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Response of seed yield of jojoba (*Simmondsia chinensis* L.) trees irrigated with saline water to compost, phosphorus and nitrogen application

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Abstract

Jojoba is a promising industrial seed oil crop that has potential in Egypt's hyper-arid lands. An experiment on jojoba was carried out at Moghra Oasis, northeast of the Qattara Depression in the Western Desert of Egypt. The experiment was carried out in two consecutive years (2020-2021 and 2021-2022) to investigate the jojoba seed yield response to compost, phosphorus (P), and nitrogen (N) fertilization in a split-split plot design. Irrigation water from the utilized well averaged 7.4 dS m^{-1}, implying that the trees were under salt stress. Main plots were assigned for three rates of compost as 0, 20 and 40 ton ha^{-1}. Sub-plots were assigned for four rates of phosphorus (P) fertilizer as 0, 80, 160, and 320 kg P_2O_5 ha^{-1}. While sub-sub plots were assigned for four rates of N as 0, 125, 250, and 500 kg N ha^{-1}. The results showed that jojoba seed yield increased in a linear fashion as the rates of all the tested parameters increased. The most effective treatment was to apply P, N, and compost at rates of 320 kg P_2O_5, 500 kg N, and 40 ton ha^{-1}. In the first and second seasons, these rates resulted in jojoba seed yields of 655 and 814 kg ha^{-1}, respectively. Higher seed yield in the second season may be due to the residual effects of compost, P and K as well as trees size. This study, therefore, revealed that jojoba trees cultivated in hyper-arid conditions and subjected to salt stress respond significantly to compost and mineral fertilizers when applied in sufficient amounts.

Keywords: Jojoba, organic fertilizer, inorganic fertilizer, P, N

Introduction

The jojoba plant (*Simmondsia chinensis*) is a member of the Buxaceae family. It is originated from the dry regions of the USA and Mexico. Currently, jojoba plants are gaining popularity due to their potential for cultivation in arid regions of the world. Even in high heat (35–40°C), the jojoba plant, a dioeciously, long-lived desert shrub, remains evergreen. It may grow well with 50 mm or even 100 mm of rainfall annually, but it only yields a small yield. Additionally, top individuals of recognized sexuality and particular significance were displayed through clonal propagation in order to guarantee the quantity of fruitful plants on a given plot. By using the common traditional techniques, its vegetative propagation is challenging **(Yermanos, 1979).** Besides being an oil crop, jojoba leaf is additionally thought to be a source of nutrient-dense food for sheep, goats, and cattle, as well as for ungulates in the wild and smaller browsers like rabbits. Just a few crops are grown in arid and marginal terrain, mainly for survival. Drought-tolerant cash crops are absent from these places.Jojoba can withstand stress conditions, has garnered much attention in recent years **(Thagana et al., 2004 & Weiss et al.,1983)**.

Nitrogen (N) is a necessary component for plant life, making it one of the macronutrients. Therefore, it is a fundamental component of the structure of numerous significant plant cell constituents, such as amino acids, which stand for the structural unit of protein, the primary constituent of protoplasm, the site of cell division, and enzymes, which are also proteins. Protein is, therefore, necessary for developing all plant components, including seeds. According to **Abdel-Motagally and Osman (2010)**, N is the most crucial nutrient required for increasing crop yield in agriculture, particularly for crops that produce a high percentage of oil in their seeds.

Because P plays a crucial role in nearly every metabolic process in all living organisms and is used to build numerous cell structures, including phospholipids, nucleic acids, nucleotides, sugar phosphates, and coenzymes, its scarcity will severely limit plant yield. P is essential for all cellular activities, including respiration, reproduction, photosynthesis, protein biosynthesis, and membrane transport for energy conversion **(Taiz and Zeiger, 2002)**. P is also a fundamental part of genetic material and is necessary for increased cell division **(Nahed and Aziz, 2007)**. A significant accumulation of P in both plant fruits and seeds is explained by the fact that P is a crucial component of seed formation **(Havlin et al., 1999)**. P also promotes root development, which boosts the effectiveness of water utilization **(Gupta, 2003).**According to **Benzioni and Ventura (1996)**, specific jojoba clones' root development was impeded by high P levels in the irrigation water. Low P did not affect the shoots' growth or the chlorophyll concentration, but it did cause a drop in the leaves' magnesium (Mg) and calcium (Ca) content.

In field trials conducted in 2008 and 2009 on five-year-old Jojoba plants cultivated in sandy loam soil under irrigation with fresh water in India, **Mohapatra and Panda (2011)** discovered that the treatment of 80 g P/plant significantly increased seed yield (219.95 kgha^{-1}) over the treatment of control (80.08 kg ha^{-1}) and the treatment of 100 g P/plant (164.92 kg ha^{-1}). According to **Gomaa et al. (2015)**, applying farmyard manure at a rate of 20 m^3 fed^{-1} with 70 kg N fed^{-1} resulted in the highest percentages of N, P, and K in jojoba, which is resulted in high seed yield. Organic fertilizers are a substantial organic source of plant nutrients, according to **Hammad et al. (2011)**. **Cheraghi et al. (2016)** reported that applying chemical fertilizer and organic manure together considerably boosted the yield and yield components of common wheat compared to applying each fertilizer separately and the control treatment, which should be applicable on jojoba as well.According to Jojoba was the subject of a field experiment by **Huda et al. (2021)** to determine the most efficient organic fertilization for growth in Libya. They treated the jojoba plant with foliar humic acid and yeast extracts. They discovered that when humic acid (10 ml/l) and bread yeast (10 g/l) were applied, the dried shoot's weight increased considerably.Using different amounts of nitrogen, such as 0, 4, 10, 50, and 100 ppm in solution culture, **Ruben (1988)** experimented in a greenhouse on sand culture to assess the growth and N and P concentration of jojoba plants. According to the findings, jojoba plants required 50 ppm of N solution for optimal vegetative development, shoot dry weight production, and shoot N concentration (1.96%). Additionally, as with dry shoot weight, shoot N and shoot P concentrations, N content increased with N rates and was higher in young leaves (2.52%) than in older ones (1.52%). Although root N concentration rose with the rate, dry root weight did not alter with N treatment levels.

Khattab et al. (2019) carried out two field experiments on five clones of jojoba (S-BS-, S-700, 610, S-L, and S-G) at ages 3 and 13 years after planting in North Sinai, Egypt, on a sandy soil to examine the effects of foliar spraying with N), P, and boron (B). They concluded that the treatments enhanced seed quality, yield, and vegetative growth. **Hegab et al. (2021)** conducted a field experiment to investigate the effects of N, P, and K fertilization and irrigation with industrial wastewater on the growth and productivity of 6-year-old Jojoba shrubs growing on sandy soil. They claimed that 240 kg N ha^{-1} combined with 150 kg P_2O_5 and 120 kg K_2O ha^{-1} resulted in the most remarkable improvement in the majority of the tested metrics, including nutrient availability, vegetative development, and yield of jojoba plants.

Balanced and adequate fertilization is critical in enhancing the production of jojoba plants under salt stress. As a result, this study was carried out to establish optimal fertilization programs for jojoba trees growing in Moghra Oasis, one of Egypt's major agricultural development areas. Specifically, determining the optimal compost, P, and N application rates to enhance seed yield, either separately or in combination.

Material and Methods:

Experimental site:

The current investigation was conducted at Moghra Oasis, northeast of the Qattara Depression. Location of the experimental site was 30^o 07' 50.8' N, 28^o 32' 53.7' E, and altitude 3 m. This area is one of the targeted areas in Egypt for agricultural development as a megaproject. Moghra Lake is located in the middle of the study area that occupies around 400 ha area and contains brackish water. There are separated jojoba, olive and pomegranate orchards irrigated from wells. There is a plan to drill several wells in this area as a source of irrigation water by the Egyptian government, however most contains high salinity water. The climate is hyper-arid with annual rainfall between 25 to 50 mm year^{-1}. The mean daily temperature averages between 36.2º and 6.5º C during summer and winter months, respectively. The prevailing wind comes from the North varying between north-west and north-east directions.

Treatments:

The purpose of this study was to examine the effect of compost, P, and N application on seed yield of jojoba plants that are irrigated with high-salinity water (7.5 dS m^{-1}). The experiment was conducted on four-year-old bushes for two consecutive years (2020-2021 and 2021-2022). The experimental field was split into plots of 1.5 × 4 m dimensions. There were roughly 700 shrubs per fedden (1666 shrubs per hectare). N fertilizer was applied in the form of ammonium sulphate at four rates, i.e. 0, 125, 250, and 500 kg N ha^{-1}. These rates were applied in three equal doses: the first at the start of the experiment during the winter service, the second during flowering, and the third one month following the second. For P, the rates were 0, 80, 160, and 320 kg P_2O_5 ha^{-1}, as a single super phosphate in a single dose. Compost was applied at three different rates: 0, 20, and 40 tons per feddan during the winter service. The used compost characterizes were pH = 7.4, EC (1:10) = 4.42 dS m^{-1}, organic carbon (C) = 12.83%, total N = 0.85%, C:N ratio = 15:1, total P = 0.61%, total K = 1.37%, and bulk density = 677 kg m^{-3}. The experiment was split-split plot design with three replications. Main plots were assigned for compost, P for the sub-plots, and N for the sub-sub plots.

Soil sampling and analysis:

Initial soil samples were collected from the experimental sites at two depths (0-30 and 30-60 cm). **Table 1** shows some soil physical and chemical characteristics of the experimental site. The collected soil samples were air dried and gently ground, then sieved through a 2 mm sieve. Values of pH and electrical conductivity (EC) were measured in 1:1 soil-water suspension and supernatant, respectively as described by **Page et al. (1982)**. Soil organic matter was determined using the procedure of **Walkely and Black** as outlined by **Page et al. (1982)**. Total calcium carbonate content was measured using calcimeter according to **Page et al.**. Available N was extracted by 2 *M* KCl solution, according to **Dahnke and Johnson (1990)** and then determined by micro-Kjeldahl method. Available P, K, Fe, Mn, Zn, and Cu were extracted by 1 *M* NH_4HCO_3 in 0.005 *M* DTPA adjusted to a pH of 7.6 **(Soltanpour, 1991)**. P was estimated colorimetrically using ascorbic acid and ammonium molybdate using spectrophotometer. Potassium was measured using flamphotometer according. Iron, Mn, Zn, and Cu were determined using inductively coupled plasma-atomic emission spectroscopy as described by **Varma (1991)**.

Table 1. Soil physical and chemical properties (Soil extract (1:1)).

Property	Soil depth (cm)	
	0 – 30	30 – 60
Very coarse sand (%)	5.17	1.62
Coarse sand (%)	11.59	7.97
Medium sand (%)	29.53	35.99
Fine sand (%)	44.54	48.99
Very fine sand (%)	5.39	4.88
Silt &clay (%)	3.79	0.53
Soil texture	Sand	Sand
$CaCO_3$ (%)	2.51	0.72
O.M (%)	0.03	0.04
EC (dSm^{-1}) in 1:1 extract	7.8	12.5
SAR	11.38	10.59
pH in 1:1 suspension	7.9	7.8
Soluble anions (mmole L^{-1})		
HCO_3^-	4.35	7.55
Cl^-	36.45	63.04
SO_4^{2-}	48.88	84.51
Soluble cations (mmole L^{-1})		
Na^+	49.36	85.38
K^+	2.72	4.70
Ca^{2+}	30.75	53.18
Mg^{2+}	6.85	11.84
Available macronutrients and micronutrients ($mgkg^{-1}$)		
Available N	18.60	15.28
Available P	2.92	2.77
Available K	27.00	21.00
Available Fe	6.78	4.25
Available Mn	0.50	0.32
Available Zn	0.27	0.55
Available Cu	0.22	0.01

Water analysis:

A water sample was obtained from the study field's well in both seasons. The collected sample was analyzed for EC, pH and soluble cations and anions as described by **Richards (1954)**. Irrigation water EC was 7.4 dS m^{-1}, indicating that water salinity is very high according to **FAO (1985)**. The pH value was 6.7 in average, seemingly because of the high water salinity that hampers the increase in pH.

Table 2. Some chemical properties of irrigation water utilized in both seasons of the study.

Parameter	EC (dSm^{-1})	pH	SAR	Soluble anions ($mmolc\ L^{-1}$)				Soluble cations ($mmolc\ L^{-1}$)			
				CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}
First season	**7.12**	**6.65**	**6.45**	**n.d.***	**2.81**	**55.6**	**12.8**	**29.42**	**0.19**	**19.11**	**22.51**
Second season	**7.69**	**6.82**	**7.44**	**n.d.**	**2.61**	**66.72**	**7.58**	**34.26**	**0.23**	**23.91**	**18.52**

* Sodium adsorption ratio

Seed yield estimation:
The purpose of this study was to examine at seed yield production as an indication of fertilizer response. Hand picking at full maturity in July was used to determine the seed yield from all trees within the plots. Harvested seeds were weighed in the field for each tree, and then multiplied to find the production per ha. Following that, a sample was taken for further analysis.

Statistical analysis:
The analysis of variance (ANOVA) was performed to determine the effects of treatments on the obtained data **(Gomez and Gomez, 1984)**. The difference between means at probability level of 0.05 was conducted using least significant difference test (LSD).

Results and discussion

The influence of compost, P, and their interaction on jojoba seed yield

Seed yield responded substantially to the compost and P applications in both seasons (Table 3 and Figure 1). The highest significant seed yield was obtained in OM2 treatment in both season. This is owing to compost's increased ability to buffer temperature and moisture changes, as well as the fact that it provides essential macro- and micronutrients to the rhizosphere. This was is in line with the finding of **Shadrack et al. (2016),** who found that a combination of manure, and in-organic fertilizers had a positive impact on Jojoba seed production. Similarly, **Huda et al. (2021)** stated that the application of humic acid and bread yeast considerably enhanced the seed yield of jojoba and the dry weight of the shoot. Furthermore, according to **Shaaban (2006),** organic residues increased the bulk density, total porosity, macro and micro pores, soil water retention, and hydraulic conductivity of the soil, which all have positive impact on plant’s performance. Pertaining to P, the highest significant seed yield was obtained in P3 treatment in both seasons. P levels' effects on jojoba seed yield can be ranked in the order of the following ascending list: 0 < P1 < P2 < P3. Accordingly, the highest significant seed yield was obtained by the interaction between OM2 and P3.

Table 3. Influence of OM, P, and OMxP interaction on jojoba seed yield (kg ha^{-1})in the two seasons of study.

P rates	First season			Mean	Second season			Mean
	OM0	OM1	OM2		OM0	OM1	OM2	
P0	52	392	531	325	61	449	617	376
P1	127	425	557	370	150	501	658	436
P2	221	453	576	417	258	537	693	496
P3	292	495	629	472	348	578	761	562
Mean	173	441	573	396	204	516	682	468
LSD5%	OM=1..28	P= 1.47	OMxP= 2.55		OM=1.54	P= 1.78	OMxP= 3.08	

P0:0 kg P_2O_5 ha^{-1} P3:160 kg P_2O_5 ha^{-1} OM0: 0 ton ha^{-1} OM2: 40 tons ha^{-1}
P1:80 kg P_2O_5 ha^{-1} P4:320 kg P_2O_5 ha^{-1} OM1: 20 tons ha^{-1}

It is clear that high compost application improved P level performance in seed production. These findings are consistent with the findings of **El-Maadawy and Moursy (2007)**, who suggested that jojoba bushes grow best when a high level of organic manure is present. It may be inferred that jojoba shrub responded to P applications when the compost was increased **(Table 3 & figure 1)**. It is noteworthy that there were more seeds produced in the second season than the first. This might be because the residual effects of compost and P are high, implying that their application in one season may have an impact on succeeding seasons. Another reasonable explanation may be increased tree production over years, owing to the increased branches.

Fig. 1: The effect of compost, P, and their interaction on jojoba seed yield in the two studied seasons.

The influence of compost, N, and their interaction on jojoba seed yield

Compost and N applications increased jojoba seed yield significantly during the two studied seasons. In terms of how much N levels, **Table 4 and Fig**. 2 demonstrate that all levels greatly outweigh the initial N content of the soil in producing jojoba seed yield. This response was essentially linear to the application of the maximum dose of N. This finding was consistent across both seasons. The application of 500 kg N ha-1 is suggested to be the ideal level of N application for jojoba seed production. The following ascending order can be used to compare how much N impacts seed yield: 0 < 125 < 250 < 500 kgNha^{-1} in each seasons. The current study contrasts the fluctuating performance in seed production reported by **Inam et al. (2017)** with a steadily rising positive response of jojoba seed yield. According to their claims, increased NPK dosage rates promote vegetative growth in seeds.

Table4 Influence of compost, N, and their interaction on jojoba seed yield (kg ha^{-1}) in the two seasons of study.

N rates	First season			Mean	Second season			Mean
	OM0	OM1	OM2		OM0	OM1	OM2	
N0	142	427	560	376	168	497	661	442
N1	168	437	569	391	196	512	673	460
N2	184	445	577	402	217	523	688	476
N3	199	457	587	414	236	533	707	492
Mean	188	240	271	396	204	516	682	468
LSD5%	OM=1.28	N= 1.47	OMxN= 2.55		OM=1.54	N= 1.78	OMxN= 3.08	

N0:0 Kg N ha^{-1} N2:250 Kg N ha^{-1} OM0: 0 ton ha^{-1} OM2: 40 ton ha^{-1}
N1:125 Kg N ha^{-1} N3:500 Kg N ha^{-1} OM1: 20 ton ha^{-1}

Table 4 shows seed production increased steadily in the second season compared to the first due to the application of compost and N levels. This makes sense when the jojoba bushes' production capacity is already higher in the second season than in the first. Additionally, there is the lingering impact of the previous season. OM2 (40tonha^{-1}) x N3 was the best combination treatment for seed production (500kgha^{-1}).

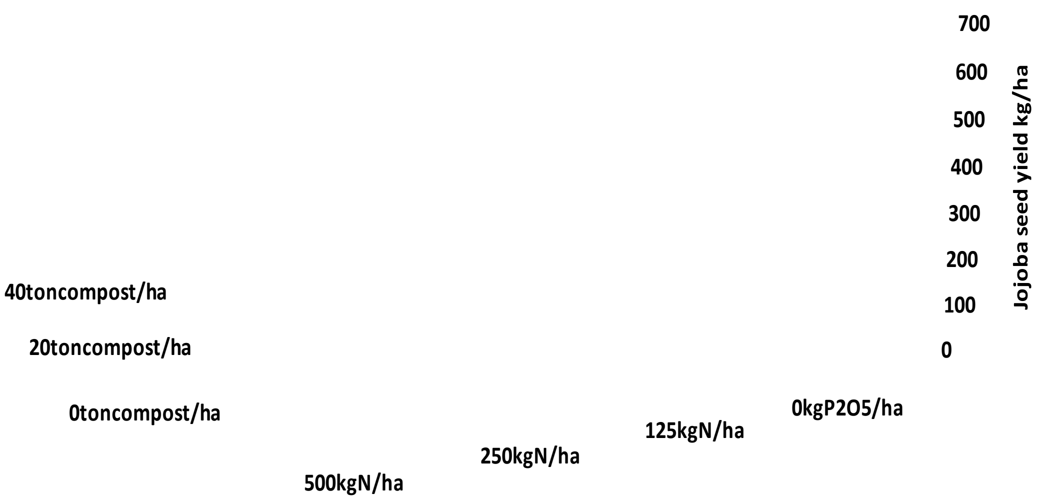

Fig.2: Influence of compost, N, and their interaction on jojoba seed yield in kg ha^{-1} for the average of both study seasons.

According to **Table 4**, the interaction OMxN had a considerably favorable effect in the second season but not the first. This can be due to the lingering effects of fertilizer treatment in both the first and second growing seasons. Using high OM levels improved the efficiency of N levels in seed formation. Both research seasons showed that this was the case. In the studies presented by **El-Maadawy and Moursy (2007),** the interaction of OMxN as averaged across different treatments appeared in a fluctuating mode. Every fertilization method, they found, had a positive impact on several growth and chemical composition aspects. Higher results were obtained by mixing 12 NPK with two or more bacterial strains (for example, combining bacteria that fix nitrogen and those that solubilize phosphorus). Even if it is implied, it is clear that in order for more than one organism to be recruited, more excellent organic manure must practically exist in order for it to serve as a substrate for the most remarkable performance by those organisms. It was coupled with 500 kg N ha^{-1} and 320 kg P_2O_5 ha^{-1}. The application of the highest compost level of (40 ton ha^{-1}), 320 kg P_2O_5 ha^{-1} and 500 kg N ha^{-1} is recommended as the optimal combination treatment for jojoba seed production.

The influence of P, N, and their interaction on jojoba seed yield

Data in **Table 5 & Fig.3** show that the highest effective combination treatment was due to the mutual application of P3 (320 kg P_2O_5 ha^{-1}) and N3 (500 kg N ha^{-1}) in both study seasons.

Table 5. Influence of P, N, and their interaction on jojoba seed yield (kg ha^{-1}) in the two seasons of study.

N rates	First season				Mean	Second season				Mean
	P0	P1	P2	P3		P0	P1	P2	P3	
N0	304	357	398	446	376	350	416	472	531	442
N1	322	366	411	466	391	371	431	491	548	460
N2	332	374	423	480	402	385	444	504	517	476
N3	343	383	434	497	414	397	454	517	599	492
Mean	325	370	417	472	396	376	436	496	562	468
LSD5%	P= 1.78	N= 1.47	PxN= 2.95			P= 1.78	N= 1.78	PxN= 3.08		

N0:0 Kg N ha^{-1} N2:250 Kg N ha^{-1} P0:0 kg P_2O_5 ha^{-1}
P3:160 kg P_2O_5 ha^{-1}
P1:80 kg P_2O_5 ha^{-1}
N1:125 Kg N ha^{-1} N3:500 Kg N ha^{-1} P4:320 Kg P_2O_5 ha^{-1}

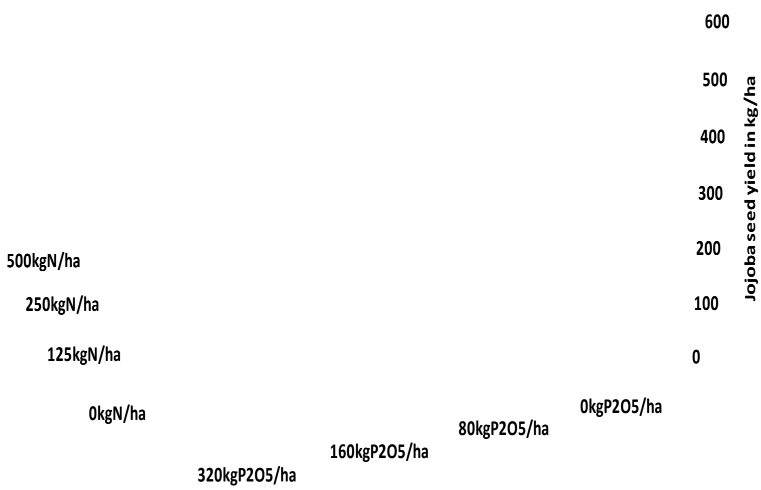

Fig.3: Influence of P, N, and their interaction on jojoba seed yield (kg ha^{-1}) for the average of both study seasons.

The influence of P, N, and their interaction on jojoba seed yield

The effects of compost-P-N interactions on the mean seed yield of jojoba are shown in **Table 6 and Fig. 4**. Mean compost-P-N interactions considerably influenced seed yield. The best course of action was OM2, P3, and N3. Comparing this treatment to the control treatment (OM0 P0 N0), the increase in mean seed yield was roughly 655 kg ha^{-1}. The same pattern was seen in the second year as well. The average seed yield in the second year, however, was higher than in the first year (814 kg ha^{-1}) than in the control treatment (OM0, P0, and N0), which was 27 kg ha^{-1}.

Table 6. Influence of the interaction between compost, P, and N on jojoba seed yield in kg ha^{-1} in the two seasons of study.

P Rates	N Rates	First Season: Mean seed yield Kg ha^{-1} OM rates			Means of P rates	Second Season: Mean seed yield kg ha^{-1} OM rates			Means of P Rates
		OM0	OM1	OM2		OM0	OM1	OM2	
P0	N0	23	369	519	324.75	27	420	603	375.67
	N1	51	387	526		58	446	610	
	N2	62	399	534		73	460	621	
	N3	71	413	543		86	471	633	
P1	N0	103	418	550	370.00	120	486	643	436.42
	N1	122	423	554		143	495	654	
	N2	136	426	559		160	509	664	
	N3	149	435	565		176	516	671	
P2	N0	184	440	569	416.67	215	523	677	496.08
	N1	216	445	572		252	534	687	
	N2	235	456	579		273	541	698	
	N3	249	469	586		292	551	710	
P3	N0	257	479	603	472.33	309	560	723	562.25
	N1	284	491	623		331	573	739	
	N2	303	501	636		361	583	770	
	N3	325	511	655		390	594	814	
Means of OM Rates		173.13	441.38	573.31		204.13	516.38	682.31	
Means of N rates									
N0			376.16				442.16		
N1			391.16				460.16		
N2			402.16				476.03		
N3			414.25				492.00		
LSD 5%			5.11				6.15		

N0:0 Kg N ha^{-1} N2:250 Kg N ha^{-1} P0:0 kg P_2O_5 ha^{-1} P3:160 kg P_2O_5 ha^{-1}
P1:80 kg P_2O_5 ha^{-1}

N1:125 Kg N ha-1 N3:500 Kg N ha-1 P4:320 Kg P_2O_5 ha-1
OM0: 0 ton ha-1 OM2: 40 ton ha-1 OM1: 20 ton ha-1

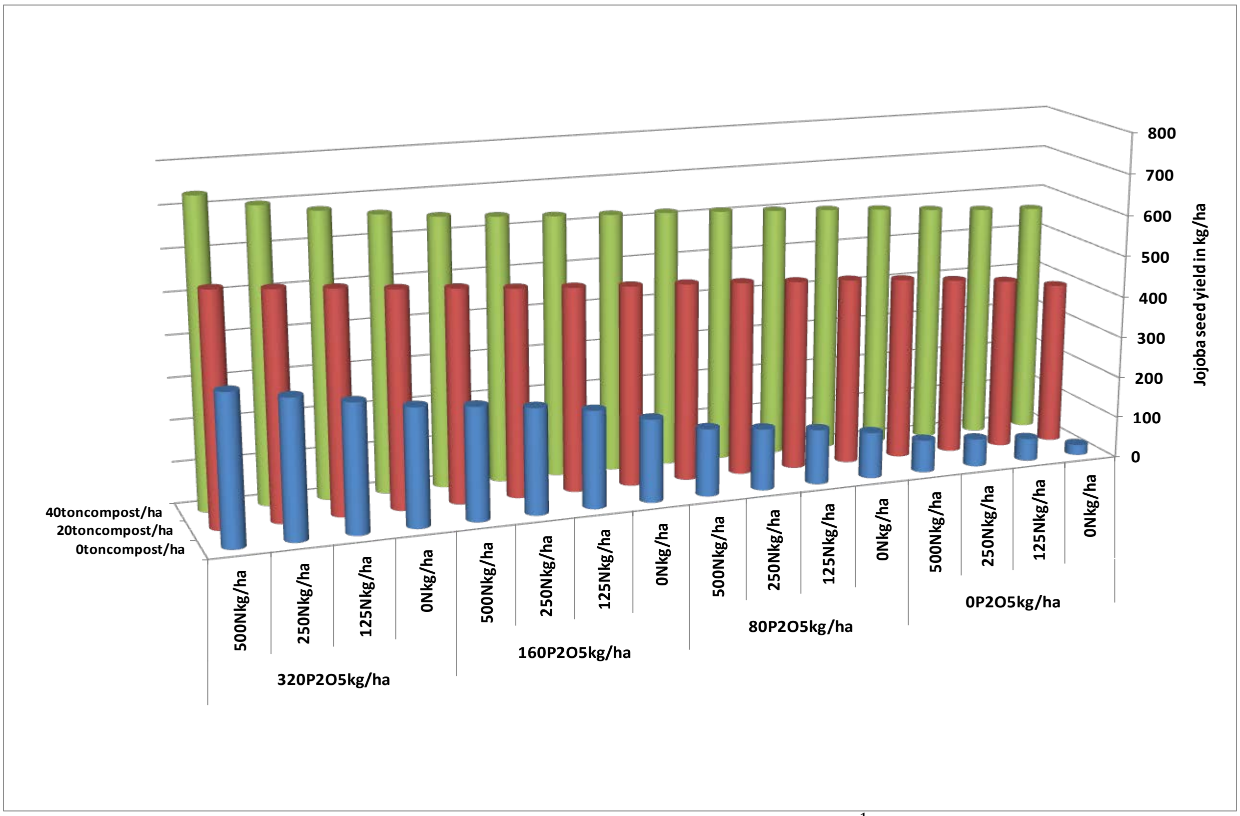

Fig.4: Influence of compost, P, and N interaction on jojoba seed yield (kg ha-1) for the average of both study seasons.

Conclusion

The purpose of this study was to determine the best fertilizer rates of compost, P, and N for jojoba trees. Because of the high salinity in the water well, the trees in the research area were exposed to salt stress. To accomplish this, successive rates of compost and inorganic P and N fertilizers were used to determine the best rate of application for each fertilizer alone and in combination. Applying compost at a rate of 40 ton ha-1, P at 320 kg P_2O_5 ha-1, and N at 500 kg N ha-1, resulted in the highest significant seed yield in both seasons. This combination resulted in jojoba seed yields of 655 and 814 kg ha-1 in the first and second season, respectively. Overall, the second season produced more seed yield than the first. This might be because to the substantial residual effects of compost and P, meaning that their application in one season may have an influence on subsequent seasons. Another possible explanation might be increasing seed yield with increasing trees size.

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استجابة محصول بذور الجوجوبا (Simmondsia chinensis L.) المروية بالمياه المالحة إلى التسميد بالكمبوست والفوسفور والنيتروجين

الجوجوبا تعتبر من اهم المحاصيل الزراعيه الصناعيه الواعده والجديده فى مصر . تم إجراء تجربة على الجوجوبا في واحة المغرة شمال شرق منخفض القطارة في الصحراء الغربية بمصر. تم إجراء التجربة على مدى عامين متتاليين (2020–2021 و 2021–2022) للتحقق من استجابة محصول بذور الجوجوبا للتسميدالعضوى(الكمبوست) ، والفوسفور (P) ، والنيتروجين (N) في تصميم قطع منفصلة. بلغ متوسط ملوحة مياه الري من البئر المستخدم 7.4 $dS\ m^{-1}$ ، مما يعني أن الأشجار كانت تحت اجهاد ملحى. العامل الرئيسى الكمبوست بثلاث معدلات 0 و 20 و 40 طن هكتار. والعامل الثانى الفوسفور(P) بأربعة معدلات 0 و 80 و 160 و 320 كجم P_2O_5 هكتار $^{-1}$. بينما العامل الثالث النيتروجين (N) بأربعة معدلات 0 و 125 و 250 و 500 كجم نيتروجين هكتار. أظهرت النتائج زيادة محصول بذور الجوجوبا بشكل خطي مع زيادة معدلات جميع المتغيرات المختبرة. كان العلاج الأكثر فعالية هو تطبيق P و N والكمبوست بمعدلات 320 كجم P_2O_5 و 500 كجم N و 40 طن هكتار. في الموسمين الأول والثاني ، نتج عن هذه المعدلات محصول بذور الجوجوبا 655 و 814 كجم هكتار $^{-1}$ على التوالي. قد يكون ارتفاع إنتاج البذور في الموسم الثاني بسبب الآثار المتبقية من الكمبوست والفوسفوروالنيتروجين ، وكذلك حجم الأشجار. لذلك ، كشفت هذه الدراسة أن أشجار الجوجوبا المزروعة في ظروف شديدة الجفاف وتتعرض لإجهاد الملحى تستجيب بشكل كبير للتسميد بالأسمدة المعدنية والعضويه عند استخدامها بكميات كافية.