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Combined effect of soil salinity and phospho-potassium fertilization on yield of degletnour date palm (Biskra Southeast Algeria)

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Abstract

The objective of this study is to focus on the spatial variability of salinity at different depths of the soil of a palm grove located in Biskra in the southern east of Algeria where two sites S1, S2 of different degree of salinities , occupied by 54 date palms variety from which Deglet-Nour has been selected in order to alleviate the influence of this salinity on the production with regard to (quality and quantity) of palms of the selected sites by the provision in appropriate doses of mineral fertilizer (potassium and phosphorus). Palms in question have been fertilized with three levels of potassium (0, 2 and 3 kg /palm) in the form potassium sulphate K_2SO_4 (50%) combined with three levels of phosphorus (0, 1 and 2 kg/palm) as superphosphate (TSP) the results obtained make it possible to affirm that the application of 2 kg of potassium / palm tree in an excessively salty environment and 3 kg / palm in a low or unsalted environment associated to 1 kg of phosphorus in the two different cases of salinity of the two sites S1 and S2 increases the yield and gives better results to fruit weight , length, diameter, weight of pulp and weight of the stone.

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Introduction

Salinity is a global phenomenon affecting nearly one billion hectares, that's 7% of the land surface (Ghassimi*et al.*, 1995). Its effects are mainly manifested by the degradation of the physical characteristics of soils (Durand, 1983) which in turn can trigger desertification processes in affected areas (Halitim, 1988). Salinisation damages are known in Maghreb countries because of poor management of irrigation water (Djili*et al.*, 2003; Daoud*et al.*, 1994).

In Algeria, irrigated areas, especially in the south, where water supplies are important because of water deficiency (PET: +200 mm / year), are largely affected by secondary salinization (Djili*et al.*, 2003). the latter contributes to falls in agricultural yields and in particular the production of date palms which are grown in the Saharan regions , where the scarcity of rainfall (<100 mm / year) has forced farmers to use water from groundwater which is strongly salted.

Mismanagement of irrigation water and drainage has detrimental consequences on the Phoenicultural environment in the Saharan regions (Munier, 1973). This led to salinisation of soil, falling yields and poor quality of dates in the Ziban oasis (The Biskra region) (Dutil, 1971; Dubost, 1991).The use of salted soils, by the usual method, allows to obtain certain harvests, but very diminished and of poor quality because of the salt content or by the poor physical properties. This decrease in yields becomes very important from certain levels of soluble salts in the soil.

In this context, the fertilization imposes itself as an essential element for reducing salinity restoring soils and making available a reserve of these elements for the benefit of crops, and consequently of having satisfactory yields in quantity and quality. Fertilization of the date palm with fertilizers of organic or mineral origin plays an important role in increasing the productivity of trees and in improving the quality of production; but its positive and significant effect requires an adequate timing of complete fertilizer input and determination of its frequency, quantity and quality in order to improve production, the rational use of fertilizers is necessary to avoid soil fatigue.

Agronomic researches on the fertilization of the date palm are still limited, especially fertilization tests with Phosphorus and Potassium. In the Algerian phoenicicol zones, date producers use manure as a principal fertilizing contribution to the palm tree. Yet, lately, with the increase of soil salinity by the irrigation water and capillary upwelling, the addition of organic manure became insufficient to obtain a better quality of date. In this context, the present study aims to realize a spatialisation of salinity in an irrigated palm grove in order to highlight the levels of soil contamination and then the adaptation of a phospho-potassium fertilization program aiming at improving the production and quality of Deglet-Nour dates grown in salty soil.

Materials and methods

The present study was conducted during the successive seasons of 2015 and 2016 in private orchard with an area of 21, 90 ha located in Biskra in the southern east of Algeria.

The plot has been delimited in the palm grove; the sampling plan was established using ARC-GIS software, in a regular grid of 50 m x 50 m, to position 81 sample points (Fig 1).

A soil auger was used to collect soil samples to a depth of 60 cm in three levels (0-20, 20-40, 40-60 cm) for the determination of electrical conductivity in the extension of the nutrition roots of date palms.In order to meet the objectives of our study, it was necessary to locate two sites S1 and S2 of different salinity class in the same plot (from the established salinity map):

Site S1: Soil salinity> 16 dS / m, occupied by 27 palms (uniform as possible, healthy of any infection, subjected to the same cultural practices, palm tree were planted at spacing 9x9 meters apart and irrigated by drip system.

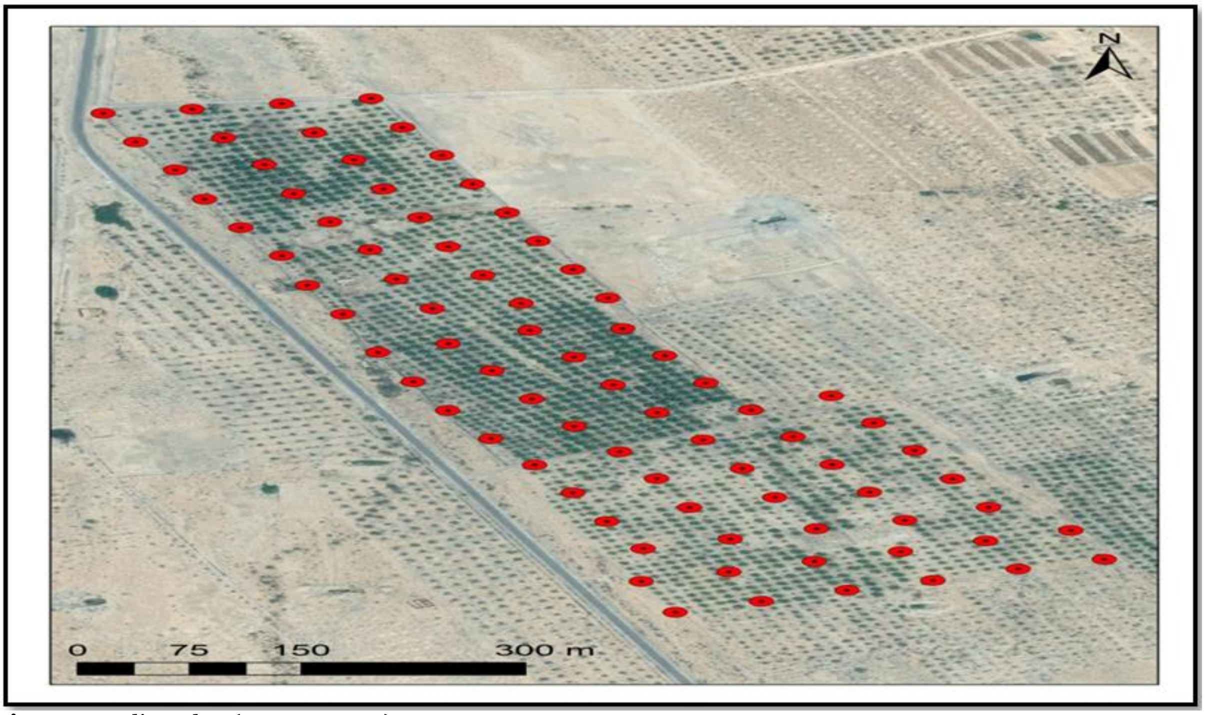

Fig. 1. Sampling Plan (ARC-GIS 9.3.).

Site S2: Soil salinity between (4-8 dS / m), occupied by 27 palms. The soil analysis of the two studied sites is presented in Table 1.

The palms were fertilized with superphosphate (46%) as a source of phosphorus and potassium sulphate (K_2SO_4 50%) as a source of potassium. Nine soil application treatments were arranged in completely randomized design with three replicate (1replicate = 1 palms) per treatment (i.e. 1x3x9 =27) ,the treatments were as follow:

T1: unfertilized tree (control),T2: 0kg K + 1kg P,T3 : 0kg K + 2kg P,T4 : 2kg K + 0kg P,T5: 2kg K + 1kg P,T6: 2kg K + 2kg P,T7: 3kg K + 0kg P,T8: 3kg K + 1kg P,T9: 3kg K + 2kg P.

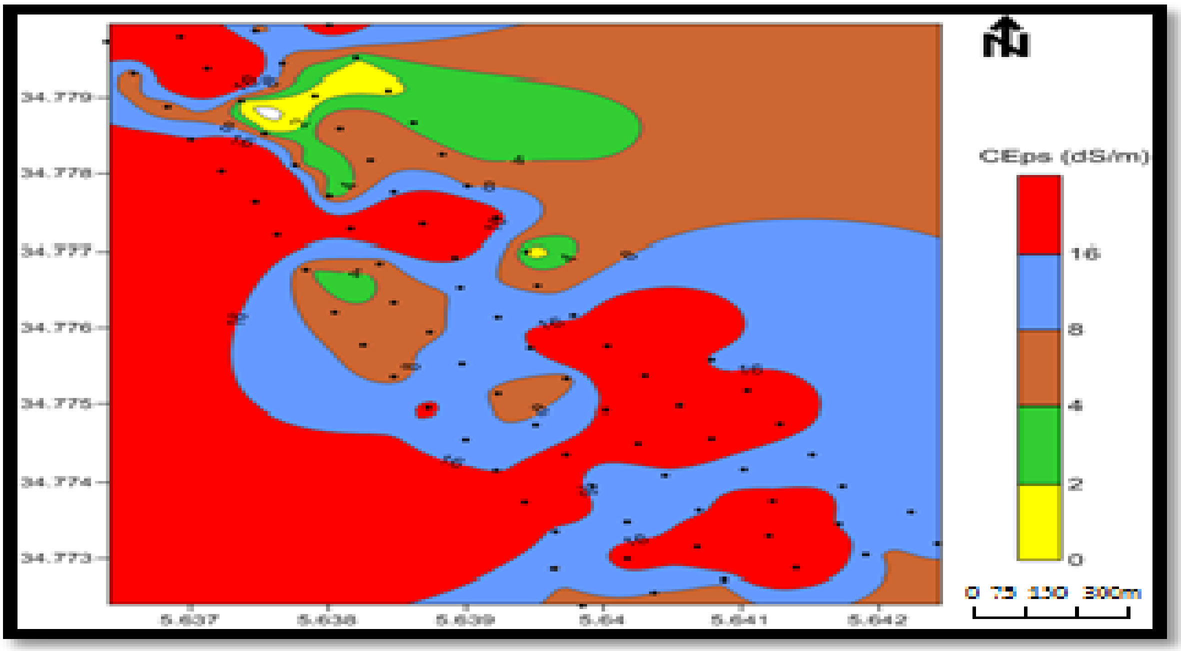

Fig. 2. Salinity map of the ground horizon of depth (0-20cm).

Each dose is buried 40 cm deep and 50 cm from the trunk of the palm tree and all around it.

Cartography

Spatial estimation of salinity was performed by the interpolation method related to simple kriging. The isovalue maps of each soil layer were established using Surfer Software 14 (Golden Software, LLC). The interpretation of the salinity maps of the experimental plot is done by calculating the areas in hectares and percentages of the different salinity classes held by the USSL,(1954).

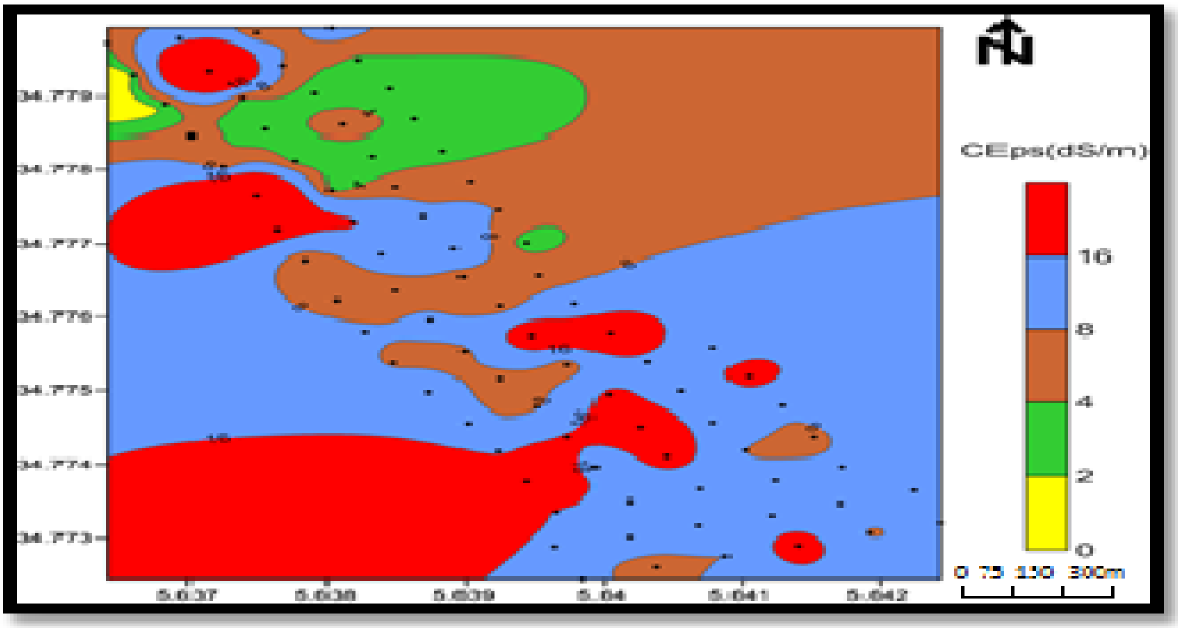

Fig. 3. Salinity map of the ground horizon of depth (20-40cm).

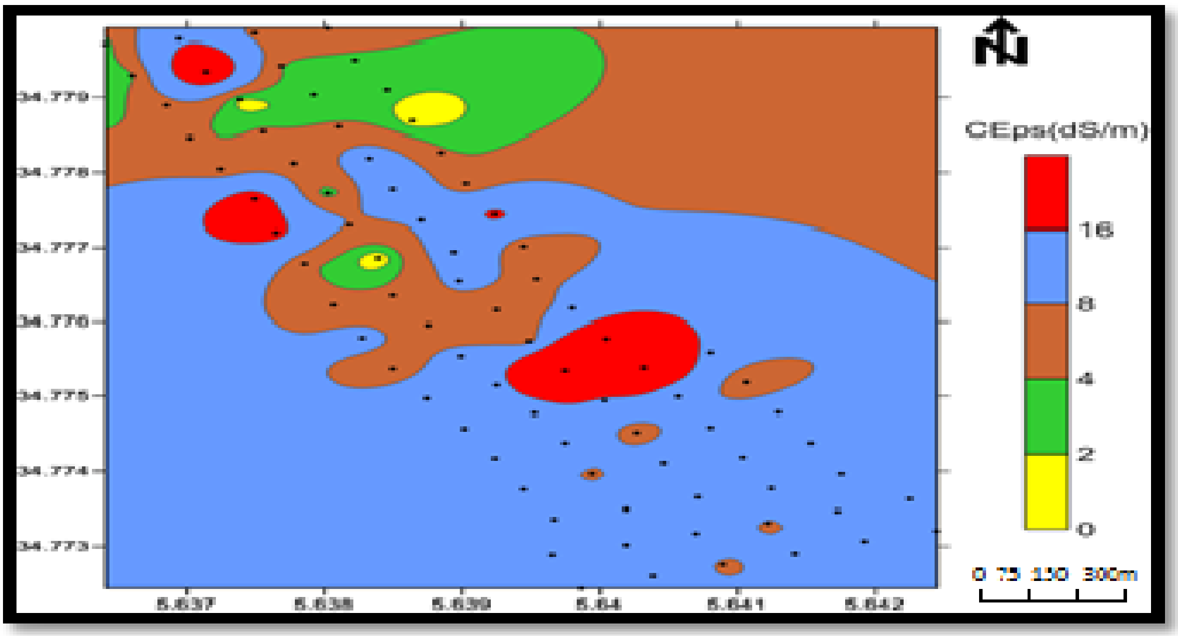

Fig. 4. Salinity map of the ground horizon of depth (40-60cm).

Yield determination

The average fruit yield was recorded in kilograms. Additionally, fruit samples were randomly taken from different branches to determine the values of physic-chemical characteristics chosen to represent fruit quality.

Fruit physical characteristics

Sample of 20 fruits have been taken on each palm tree for the determination of the physical characteristics (weight, diameter and length of fruit, weight of pulp and weight of stone).

Statistical analysis

All data were tested by analysis of variance (ANOVA) technique by Xlstat 2016 (Addinsoft. 2016 data analysis and statistical solution for Microsoft Excel). Treatments means were separated and compared using the significant differences at 0.05 levels of significance according to Snedecor and Cochran,(1989).

Results and discussion

Spatial distribution of salinity in the soil

The results related to the electrical conductivity (extracted from the saturated paste) of the 81 soil samples taken from three levels of depth.

Table 1. Soil and irrigation water analysis of the two experimental sites.

properties	Site S1 (EC_{soil}> 16 dS/m)	Site S2 (EC_{soil}4-8dS/m)
pH	7.98	7.96
Na(meq/l)	37.3	6.87
Ca(meq/l)	6.8	11.06
Mg (meq/l)	30.53	24.2
K (meq/l)	2.06	0.6
Cl (meq/l)	67.33	7.66
SO_4 (meq/l)	17.78	12.56
HCO_3(meq/l)	2.5	1.5
Gypsum%	60.10	57.33
$EC_{irrigation\ water}$ (ds/m)	5.5	3,93

The EC_{SP} isovalue maps of the three layers show the presence of five classes of salinity heterogeneously distributed at the plot level (Figures 2, 3 and 4); The highest concentrations of salinity are located on the southern part of the plot while the lowest concentrations are located on the northern part, this situation can be explained by the contribution of soluble salts of irrigation water and poor drainage.

The average values of the ECsp increase from 9.55dSm^{-1} in the third horizon and gradually increase towards the surface horizon to reach a value of 16.47 dSm^{-1}.The average salinity of the horizon (0-60cm) reveals that the average saline profile is of descending type with an average of 12.28dSm^{-1}. The nature of this profile is the consequence of the quality of irrigation water and intense evaporation that characterizes the irrigated oasis where irrigation frequencies are more important.

The analysis of Figure 5 and the visualization of the salinity maps of the three layers revealed a variation of the salinity level at one layer to another. The H1, H2, H3 layers include all classes of salinity (non-saline to extremely saline) with a predominance of the 'very saline' class (56%) in H1, (65%) in H2 and (74%) in H3, the 'not saline' classes (2, 0.1 and 0 .5% in H1, H2 and H3 successively) 'slightly saline' (5%) in all the layers very little represented.

Yield

The found results (Tab 2) show that the effect of treatments applied during both seasons on the production of dates is highly significant.

The efficiency during the first year on site S2 during the first year is comparatively higher to that of the S1 site, with averages of 77.85 and 92.59 Kg / palm in the S1 and S2 sites successively. The efficiency during the second year oscillates between 81 and 127 kg / in the site S1 and between 78.67 and 130 kg / palm in the site S2 with averages of 95.62 and 101.77 in the site S1et site S2 successively. The yield of dates in the second year is much higher than in the first year. It is to be noted, however, that the yield is greater on site S2 compared to that of site S1. The highest production during the first season is obtained for the T2 treatments (0kg K / 1kg P) on site S1 site and the T8 treatment (3kg K / 1kg P) in the S2 site. On the other hand, during the second year, the T5 (2kg K / 1kg P) and T8 treatments on S1 and S2 sites, show a higher production which varies between 127 and 130 kg / palm compared to the control and the other treatments.

Tab 2. Effect ofphospho-potassium fertilization on yield, weight, diameter and length of the fruit, of Deglet–Nour date cultivar in different degrees of salinity during 2015 / 2016 seasons.

Treatments		Yield (kg/palm)		Fruit weight (g)		Fruit diameter(cm)		Fruit length (cm)	
		2015	2016	2015	2016	2015	2016	2015	2016
Site S1	T1	88.00ABC	81ABC	7.92F	8.06F	1.5DE	1.29E	3.57EF	3.45F
	T2	97.33ABC	97.00BC	8.15EF	10.17ABCD	1.49DE	1.69BCD	3.61DEF	3.80BCDE
	T3	65.00ABC	97.00BC	8.17EF	10.64ACDE	1.47DE	1.67 BCD	3.69CDEF	3.94ABC
	T4	84.67ABC	97.33BC	9.19CDEF	11.51AB	1.53CD	1.76AB	3.84ABC	3.89ABCD
	T5	94.00ABC	127.00A	9.35CDEF	11.98A	1.51CDE	1.93A	3.81BCDE	4.12 A
	T6	78.67ABC	98.67BC	9.29DEF	9.86BCDEF	1.53CD	1.64BCD	3.72 CDEF	3.80BCDE
	T7	60.00ABC	99.00B	8.73CDEF	10.96ABC	1.51DE	1.73ABC	3.69 CDEF	3.88ABCD
	T8	71.67ABC	76.33ABC	8.94DEF	11.74BCDEF	1.53BCD	1.77AB	3.73 CDEF	4.07AB
	T9	61.33ABC	87.33ABC	8.66BCDEF	9.80 BCDEF	1.51DE	1.60BCD	3.68CDEF	3.86ABCDE
	Mean	77.85B	95.62A	8.71B	10.52A	1.50B	1.67A	3.70 B	3.87A
Site S2	T1	92.00ABC	85.67ABC	8.09ABC	8.23ABC	1.54ABC	1.49CD	3.80ABC	3.67
	T2	123.67AB	107.33ABC	8.38ABC	12.30ABC	1.48CD	1.73ABC	3.69ABC	4.03ABC
	T3	116.67AB	81.00ABC	8.45ABC	12.41ABC	1.53ABC	1.87ABC	3.63ABC	4.15ABC
	T4	84.33ABC	78.67ABC	7.57ABC	11.91ABC	1.60ABC	1.82ABC	3.83ABC	4.10A
	T5	82.67ABC	110.0ABCo	8.33ABC	11.48ABC	1.55ABC	1.86ABC	3.69ABC	4.07AB
	T6	69.00ABC	83.00ABC	8.30ABC	12.06ABC	1.59ABC	1.81ABC	3.79ABC	4.06AB
	T7	67.67A	115.67ABC	8.11ABC	12.97AB	1.45D	1.81ABC	3.68ABC	4.11ABC
	T8	125.00AB	130.33A	9.39ABC	13.54A	1.54ABC	1.91A	3.45C	4.19A
	T9	72.33AB	124.33ABC	7.95ABC	12.27ABC	1.49CD	1.83ABC	3.71ABC	4.09AB
	Mean	92.95B	101.78A	8.28B	11.91A	1.53B	1.79A	3.70B	4.05A

The results obtained are in agreement with the results of El Hammady *et al.*, (1991) who found that the highest yield and quality of dates (Seewy) were obtained by the addition of 2 kg of Potassium sulfate / palm / year. Bamiftah *et al.*, (2000) recommended 2 or 3 kg of potassium sulfate / palm / year for higher yield.

These results can be attributed to physiological role of potassium in the improvement of many metabolic processes such as formation of carbohydrate. Archer, (1986), Even and Sorger, (1996) reported that photosynthetic translocation depended on the cell concentration of Potassium. Phosphorus is necessary in metabolic processes: the synthesis of proteins and energy of ATP as support of Adenosine (Mengel and Kirbry, 1978). The increase in yield of palm trees by the use of phosphate fertilizers was also reported by Bliss and Mathez, (1983); Karami, (2007).

Fruit physical characteristics

The found results (Tab 2 and 3) show that the biometric parameters of the Deglet-Nour dates were affected by phospho-potassium treatments which have considerably improved the quality of the yield on site S2 compared to the site S1 during the second year.

Average weight of fruit and weight of pulp significantly increased by T5 treatment (2kg K / 1kg P) in site S1, also T8 treatment (3kg K / 1kg P) at site S2 in both seasons of study.

In this regard, the control T1 recorded the lowest value. The results obtained show that the variation in the weight of the dates between the two studied seasons and the two sites S1 and S2 is highly significant.

Tab 3. Effect of phospho-potassium fertilization on Weight of the stone and weight of pulp of Deglet–Nour date palm cultivar in different degrees of salinity during 2015 / 2016 seasons.

Treatments		Weight of the stone (g)		Weight of pulp (g)	
		2015	2016	2015	2016
Site S1	T1	0.84BCD	0.75D	7.08F	7.31EF
	T2	0.81CD	0.88ABC	7.34 EF	9.29 ABCD
	T3	0.85ABCD	0.96A	7.33 EF	9.68 ACDE
	T4	0.85 ABCD	0.90ABC	8.34 CDEF	10.61 AB
	T5	0.85 ABCD	0.90ABC	8.50 CDEF	11.08A
	T6	0.81 BCD	0.89ABC	8.48 DEF	8.97 BCDEF
	T7	0.89 ABC	0.93AB	7.84 CDEF	10.03 ABC
	T8	0.87 ABC	0.96A	8.07 DEF	10.7 DEF
	T9	0.79 CD	0.83BCD	7.87 BCDEF	8.97 BCDEF
	Mean	0.84B	0.89A	7.87ABC	9.63A
Site S2	T1	0.77D	0.74ABC	8.31DE	7.49C
	T2	0.79CD	0.92BCD	7.59DE	11.38ABC
	T3	0.79CD	0.92ABC	7.66DE	11.49ABC
	T4	0.84CD	0.99ABC	8.55ABC	10.92ABC
	T5	0.83BCD	1.00ABC	7.49DE	10.48DE
	T6	0.87BCD	0.89ABC	7.43DE	11.17ABC
	T7	0.77D	1.10AB	7.33DE	11.87AB
	T8	0.81BCD	1.05A	8.58DE	12.49A
	T9	0.78D	1.05	7.17DE	11.23AB
	Mean	0.81B	0.69AB	7.48B	10.94A

The results shown in Tab 2 , indicate that fruit length in both season of study was significantly affected by the treatments for Deglet-Nour date palm, the best results were obtained by T5 (2kg K / 1kg P) and T4 (2kg K / 0kg P on siteS1 and by T4 on siteS2, while in the second season, the T5 (2kg K / 1kg P) and T8 treatments (3kg K / 1kg P) gave the longest fruit compared to the control T1 which gave shorter fruits on site S1 and S2 successively.

The results obtained show that the variation in the length of the dates between the two seasons and the two sites is highly significant.

The average fruit diameter presented in Tab2 indicates that the best results in the first season were obtained from T4 (2kg K / 0kg P), T6 (2kg K / 2kg P) and T8 (3kg K / 1kg P) with 1.53 cm on site S1and T4 on site S2 , while in the second season, the diameter of the dates increases by the treatments T5 (2kg K / 1kg P) and T8 where the highest values were recorded with regard to control T1.

The Sites S1 and S2 have the lowest values for the control treatment. The results obtained show that the variation of the date diameter between the two seasons and the two sites S1 and S2 is highly significant.

During the first season, the best results of the stone weight were obtained by T7 (3kg K / 0kg P) on site S1 and by T6 (2kg K / 2kg P) on site S2,while in the second season, treatmentsT3 (0kg K / 2kg P) and T8 (3kg K / 1kg P) on site S1 and T7 (3kg K / 0kg P)on site S2 had a significant effect on the stone of fruit compared to the control T1 (Tab 3).

The total improvement in physical characteristics could be explained by the role of potassium. The increase in weight of the fruit can be attributed to the physiological effect of potassium in increasing the osmotic potential of fruit cell, which could promote the circulation of water in fruit and consequently its volume and weight.

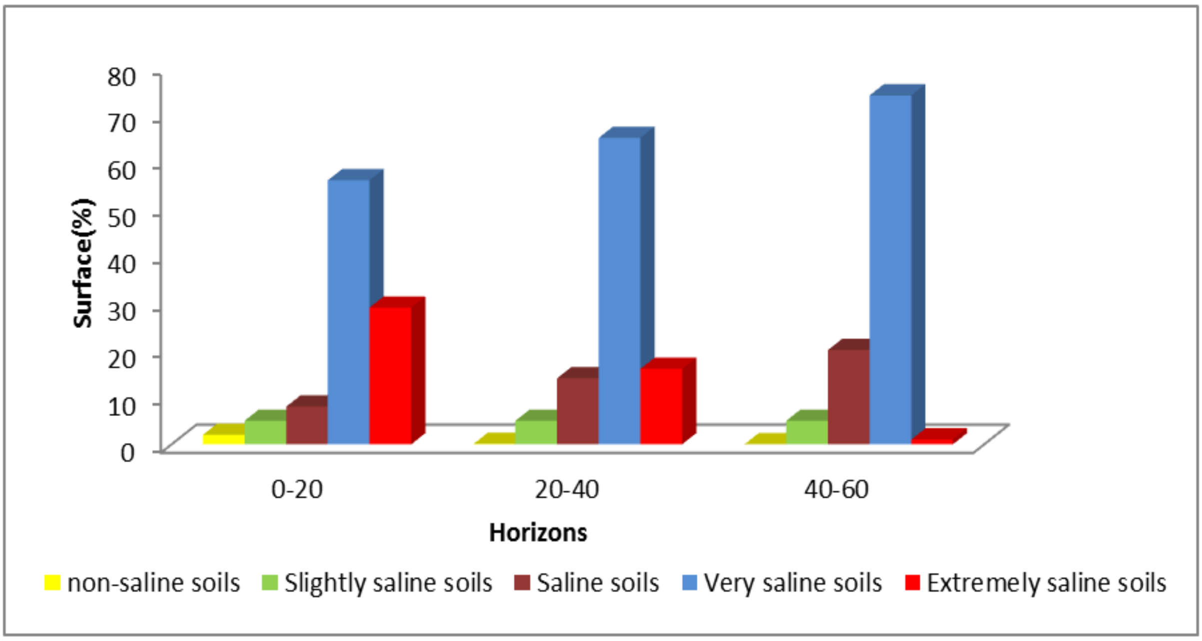

Fig. 5. Distribution (%) of salinity classes in soil horizons.

These results are in agreement with Houssine *et al.*,(2012); Bacha *et al.*, (1982) ; Sinclair *et al.*,(1981), who reported a spray application of fruit with 2% potassium, caused an increase in fruit weight, volume and concentration of potassium in fruit varieties "Halawy". Dialmi et Rezhman, (2005) ; Soliman et Osman,(2003) ;El- Deeb and al.,(2000);Ismail, (1999) Have affirmed that an application of pure potassium sulfate (5kg / 1000L) on leaves had substantially provoked yield improvement and other characteristics such as fruit weight, length, diameter, and pulp weight of the date variety 'Toory'.

Fisher *et al.*, (1959) have mentioned that potassium is essential for the enlargement of fruit.

Conclusion

In the Saharan and Pre-Saharan regions, the oasis environment is fragile and is continually suffering the effect of aggression factors that continue to weaken it further; the development of agriculture in these areas is currently facing new problems, apart from the scarcity of water resources, such as the risk of soil salinization, which contributes to falls in agricultural yields. Finally, we were able to highlight the effect of phospho-potassium fertilization in improving the production of dates in quantity and quality as an appropriate action to minimize the consequences of different constraints.

So in order to increase the yield and improve the quality of the fruits, it is recommended to apply 2kg of potassium sulphate / palm in an excessively salty environment and 3kg / palm in a not too salty environment with 1 kg of phosphorus in both situations. The quality of the dates obtained in the framework of this study is conform with the criteria of qualitative evaluation of the dates of the cultivars Algerians, Moroccans, Tunisians, Egyptians and Iraqis which are reported by Rygg,(1953) ; Meligi et Sourial,(1982) et Mohamed *et al*.,(1983) ; Rayens*et al* ., (1994) ;Othman,(1995).

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