ml per plant until the end of the experiment Foliar applications of PGP with three concentrations started on 1^{st} October 2020, every 10-day interval for four times during the growing season. A factorial experimental design (RCBD) (4 nutrient solution x 3 PGP concentrations) with 3 replicates were used; each replication consisted of 4 plants as an experimental unit, Statistical analysis had done by using (LSD) significant test probability level of 5% by Genstat. On 24 November, 2020 plants were sampled from each container For leaf tissue analysis for NPK %, While the cumulative numbers were recorded throughout the flowering period for the number of flowers, petals, average of flower diameter , dry matter, and essential oil (EO's) amount. The physical characteristics of EO's were determined as specific weight , refractive index and optical rotation of in Rosa damascena plant, and anatomical features that included, glandular capillary length and head diameter (micrometers) in *Rosa damascena* plant.

RESULTS AND DISCUSSION

Leaf NPK content

The Results in Figure (1) indicat that there were significant differences between the treatments irrigated with different nutrient solutions , higher significant for N% was (2.8%) in plant leaves of high Nitrogen nutrient solution treatment ,P% (0.66 %)in the plant of high phosphorous nutrient solution and for the K% (3.16 %) in plant of high Potassium Nutrient Solution

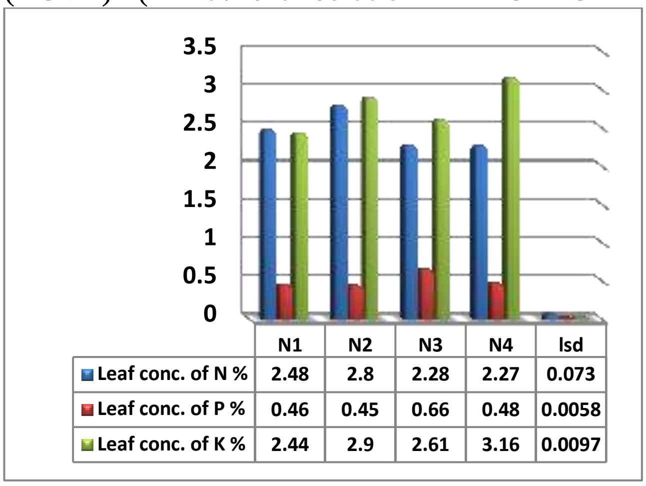


Figure 1. Effect of different nutrient solutions on N, P, K (%) in *Rosa damascena* leaves

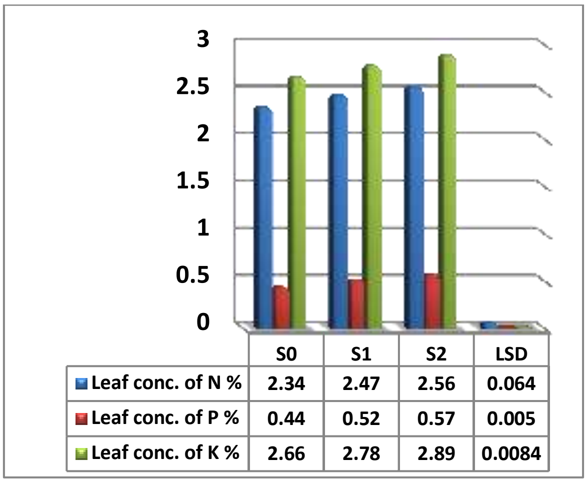
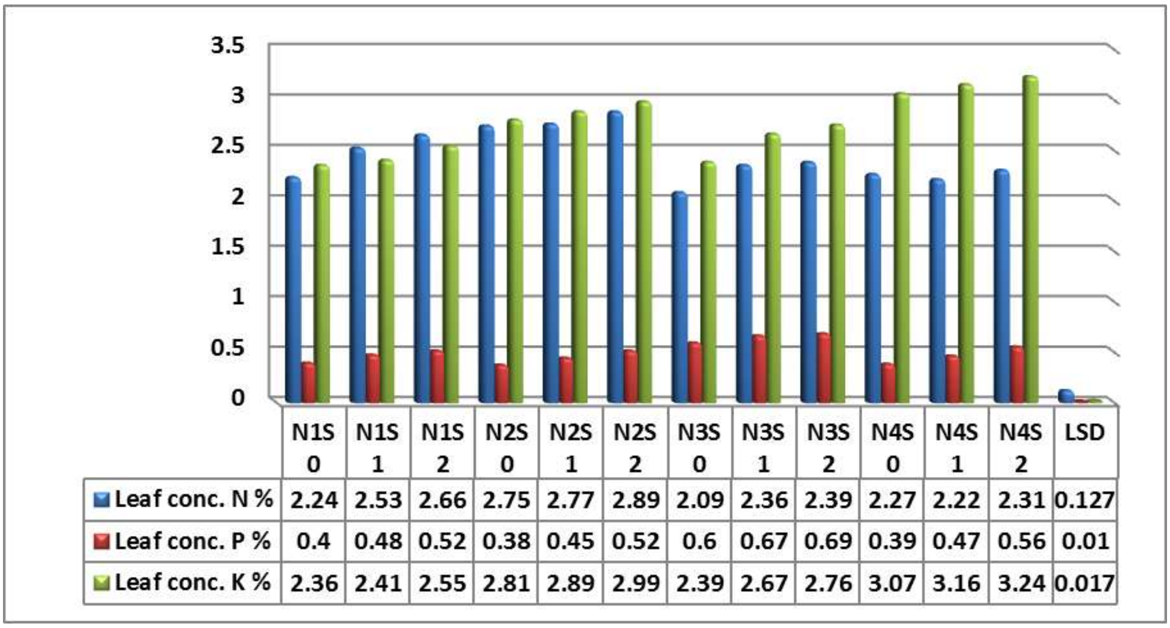


Figure 2. Effect of plant growth promoters (PGP) on N, P, K (%) in *Rosa damascena* leaves



	N1S0	N1S1	N1S2	N2S0	N2S1	N2S2	N3S0	N3S1	N3S2	N4S0	N4S1	N4S2	LSD
Leaf conc. N %	2.24	2.53	2.66	2.75	2.77	2.89	2.09	2.36	2.39	2.27	2.22	2.31	0.127
Leaf conc. P %	0.4	0.48	0.52	0.38	0.45	0.52	0.6	0.67	0.69	0.39	0.47	0.56	0.01
Leaf conc. K %	2.36	2.41	2.55	2.81	2.89	2.99	2.39	2.67	2.76	3.07	3.16	3.24	0.017

Figure 3. Effect of different nutrient solutions and plant growth promoters (PGP) on N, P, K (%) in *Rosa damascena* leaves

While the lowest concentration of nitrogen was (2.27 %) at high potassium nutrient solution the lowest concentration of P and K were at balanced Nnutrient solution (0.46%) and (2.44%)respectively . Resultes in Figure (2) illustrat that 1.5 ml.L^{-1} (S2) growth promoters (PGP) increased leaf content of NPK % (2.56% , 0.57% and 2.89 %) respectively . The lowest concentrations of N, P, K, were in the plant leaves that were not treated with growth stimulant (S0) (2.34 , % 0.44 % , 2.66 %) respectively. Figure (3) shows the superiority of the study factors interact in the plant leaf content of NPK elements, the treatment N2S2 had highest concentration of N (2.89 %) and N3S0 had lowest N (2.09 %). Treatment N3S2 had the highest concentration of P (0.69 %) and the lowest P (0.38%) was in N2S0, The highest K (3.24%) was in treatment N4S2 plants, and N1S0 recorded the less value of K (2.36%.)

Flowers number, dry matter, diameter, and number of petals: Results of Table (1) show that there were significant differences between the trait rates of treatments irrigated with different nutrient solutions, It reached the highest rate of number of flowers (16.9 flower.plant^{-1}) , Dry matter percentage (13.9 %) and flower diameter (12.4 cm) In plants fed with a high nitrogen nutrient solution (N2) when compared with the lowest value of flowers numbers (13.3 flower.plant^{-1}) In plants fed with a high phosphorous nutrient solution (N3), While the lowest values of dry matter (10.3 %) and flower diameter (9.9 cm) were In plants fed with a balanced nutrient solution (N1), high petals number was (58.4 petal.flower^{-1}) In plants fed with a high Potassium nutrient solution (N4) , while the lowest values of petals number was . (53 .8 petal.flower^{-1}) from high phosphorous nutrient solution (N3) . Plant growth promoter (PGP) concentrations showed an increase in flowers numbers, Dry matter and diameter (15.2 flower. plant^{-1}), 13.2 % and 11.9 (cm) respectively, when plants treated with disper bloom (PGP) 1.5 ml.L^{-1} (S2), petal number (59.4 petal. Flower^{-1}) increases when the concentration of PGP was 1 ml. L^{-1} (S1), however it's all decreases when PGP was Zero concentration (S0) (13.4 flower. Plant^{-1}), (11.7 %, 9.8 cm) and (52.9 petal. Flower^{-1}) respectively. The effect of the interaction of this study factors, showed a significant value of flowers number, dry matter and flower diameter (21.7 flower.plant^{-1}), (15.18 %) and (14 cm) respectively in plants of the treatment N2S2. The treatment N4S1 showed highly significant value in petal numbers (70.5 petals. flower^{-1}) the lowest values of flowers numbers ,dry matter ,flower diameter and petals numers recorded in the treatment N1S0 (11.3 flower. Plant^{-1}), (9.100%), (8.3 cm) and (49.2 petal. Flower^{-1}). The high Nitrogen treatment (N2S2) exceed in number of flowers formed per plant compared to the rest of the studied treatments

(Table1), and this may be attributed to role of nitrogen in influencing plant growth regulators, which affects the quality and number of flower buds formed (10). The results are in agreement with Ghafoor, Abdul (12) Which stated that the application of a high nitrogen feeding system gave the highest rate of flowers compared to the control treatment, the results also agreed with Alkhafaji & Khalil (2) that nitrogen fertilization increases the percentage of dry matter in plants.On the other hand, Oosten et al (23) indicated the role of growth stimulants in stimulating natural processes to increase the utilization of nutrients, increase their efficiency, plant tolerance to abiotic stresses and improve flowering quality

Table 1. Effect of different nutrient solutions and growth stimulator on number of flowers (flower. Plant^{-1}), Dry matter percentage %, flower diameter (mm), number of petals (petal. Flower^{-1}) in *Rosa damascene*

treatment Nutrient solutions	flowers number (flower. plant^{-1})	flowers Dry matter %	flower diameter (cm)	number of petals (petal. flower^{-1})
N1	13.3	10.3	9.9	55.4
N2	16.9	13.9	12.4	55.7
N3	13.3	12.9	11.0	53.8
N4	14.4	12.3	10.8	58.4
LSD	0.445	0.399	0.277	0.559
growth stimulator				
S0	13.4	11.7	9.8	52.9
S1	14.9	12.2	11.4	59.4
S2	15.2	13.2	11.9	55.2
LSD	0.385	0.345	0.240	0.484
N*S				
N1S0	11.3	9.1	8.3	49.2
N1S1	15.7	10.9	10.9	61.2
N1S2	13.0	10.9	10.5	55.8
N2S0	15.3	12.2	11.4	53.2
N2S1	13.7	14.4	11.8	53.4
N2S2	21.7	15.2	14.0	60.6
N3S0	13.3	12.8	10.1	55.5
N3S1	15.1	12.5	11.0	52.8
N3S2	11.5	13.3	11.9	53.2
N4S0	13.6	12.7	9.4	53.8
N4S1	15.0	10.8	11.7	70.5
N4S2	14.5	13.5	11.2	51.0
LSD	0.770	0.691	0.479	0.968

EOs amount, specific weight, refractive index and optical rotation

Results of Table (2) show that includes EOs amount (ml) and physical tests (specific weight, refractive index and optical rotation) of the essential oil extracted from plants flower petals of treatments irrigated with different nutrient solutions, showed significant differences compared to treatments irrigated with balanced nutrient solutions. The treatments with high nitrogen nutrient solution had high amount of EOs (0.46 ml) , with a specific weight rate of (0.87889), a refractive index of (1.46789) and an optical rotation of (-4.5444) in comparison with the lowest rates obtained for the tests of EOs Amount specific weight and refractive index with values of 0.21 ml , 0.84711 and 1.45633, respectively, in the treatment of the balanced nutrient solution, while the lowest rate of optical rotation value was(-3.2556) in plants treated with high potassium nutrient solution. There was a significant increases in the rates of EOs amount (ml) and physical tests by increasing the concentration of growth stimulator, as the highest value of EOs amount (ml) , specific weight, refractive index and optical rotation reached (0.35 ml , 0.86433, 1.46475 and -

3.8667) respectively, after spraying plants with a growth stimulator of 1.5 g.l^{-1}, followed by plants that were spraie concentration of 1 g.l^{-1}, which gave EOs Amount (0.33 ml) specific weight of (0.86258) a refractive index of (1.46208) and optical rotation of (-3.7333) compared to the lowest rates recorded values (0.30 ml 0.85258, 1.45783 and -3.2450) for each of the EOs amount (ml) , specific weight, refractive index and optical rotation , respectively in plants that had not treated with a growth stimulator. The interaction effect of study factors showed a significant difference in the values of EOs amount (ml) and physical tests of extracting essential oil. The treatment (N2S2) recorded the highest values of (0.49 ml) for EOs amount ml, (0.891) for specific weight and refractive index. It reached (1.473) and optical rotation (-5.1667) while the lowest value for EOs amount ml, specific weight and refractive index were (0.19 ml, 0.84533 and 1.45333) respectively, for treatment (N1S0), while the lowest value of optical rotation reached (- 3.08) in treatment (N3S0). The superiority of treatment (N2S2), the anatomical trait represented by the diameter of the glandular head And all the qualities of the essential oil (Tables 2) It is attributed to the important basic physiological role of nitrogen, as this element plays an important role in the biosynthesis of plant components through the activity of various enzymes and protein synthesis (14) . Which was reflected significantly on the increase of growth factors and chemical components of rose plant. as the concentrations of NPK and their interactions drastically affect the quantitative and qualitative characteristics of the essential oil content (7). The results of the oil in the current study agreed with the results of Kumar et al (17) Which showed that rose plants treated with high concentrations of nitrogen in the nutrient solution produced the highest amount of essential oil compared to the control treatment,the results also agreed with those obtained by Khalid (14) from the study of the black seed plant, which recorded a significant increases in the productivity of the essential oil after treatment with nitrogen and phosphorous. It also agreed with the results of Arancon et al (4) , which indicated that Increasing the nitrogen concentration in the nutrient solution had a positive effect on enhancing the essential oil content of the pepper plant. While the study of Sharafzadeh (26) showed that treatment with high levels of nitrogen gave higher percentages of Thymus vulgaris essential oil compared to the control treatment.

Glandular capillary length, and head diameterµm: Table (2) and Figure (4) shows significant differences among the treatments irrigated with different nutrient solutions for the two characteristics of glandular capillary length and glandular head diameter compared to those irrigated with a balanced nutrient solution. The highest potassium nutrient with an average length of (397.8 µm) followed by the treatment of high nitrogen solution, which reached (353.3 µm) compared to the lowest rate of glandular capillary length in the treatment of plants irrigated with the solution from the balanced nutrient with a length of (345.2 µm). As for the characteristic of glandular head diameter, the highest rate of glandular head diameter was (316.89 µm) in treatments irrigated with a high-nitrogen nutrient solution, followed by the high-phosphorous and high-potassium treatments with a glandular head diameter of (294.89 and 293.89 µm) respectively, compared to the average of the glandular head diameter in the treatments irrigated with the balanced nutrient solution was(261.44 µm). A significant decreases in the length of the glandular capillary average in plants treated with growth stimulator, as the shortest average glandular capillary lengths reached (393.2 µm) when plants were treated with a growth stimulator at 1.5 g.L^{-1} concentration, treatments that were treated with 1 g.l^{-1} concentration average lengths of (449.2µm) compared to the average length of glandular in plants that were not treated with growth stimulator, which reached(471.8 µm). As for effect of the growth stimulator on the average diameter of the glandular head, treatments that were treated with a growth stimulator at 1.5 g.L^{-1} concentration recorded the highest average diameter of the glandular head that was (338.83 µm), followed by the plants that were treated with a growth stimulator at 1 g.l^{-1} concentration, the average diameter of the glandular head of its capillaries was(292.17 µm), compared to (244.33 µm), which represents the lowest rate recorded in the treatments that were not treated with growth stimulant. The interaction effect of study factors was a significant superiority for the length of glandular in *Rosa damascena*, treatments, (N3S0) recorded the highest value of (765 µm), while the shortest length of glandular capillaries reached (302.3 µm) in treatment (N2S2),. While the results of the interaction of study factors on the diameters of the glandular heads, showed significant differences, as the highest value in the treatment (N2S2) reached (355 µm) compared to the lowest value of (200.67 µm) in the treatment (N1S0) The results of the anatomical study, which included measuring the length of the glandular capillary and the diameter of the glandular head . Table 2 shows the superiority of the highest nitrogen treatment (N2S2). With the largest diameter of the glandular head of the glandular capillary, which is responsible for secreting the essential oil, as the study of El-Sayed et al (9) showed an increases in the thickness of the groun tissue of the leaf, especially the parenchyma tissue, the high nitrogen treatment , and the high-phosphorous treatment, and this leads the researcher to the conclusion that the increases in the proportion of the elements nitrogen and phosphorous in the nutrient solution leads to an increase in the number of layers of the primary tissue and thus an increase in the number of layers of cells forming the glandular head in the treatment N2S2.

Table2. Effect of different nutrient solutions and growth stimulator on essential oil (EOs) amount (ml), specific weight, refractive index and optical rotation in *Rosa damascena* plant

treatment Nutrient solutions	EOs Amount (ml)	EOs specific weight	EOs refractive index	EOs optical rotation	Glandular capillary length Mm	Glandular capillary head diameter µm
N1	0.21	0.84711	1.45633	-3.3778	345.2	261.44
N2	0.46	0.87889	1.46789	-4.5444	353.3	316.89
N3	0.35	0.85656	1.46022	-3.2822	655.9	294.89
N4	0.29	0.85678	1.46178	-3.2556	397.8	293.89
LSD	0.00828	0.000780	0.000828	0.04495	16.31	0.730
growth stimulator						
S0	0.30	0.85258	1.45783	-3.2450	471.8	244.33
S1	0.33	0.86258	1.46208	-3.7333	449.2	292.17
S2	0.35	0.86433	1.46475	-3.8667	393.2	338.83
LSD	0.00717	0.000675	0.000717	0.03893	14.12	0.632
N*S						
N1S0	0.19	0.84533	1.45333	-3.2667	361.0	200.67
N1S1	0.21	0.84700	1.45700	-3.4000	352.7	252.00
N1S2	0.22	0.84700	1.45867	-3.4667	322.0	331.67
N2S0	0.41	0.85700	1.46100	-3.5000	385.7	284.67
N2S1	0.47	0.88867	1.46967	-4.9667	372.0	311.00
N2S2	0.49	0.89100	1.47300	-5.1667	302.3	355.00
N3S0	0.32	0.85300	1.45700	-3.0800	765.0	259.33
N3S1	0.35	0.85667	1.46067	-3.3333	657.7	304.67
N3S2	0.37	0.86000	1.46300	-3.4333	545.0	320.67
N4S0	0.28	0.85500	1.46000	-3.1333	375.3	232.67
N4S1	0.29	0.85800	1.46100	-3.2333	414.3	301.00
N4S2	0.30	0.85733	1.46433	-3.4000	403.7	348.00
LSD	0.01434	0.001351	0.001434	0.07786	28.24	1.265

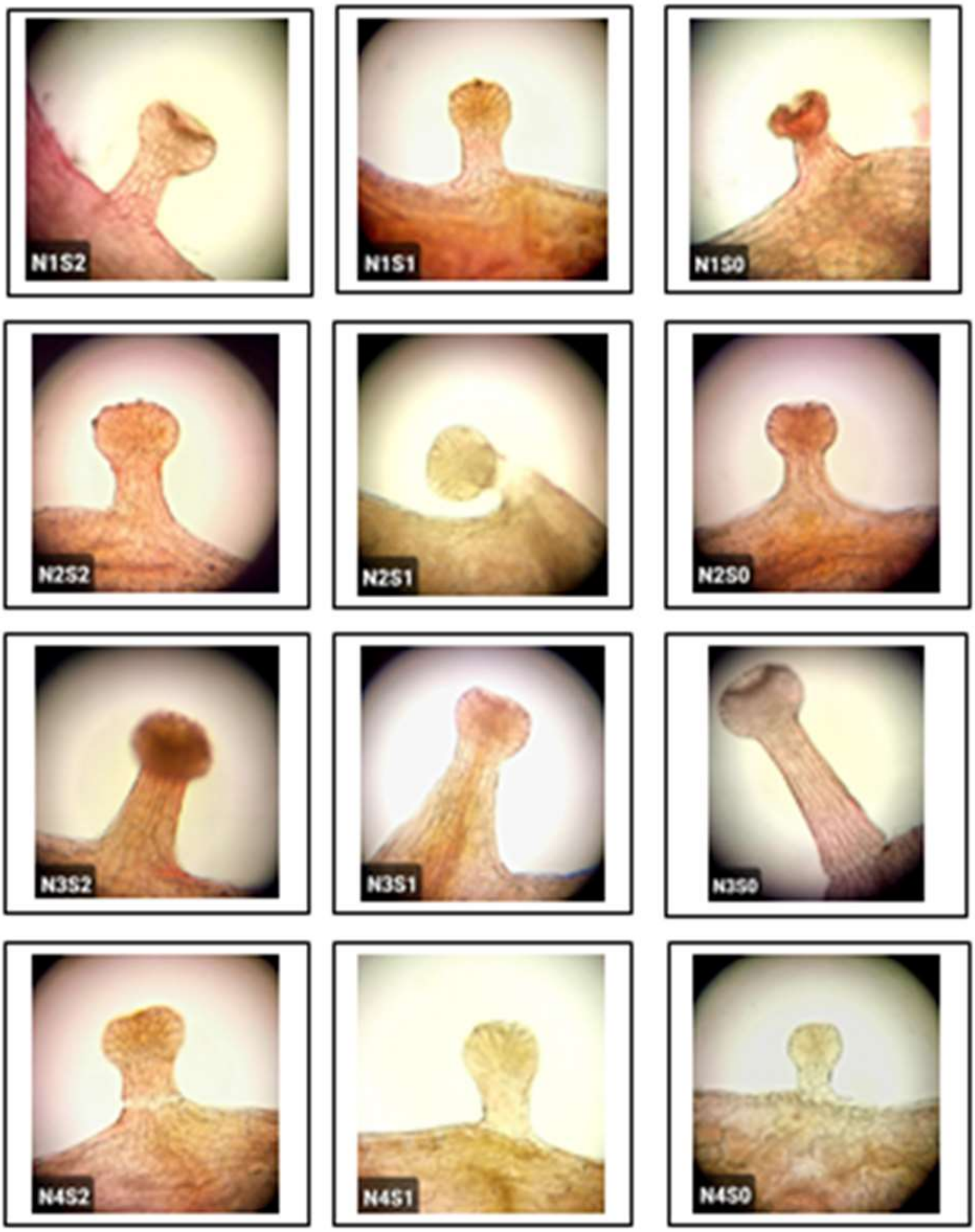


Figure 4. Glandular capillary under a light microscope (15X power) in the studied treatments in *Rosa damascena* (50 µm)

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