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Utilizing organic manures and seaweed extract to promote the vegetative growth of young solar eclipse plum trees

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Abstract

Organic fertilization has been proposed as an alternative method for supplying fruit trees with nutrients in the context of organic and sustainable agriculture. Seaweed extracts offer a natural alternative to chemical fertilisers. A field experiment was conducted in the plum research orchard at the Faculty of Agriculture, Cairo University, Giza, Egypt, over two successive seasons (2022-2024) to evaluate the impact of organic manures and foliar seaweed application on enhancing the vegetative growth of young solar eclipse trees. Organic manure treatments were applied as cattle manure (12.6 kg per tree), sheep manure (10.6 kg per tree) and cattle plus sheep manures (1:1) compared to NPK chemical fertilizers (120 N, 60 P and 100 K). The treatments were applied alone or in combination with the foliar application of seaweed extract at a rate of 0.75 g/L once every two weeks during the growing season. The obtained results revealed that the treatment cattle plus sheep manures exhibited significantly the highest values in trunk diameter, new shoot length, leaf number and tree canopy volume. The cattle plus sheep manure treatment had almost the highest leaf area. Leaf chlorophyll content was significantly higher using cattle plus sheep manures. In addition, a mixture of cattle and sheep manures applied to the soil, combined with foliar application of seaweed extract, showed the highest content of leaf nutrients, total carbohydrates, and total amino acids. Chemical characteristics and vegetative growth were improved by using organic manures combined with foliar applications of seaweed extract. This method could be considered an alternative to traditional fertilisation of young plum trees.

Key words: Sheep manure, cattle manure, organic, seaweed, plum.

Introduction

Plum (*Prunus salicina*), also known as Japanese plum, belongs to the family Rosaceae within the genus Prunus (Hussain *et al.*, 2021). World plum production reaches 12,391,467 tons, while Egypt's plum production stands at 23,703 tons in 2022. Currently, the world area harvested with plum is 2,599,624 ha and in Egypt, it was 1,748 ha in 2022 (FAO, 2022). Continuous application of chemical fertilizers can alter the pH of the soil, increase pests, and decrease organic matter content, and beneficial micro-organisms in soil. It may additionally affect the development of plants (Pahalvi *et al.*, 2021).

In the context of organic and sustainable agriculture, organic fertilization has been proposed as an effective alternative for supplying crops with essential nutrients. Its objectives include reducing the excessive use of inorganic fertilizers, enhancing beneficial soil microorganisms, improving soil physical properties and fertility, protecting the environment, and lowering production costs for farmers (Chatzistathis *et al.,* 2021). The application of organic manures improves the chemical, physical, and biological characteristics of soil. Moreover, these attributes make organic manures a promising option for improving fertility in nutrient-poor soils (Tofanelli *et al.,* 2022). For example, the application of small ruminant manure has been shown to increase leaf area and chlorophyll content (Rizwan *et al.,* 2021), while cattle manure has improved vegetative growth in cactus pear plants (El Gammal and Salama, 2022). Similarly, organic manure application significantly enhanced tree volume in Eureka lemon trees (Ennab, 2016). In fig orchards, applying 10 kg of cow or sheep manure per plant led to notable improvements in both fruit quality and productivity (Jafari *et al.,* 2024).

A plant bios-stimulant is applied to plants to improve crop quality, abiotic stress tolerance, and nutrient efficiency (Sun *et al.,* 2023). Seaweed extracts can be applied as organic nutrient supplements, bio-stimulants, or bio-fertilisers that improve vegetative growth and productivity instead of using chemical fertilizers (Kavipriya and Boominathan 2018; Taha *et al.*, 2025). It is preferable for sustainable agriculture and organic farming due to its properties, such as biodegradable, non-toxic and eco-friendly, compared to chemical fertilizers (Mukherjee and Patel 2020). Seaweed extract contains macro and micro nutrients, polyamines, vitamins and some growth regulators, which were applied to improve nutritional status, vegetative growth, yield and fruit quality in different orchards (El-Sharony *et al.*, 2015).

Therefore, the aim of this study was to promote the vegetative growth, tree canopy volume, and chemical properties of the leaves of young solar eclipse trees by using some organic manures from various sources along with seaweed extract, compared to chemical fertilizers.

Material and methods

Experimental location: The experiment was applied in the plum Research farm in the faculty of agriculture at Cairo University in Giza City, Egypt (30°01'04.9"N 31°12'30.7" E). The average annual temperature is approximately 27.7°C, an average relative humidity of around 55%, and an average daily sunshine duration of about 9 hours during the growing season. According to the

physical enquiries, the soil featured a silty clay texture and a field capacity of 42.56% by volume and pH was 7.78 according to the chemical analysis.

Plant material: The experiment was conducted on the solar eclipse plum cultivar. Trees were two years old and propagated through the T-budding grafting process on Mariana rootstock. Planting distances were established at 2 meters distance between trees in the same row and 6 meters between the rows. Soil analysis was divided into physical and chemical analysis. The irrigation system in the orchard was drip irrigation and the emitters were at a distance of 50 cm, dispensing 6 liters per hour. Irrigation period ranged between 2-4 hours, two to three times a week, depending on the period of the season, pests and diseases (insect, fungal, and mites) were periodically controlled.

Treatments: Organic manures were analyzed to determine their mineral content (nitrogen, phosphorus, potassium). NPK content of cattle manure was N 0.95 %, P 0.22%, and K 0.39%, while in sheep manure, it was N 1.13 %, P 0.21%, and K 0.42 %.

The experiment was laid out in a split plot in a randomized complete block design with three replications. The main plots consisted of soil applications (Control, NPK, cattle, sheep and cattle plus sheep). The subplots consisted of or without foliar application of seaweed extract.

Organic fertilization treatments were added based on N content as follows:

Treatment	N	P	K
Control	0	0	0
NPK	120	60	100
Cattle manure	120	27	49
Sheep manure	120	23	44
Cattle+ sheep manures	120	25	47

Organic fertilizers were added during winter by digging a hole beside the trees and the required amounts according to NPK equation (Cattle manure was applied at a rate of 12.63 kg and sheep manure at 10.62 kg, while the combined cattle and sheep manure treatment consisted of 6.30 kg and 5.30 kg, respectively). All application rates were calculated on a dry weight basis, considering the moisture content of cattle and sheep manures, which were 5.53% and 6.93%, respectively, through both studied seasons. Only mineral fertilization NPK treatment was divided into equal doses along the growing season through injection in the irrigation system in the last half hour of the irrigation process. Used mineral nutrients were phosphoric acid (85%), ammonium nitrate (33.5%) and potassium sulphate (48%). Seaweed application treatments were sprayed (0.75 $g.L^{-1}$) once every two weeks during the growing season.

Tree growth parameters: The diameter of the main trunk was measured at a distance of 10 cm from the soil surface using a Vernier caliper (mm). Length of new shoots was measured by using a ruler (cm).

New shoot leaves number: Randomly counted on three new shoots at the end of the studied season

Leaf area (cm^2): The selected leaves were the fourth and fifth leaves from the base of the new shoots. In September, leaf dimensions were measured manually using a ruler. Leaf area was then calculated using the equation ($0.007 + 0.687 \times L \times W$), according to reference (Sabouri *et al.,* 2022).

Tree canopy volume (m^3): It was measured through method described by (Thorne *et al.*, 2002) using the following equation: CV=2/3 π H (A/2 x B/2): Where H = Height of the tree from base to top (m), A = Canopy diameter (m) in E-W and B = Canopy diameter (m) in N-S direction.

Leaf Chlorophyll content (mg/g FW): Chlorophyll A, B and Total chlorophyll were determined using method of Lichtenthaler and Wellburn (1983) where Chlorophyll content (mg/g FW): Chlorophyll a (Ch) and Chlorophyll b (Ch) concentrations were determined through taking leaf samples (0.25 g FW) were immersed in 20 mL of aceton (80%), and the absorbance was measured using a spectrophotometer at 646 and 663 wave lengths. Cha and Chb concentrations were calculated according to the following equations:

Chlorophyll a (Ch_a) = (12.25× A663) - (2.798× A646).
Chlorophyll b (Ch_b) = (21.5 × A646) - (5.1× A663).
Total Chlorophyll = (Ch_a) + (Ch_b)

Leaf mineral content (%): Leaf samples were collected in the first week of July of both seasons, the chosen leaves fourth and fifth from the base of new shoots. Samples were oven-dried in the laboratory, then ground to a fine powder and digested using standard procedures for subsequent analysis. Total nitrogen (N) was determined by Kjeldahl analysis according to Bradstreet (1965). Total Phosphorus (p) was analyzed spectrophotometrically by the phosphovanadate colorimetric method according to AOAC (2005). Total Potassium (k) was determined by flame spectroscopy according to Christian and Feldman (1970).

Total carbohydrate content (mg/g FW): Total carbohydrate content was determined according to Jain *et al.* (2017) with slight modifications. Fresh leaf samples (0.5 g) were extracted in 10 mL of 70% ethanol for three days. Then, 5 mL of 2.5 N HCl was added, and the mixture was hydrolyzed by boiling in a water bath for 3 hours. After cooling, solid sodium carbonate was added gradually, and the volume was adjusted to 100 mL with distilled water. For color development, 1 mL of phenol and 5 mL of sulfuric acid were added. The mixture was shaken, left for 10 minutes, then incubated in a water bath at 25–30°C for 20 minutes. Absorbance was measured at 490 nm using a spectrophotometer

C/N ratio: The carbon-to-nitrogen ratio was determined using the equation: C/N = Total Carbohydrate / Total Nitrogen.

Amino acids content (%): The sample was collected in September. The chosen leaves were fourth and fifth from the base of the new shoots. The sample was diluted and a standard amino acid solution was prepared. A reaction was made between the sample and the ninhydrin reagent. Heating in a boiling water bath for 15 minutes was performed and then it was cooled to room temperature. The sample was measured at an absorbance of 570 nm using a spectrophotometer. This method was used according to Rosen (1957).

Experimental design and statistical analysis: The experimental design was a Split-Plot Design (SPD). It contained ten treatments and each treatment contained three replicates with one tree for each replicate. In this study, the limited sample size resulted from the selection of suitable trees that were uniform in size and height. Data followed a normal distribution with homogeneous variances, supporting the validity of this approach. The experimental data were analyzed by analysis of variance (ANOVA) performed using

XLSTAT (Addinsoft, version: 2023.1.1.1405, France). ANOVA was applied to compare group means, which remain effective with relatively small sample sizes and provided that statistical assumptions are satisfied. Significant differences between treatments were determined by LSD tests at $p \leq 0.05$.

Results and discussion

Main trunk diameter (mm): The results presented in Table 1 indicate a significant positive impact of soil application on trunk diameter. Cattle plus sheep manure significantly outperformed other soil treatments in trunk diameter, while the control had the lowest values. Seaweed foliar spray further increased trunk diameter, especially when combined with manure. The control showed the lowest values. These findings are in agreement with those reported by Sharma *et al.* (2022), whose data explained the substantial increase in stem diameter as a response to the organic manure application. In a related study, Arji *et al.* (2021) concluded that cattle and sheep manure improved trunk diameter. Moreover, these results align with those of Al-Temimi *et al.* (2019), who found that foliar application of seaweed extract resulted in the highest stem diameter.

New shoots length (cm): Table 1 illustrates the impact of both soil and foliar applications on the elongation of new shoots. Soil amendments had a clear effect on shoot length, with the combined application of cattle and sheep manure achieving the highest values across both seasons. Although NPK improved shoot growth, the differences were not statistically significant. Foliar application of seaweed extract significantly enhanced shoot length compared to unsprayed trees. The combined treatment of manure and seaweed resulted in the maximum shoot lengths. The obtained results are in agreement with those reported by Ennab (2016), who reported that reducing chemical fertilization to 50% and supplementing with organic manure significantly improved shoot length. (Osama *et al.*, 2016) concluded that the application of animal manure led to a progressive enhancement in shoot length. Additionally, the results align with the research conducted by Hussein *et al.* (2021); Harhash *et al.* (2024), who exhibited that foliar spraying of fruit trees with seaweed extract significantly increased the average length of vegetative growth.

Leaves number: Cattle and sheep manure application led to the highest leaf count per shoot, with NPK ranking second. Seaweed foliar spray further improved leaf development. The combined manure and seaweed treatment yielded the highest values, while the untreated control consistently recorded the lowest. These results also align with Mazeh *et al.* (2021), who reported that the use of organic fertilizers significantly enhanced leaf production in comparison to chemical fertilization or untreated controls. Similarly, Al-Temimi *et al.* (2019) reported a significant increase in leaf number in plants sprayed with seaweed extract.

Leaf area (cm^2): The application of organic manures in newly established plum trees resulted in notable improvements in leaf area. Specifically, the combined use of cattle and sheep manure significantly outperformed the control treatment, achieving an approximate increase of 15%. In addition, foliar application of seaweed extract enhanced leaf characteristics compared to non-sprayed treatments. The interaction between soil and foliar treatments further amplified these effects, with the combination of cattle and sheep manures and seaweed spray producing the highest leaf area values among all treatment groups. These findings are also consistent with those of Jafari *et al.* (2024), who noted that the application of cattle and sheep manures significantly increased leaf length, width, and area compared to the control treatment. Moreover, the sprayed treatments recorded significantly higher values than the non-sprayed treatments, which can be attributed to the composition of seaweed extracts. Similarly, Al-Temimi *et al.* (2019) concluded that foliar application of seaweed extract enhanced the leaf area of treated trees compared to untreated ones.

Tree canopy volume (m^3): It is evident from the data in Table 2 that the volume of the tree canopy differed significantly between

Table 1. Effect of organic manures and seaweed utilization on trunk diameter, new shoots length, leaves number and leaf area of young solar eclipse plum trees

Treatments		1st Season (2022-2023)				2nd Season (2023-2024)			
Soil application	Foliar application of seaweed	Trunk diameter (mm)	New shoots length (cm)	Leaves number	Leaf area (cm^2)	Trunk diameter (mm)	New shoots length (cm)	Leaves number	Leaf area (cm^2)
Control	0	39.82a	65.76a	45.78a	21.31a	41.16a	35.18a	46.38a	10.60a
	0.75 $g.L^{-1}$	43.01ab	95.58c	59.94d	22.51ab	44.36b	45.14b	61.10bc	13.14de
	Average	41.42a	80.69a	52.86a	21.91a	42.76a	40.16a	53.74a	11.87a
NPK	0	44.43abc	79.04b	47.91ab	24.42c	45.44bc	47.20b	54.56abc	11.91bc
	0.75 $g.L^{-1}$	48.34cd	109.93d	51.46bc	26.31d	49.37d	59.00de	74.13e	15.41g
	Average	46.38b	94.49b	58.29bc	25.36c	47.41b	53.10c	64.34bc	13.66b
Cattle Manure	0	43.19ab	72.47ab	47.91ab	23.38bc	43.86b	43.55b	49.49a	11.16abc
	0.75 $g.L^{-1}$	46.52bc	96.25c	60.56de	25.00cd	47.73cd	53.01c	64.28cd	14.12ef
	Average	44.85ab	84.40a	54.23ab	24.19b	45.80b	48.28b	56.88ab	12.64a
Sheep Manure	0	43.53ab	72.55ab	48.50ab	23.80bc	45.19bc	45.70b	52.50ab	10.66ab
	0.75 $g.L^{-1}$	46.89bc	101.59cd	61.06de	25.18cd	48.87d	57.40cd	68.28de	14.85fg
	Average	45.21ab	87.03a	54.78ab	24.49b	47.03b	51.55bc	60.39bc	12.75a
Cattle plus sheep manures	0	44.48abc	81.25b	65.11e	24.69cd	45.67bc	46.38b	56.75abc	12.27cd
	0.75 $g.L^{-1}$	52.82d	111.33d	69.63f	26.54d	53.84e	64.01e	76.92e	17.44h
	Average	48.65b	96.29b	62.27c	25.62c	49.76c	55.19c	66.84c	14.86c
Average of foliar application	0	43.09A	74.21A	49.71A	23.52A	44.26A	43.60A	51.93A	11.32A
	0.75 $g.L^{-1}$	47.51B	102.93B	63.26B	25.11B	48.84B	55.71B	68.94B	14.99B

*Different letters within the same column indicate statistically significant differences ($P \leq 0.05$). Average indicates the main effect of soil application; uppercase letters represent the main effect of foliar application, while lowercase letters denote the interaction between soil and foliar applications.

treatments. The application of cattle plus sheep manures to the soil yielded the highest results, with NPK treatment following in second. However, the lowest values were achieved by the control treatment. The volume of tree canopy was additionally enhanced by seaweed spraying. The control treatment yielded the lowest values, while the combination of seaweed spraying and cattle plus sheep manure treatment recorded the highest values in both seasons. The obtained data are consistent with those reported by Ennab (2016), who found that applying organic manure combined with a 25% reduction in mineral fertilization significantly increased tree volume. Furthermore, the results agree with Sharma *et al.* (2021), who concluded that the application of seaweed extract had a positive effect on plant canopy volume.

Table 2. Effect of organic manures and seaweed utilization on the Tree canopy volume of young solar eclipse plum trees

Treatments		1st Season (2022-2023)	2nd Season (2023-2024)
Soil application	Foliar Application of Seaweeds	Tree canopy volume (m^3)	Tree canopy volume (m^3)
Control	0	0.66a	1.24a
	0.75 g.L^{-1}	1.68bc	2.58bc
	Average	1.17a	1.91a
NPK	0	1.58b	3.21c
	0.75 g.L^{-1}	4.54ef	6.14d
	Average	3.06c	4.68b
Cattle Manure	0	1.17ab	1.93ab
	0.75 g.L^{-1}	2.43cd	2.92c
	Average	1.80b	2.43a
Sheep Manure	0	1.24ab	3.04c
	0.75 g.L^{-1}	4.40e	5.99d
	Average	2.82c	4.52b
Cattle plus sheep manures	0	2.69d	3.30c
	0.75 g.L^{-1}	5.16f	6.60d
	Average	3.92d	4.95b
Average of foliar application	0	1.47A	2.54A
	0.75 g.L^{-1}	3.64B	4.85B

*Different letters within the same column indicate statistically significant differences (P ≤ 0.05). Average indicates the main effect of soil application; uppercase letters represent the main effect of foliar application, while lowercase letters denote the interaction between soil and foliar applications.

Table 3. Effect of organic manures and seaweed utilization on leaf chlorophyll content of young solar eclipse plum trees

Treatments		1st Season (2022-2023)			2nd Season (2023-2024)		
Soil application	Foliar application of seaweed	Ch_a (mg/g)	Ch_b (mg/g)	Total Chlorophyll (mg/g)	Ch_a (mg/g)	Ch_b (mg/g)	Total Chlorophyll (mg/g)
Control	0	8.08a	5.59a	13.67a	9.08a	6.59a	15.67a
	0.75 g.L^{-1}	9.83bc	7.16a	16.98abc	10.83ab	8.49ab	19.32abc
	Average	8.96a	6.37a	15.33a	9.96a	7.54a	17.49a
NPK	0	9.79abc	7.87a	17.66abc	11.46ab	9.21ab	20.66abc
	0.75 g.L^{-1}	10.39bc	8.19a	18.58bc	13.16bc	9.86b	23.02bc
	Average	10.09ab	8.03ab	18.12ab	12.31ab	9.53ab	21.84ab
Cattle Manure	0	9.22abc	6.64a	15.86ab	10.22ab	7.64ab	17.86abc
	0.75 g.L^{-1}	9.86bc	7.36a	17.23abc	11.86ab	8.7ab	20.56abc
	Average	9.54ab	7.00ab	16.54ab	11.04ab	8.17ab	19.21ab
Sheep Manure	0	9.49abc	6.80a	16.28ab	10.49ab	7.8ab	18.28abc
	0.75 g.L^{-1}	10.04bc	7.59a	17.63abc	12.71bc	8.92ab	21.63abc
	Average	9.76ab	7.19ab	16.96ab	11.6ab	8.36ab	19.96ab
Cattle plus sheep manures	0	10.08bc	8.07a	18.16bc	12.42bc	9.4ab	21.82abc
	0.75 g.L^{-1}	11.00c	9.40a	20.40c	14.00c	10.42b	24.42c
	Average	10.54b	8.74b	19.28b	13.21b	9.91b	23.12b
Average of foliar application	0	9.33A	6.99A	16.33A	10.73A	8.13A	18.86A
	0.75 g.L^{-1}	10.22B	7.94A	18.17B	12.51B	9.28A	21.79B

*Different letters within the same column indicate statistically significant differences (P ≤ 0.05). Average indicates the main effect of soil application; uppercase letters represent the main effect of foliar application, while lowercase letters denote the interaction between soil and foliar applications.

Leaf chlorophyll content (mg/g FW): Values demonstrated in Table 3 show the positive effect of soil application on leaf chlorophyll content. Cattle plus sheep manure treatment resulted in the highest chlorophyll A, B, and total chlorophyll levels in both seasons, followed by NPK, while the control had the lowest. Seaweed foliar spray further enhanced chlorophyll content, with the manure plus seaweed combination achieving the highest values. The control without seaweed recorded the lowest in both seasons. The findings of the present study are consistent with those reported by Sharma *et al.* (2022), who obtained data that exhibited a significant influence on leaf chlorophyll content through organic manure addition. Rizwan *et al.* (2021) also reported that goat manure had a positive effect on leaf chlorophyll content, with significantly higher values recorded compared to the control group. Moreover, foliar application of seaweed extract significantly increased chlorophyll content compared to untreated trees. These findings are consistent with Al-Saif *et al. (*2023), who reported that seaweed extract application positively affected the chlorophyll content in leaves.

Leaf mineral content (%): Data reveal in Table 4 the effect of soil application on leaf nutrient content. Soil application significantly influenced leaf nutrient content, with cattle plus sheep manure showing the highest values across both seasons, followed by NPK. Seaweed spraying further enhanced nutrient levels. The combination of cattle plus sheep manure and seaweed spray gave the best results. In contrast, the control without seaweed recorded the lowest values in both seasons. These findings are consistent with those reported by Osama *et al.* (2016), who indicated that applying 39 kg/plant of organic manure significantly improved leaf nutrient content compared to other treatments. Cattle manure is recognized as a good source of nitrogen; however, the levels of nitrogen (N)

and potassium (K) in manure from small ruminants have been reported to be higher than those found in cattle manure (Arji *et al.,* 2021). Regarding the foliar application of seaweed extract, the treated plants exhibited significantly higher nutrient contents than the untreated controls. The current results are in line with Mousavi *et al.* (2024), who demonstrated that replacing mineral nitrogen fertilization with foliar application of seaweed extract led to a notable improvement in leaf nutrient composition.

Table 4. Effect of organic manures and seaweed utilization on some leaf nutrient content of young solar eclipse plum trees

Treatments		1st Season (2022-2023)			2nd Season (2023-2024)		
Soil application	Foliar application of seaweed	N %	P %	K %	N %	P %	K %
Control	0	1.83a	0.18a	1.24a	1.65a	0.22a	1.31a
	0.75 g.L^{-1}	1.99ab	0.21b	1.39abc	2.22d	0.35d	2.41cd
	Average	1.91a	0.20a	1.32a	1.94a	0.29a	1.86a
NPK	0	2.01ab	0.22bc	1.57bc	2.21d	0.28c	2.12bc
	0.75 g.L^{-1}	2.10ab	0.24d	1.85d	2.57h	0.39e	2.82d
	Average	2.05ab	0.23b	1.71bc	2.39d	0.34c	2.47c
Cattle Manure	0	1.95ab	0.18a	1.31abc	1.70b	0.25b	1.53a
	0.75 g.L^{-1}	2.03ab	0.21b	1.42abc	2.25e	0.38e	2.44cd
	Average	1.99ab	0.20a	1.36a	1.98b	0.32b	1.98ab
Sheep Manure	0	1.97ab	0.18a	1.33abc	2.00c	0.25b	1.77ab
	0.75 g.L^{-1}	2.08ab	0.22bc	1.64cd	2.33f	0.38e	2.46cd
	Average	2.03ab	0.20a	1.49ab	2.17c	0.32b	2.12b
Cattle plus sheep manures	0	1.96ab	0.23c	1.66cd	2.49g	0.38e	2.97d
	0.75 g.L^{-1}	2.29b	0.24d	1.89d	3.69i	0.51f	2.61e
	Average	2.13b	0.24b	1.78c	3.09e	0.45d	3.79d
Average of foliar application	0	1.95A	0.20A	1.42A	2.01A	0.28A	1.94A
	0.75 g.L^{-1}	2.10B	0.23B	1.64B	2.61B	0.40B	2.95B

*Different letters within the same column indicate statistically significant differences (P ≤ 0.05). Average indicates the main effect of soil application; uppercase letters represent the main effect of foliar application, while lowercase letters denote the interaction

Table 5. Effect of organic manures and seaweed utilization on leaf total carbohydrates, C/N ratio and amino acids of young solar eclipse plum trees

Treatments		1st Season (2022-2023)			2nd Season (2023-2024)		
Soil application	Foliar application of seaweed	Total carbohydrates (mg/g)	C/N ratio	Amino acids%	Total carbohydrates (mg/g)	C/N ratio	Amino acids%
Control	0	5.94a	3.25a	13.57a	6.61a	4.01e	13.82a
	0.75 g.L^{-1}	7.72abc	3.87ab	20.93c	8.41bc	3.79cd	23.38b
	Average	6.83a	3.57a	17.25a	7.51a	3.88bc	18.60a
NPK	0	7.91abc	3.94ab	28.6e	8.67bcd	3.92cd	30.81cd
	0.75 g.L^{-1}	9.52cd	4.54b	39.1i	9.88de	3.84bc	45.41e
	Average	8.71bc	4.24b	33.85d	9.28cd	3.88b	38.11d
Cattle Manure	0	6.64ab	3.40a	15.17b	7.49ab	4.41f	15.38a
	0.75 g.L^{-1}	8.66bcd	4.26b	37.17g	9.05cd	4.02cde	42.76e
	Average	7.65ab	3.84ab	26.17b	8.27b	4.19c	29.07b
Sheep Manure	0	7.65abc	3.88ab	27.37d	8.37bc	4.19e	28.00c
	0.75 g.L^{-1}	9.4cd	4.53b	37.97h	9.63cde	4.13de	43.20e
	Average	8.53bc	4.21b	32.67c	9.00c	4.16c	35.60c
Cattle plus sheep manures	0	8.15bcd	4.15b	29.4f	8.69bc	3.49b	33.66d
	0.75 g.L^{-1}	9.88d	4.31b	39.8j	10.49e	2.84a	45.94e
	Average	9.01c	4.23b	34.6e	9.59d	3.10a	39.80d
Average of foliar application	0	7.26A	3.73A	22.82A	7.97A	3.97A	24.34A
	0.75 g.L^{-1}	9.04B	4.31B	34.99B	9.49B	3.63B	40.14B

*Different letters within the same column indicate statistically significant differences (P ≤ 0.05). Average indicates the main effect of soil application; uppercase letters represent the main effect of foliar application, while lowercase letters denote the interaction between soil and foliar applications.

Total carbohydrate content (mg/g FW): The obtained results from Table 5 showed the impact of soil application and the foliar application of seaweed on total carbohydrates. Soil and seaweed foliar applications significantly affected leaf total carbohydrates. Cattle plus sheep manure showed the highest values in both seasons, followed by NPK, with no significant difference. Seaweed spraying further increased carbohydrate content, especially when combined with manure. Non-sprayed treatments had lower values. These findings are consistent with those reported by (Mousavi *et al.*, 2024; Ismaiel and Ismail 2024), who stated that foliar spraying with seaweed extract significantly increased total carbohydrate content in treated trees compared to the control in both studied seasons.

C/N ratio: In the first season, NPK soil application gave the highest C/N ratio, while the control recorded the lowest. In the second season, the control had the highest C/N ratio, and cattle plus sheep manure had the lowest. For foliar applications in 2023, NPK spray achieved the highest C/N value, whereas sheep manure spray showed the most impact in the second season. The combined cattle and sheep manure treatment had the lowest C/N ratio across both seasons. These findings are consistent with those reported by Jaff and Medan (2024), who concluded that the application of organic manures enhanced the carbon-to-nitrogen (C/N) ratio. Likewise, the results obtained from the foliar application of seaweed extract are in line with the observations of Hameedawi and Malikshah (2017), who demonstrated that seaweed treatment significantly increased the C/N ratio in treated plants.

Amino acids content (%): Amino acid content varied significantly across treatments in both seasons. In soil applications, cattle plus sheep manure gave the highest values, while the control recorded the lowest. Seaweed spraying further enhanced amino acid levels, with the cattle and sheep manure plus seaweed combination showing the highest effect in both 2023 and 2024. The substitution of organic fertilizers increased the amino acid content by up to 7.8% compared to conventional fertilization (Dai, 2025). However, using seaweed extract (1%) significantly enhanced vegetative growth and increased amino acid content (Radjasegarin and Perumal, 2021)

Based on the findings of this investigation, it can be concluded that the combined application of sheep and cattle manure, along with foliar spraying of seaweed extract, improves and supports the healthy growth of newly established plum trees. Further research is required to optimize the frequency, concentration,

and long-term effects of these treatments under different environmental conditions.

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