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The Study of the Germination Behavior of Forage Species on Substrates Taken from the Soil of Awleigatt National Park in Mauritania

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ABSTRACT

Awleigatt National Park (ANP) is a zoological site ensuring both the conservation and restoration of biodiversity on a national scale. In this perspective, the ANP has set as one of its ambitious objectives the autonomy in fodder needs. The objective of this work was to study the adaptability of three forage species (*Medicago sativa*, *Acacia senegal* and *Dolichos lablab*) to the edaphic conditions of the NAP. The adopted approach was to characterize three types of representative ANP soil substrates in order to develop an interpolation map of EC conductivity and pH data. Subsequently, the germination behavior of the three species was studied in the laboratory on three substrates taken from the study area (Dune, Dune flank and Interdune) in the absence and presence of NaCl (0, 50 and 100 Mm). The obtained results show that the soils are basic and the electrical conductivity is higher in the inter-dune substrate. The mapping of the study area corroborates the experimentally obtained data. Germination behavior shows that germination is best on dune and dune flank substrates. The addition of high concentrations of NaCl (100mM) shows that *Dolichos lablab* is the most resistant to salinity. *Medicago sativa* and *Acacia senegal* show low germination capacity both in the absence and in the presence of NaCl, most likely reflecting a low embryonic longevity of the seeds used. The parameters deduced from the germination kinetics curve show that the adverse effect of salinity in the three species is observed at all three germination phases (TL, GSS and CG). As a result, the effect of salinity on germination of all three species is both osmotic and toxic.

Keywords: EC; pH; interpolation map, germination behavior; salinity.

INTRODUCTION

The lands of arid and semi-arid zones represent one third of the surface of the globe. These ecosystems are characterized by irregular precipitation associated with significant evaporation favoring the accumulation of salts in the soil. This explains the poor quality of water resources available in these areas (Alaoui et al. 2013). Soil salinization is considered one of the main factors limiting plant development (Benidire et al., 2015). In Mauritania, ecosystem degradation is becoming increasingly severe. This is mainly due to poor climatic conditions and human activities, such as overgrazing and salinization of agricultural lands (Aly El Hor, 2018). One of the strategies to counteract the negative effects of ecosystem degradation is their conservation or even restoration. Creation of zoos and botanical gardens is the most successful approach in arid and semi-arid areas. Awleigat National Park (ANP) was created in 2015–2016 in the Wilaya of Trarza. This park ensures, at the same time, the conservation and restoration of the country's biodiversity. The choice of the site is based primarily on the assets of the area in biological resources that can contribute to the satisfaction of food needs of some of the targeted animal species, especially with relatively strong natural regeneration of the area (Awleigat National Park, 2020). It is in this context that this modest work fits. It aims to characterize certain physico-chemical parameters of the soil. During the prospection, in order to define the subject, it was noticed that the texture of the soil presents certain hostility to the installation of the vegetation. Thus, the park was zoned according to these landforms. From each zone, 30 to 52 soil samples were taken, for a total of 192 samples. These samples were used to determine the physico-chemical parameters of the soil (pH and EC). The results obtained were used to establish the mapping of the NAP. Subsequently, in the laboratory, three forage species were germinated, considered the most palatable by the animals in the park, (*Medicago sativa*, *Acacia senegal* and *Dolichos lablab*) on the soils collected, both in the presence and absence of NaCl.

MATERIAL AND METHODS

Site description

Awleigat National Park created on 6th October, 2016 by Presidential Decree No: 0178 is a public establishment with administrative character (EPA). The ANP was a zoological park project with an area of 400 ha created by the decree N°:0406 of the Minister of Environment and Sustainable Development on 18th March 2015. The park is located 60 km east of the capital (Nouakchott) between the town of Awleigat and Ouad Naga (Willaya of Trarza). It is located 8 km south of the village of Idini. It currently covers an area of 1600 ha, located between the geographical coordinates: 17°52'37.50" North and 15°30'34.50" West (Figure 1). ANP is located in a transition zone between the desert climate of the Sahara with annual rainfall of less than 100 mm and a Sahelian climate with average rainfall between 200 and 400 mm. Rainfall is low and irregular, with rains concentrated in a short period of the year, i.e. July-September (Yacoub and Tayfur, 2019). The relief of PNA is defined by a series of parallel dunes of orientation separated by small valleys of clay soil (wadis). These clay soils have wadis in some areas a chalky texture characterized by an opacity making the soil hostile to vegetation while the clay soil is characterized by the presence of a stand dominated by *Balanites aegyptiaca* (Mohamed et al., 2014; Mohamed, 2012). The dunes are shifting and have steep slopes characterized by sparse vegetation. The back of the dunes seems to be more favorable to the presence of ephemeral vegetation. The PNA is a restoration zoo. It has received funding that has already allowed the introduction of several indigenous animal species including: Eland; Oryx; Nyala; Dorcas Gazelle; Giraffe, Ostrich; etc. PNA is characterized as a native ecosystem dominated by *Acacias, Balanites aegyptiaca, Leptedonia pyrotechnica, Capparis decidua, Maerua crassifolia*. The double role of this site, i.e. zoo and conservation, suggested to its administration to launch an ambitious project of self-sufficiency by introducing the culture of forage species with high nutritional value. The general approach of the present work fits in this context.

Sampling technique

Soil samples (n = 192) were taken from the top twenty centimeters of soil (0 to 20 cm). The sampling targeted three geo-morphological zones of different relief: dune; dune slope; inter-dune. Each sampling point was geo-referenced using a GPS.

Laboratory analysis

The soil samples were first dried in an oven at 105°C for 12 hours, then ground and sieved. Afterwards, the measurements of the pH and the electrical conductivity of the soil were conducted.The measurement of the pH was carried out using a pH meter of the Mahita type. The protocol consists in mixing 20 g of dry, crushed and sieved soil sample with 100 ml of distilled water method (El Oumri & Vieillefon, 1983; Montoroi, 1997). The whole is stirred for 1h30 mby a Hanna shaker, then left to rest until sedimentation and filtered on a filter paper. The filtrate obtained is used for pH measurements. The electrical conductivity of the soil was measured with a Hanna type conductivity meter. The filtrate previously obtained was also used for the electrical conductivity measurements. The electrode was rinsed three times with distilled water after each measurement.

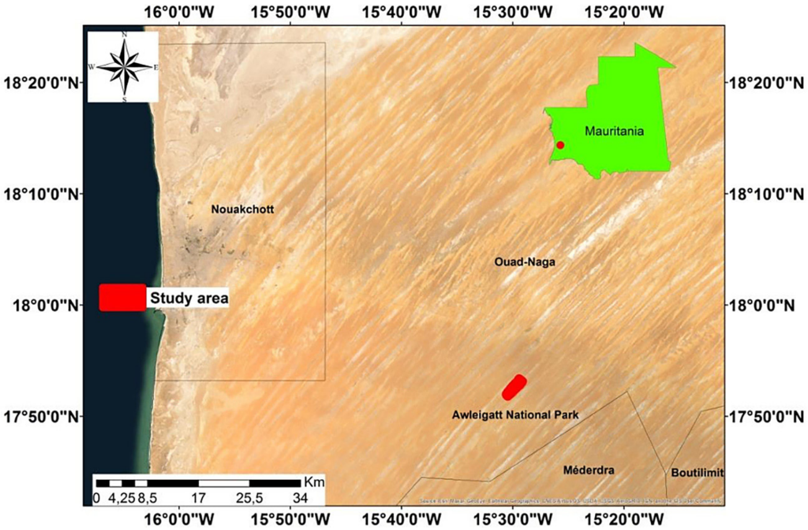

Figure 1. Map of the study area

Prediction by the ok method

The prediction of conductivity and pH by the ok method was calculated by the following equation:

$$y(h) = \frac{1}{2N}\sum_{i=}^{N(h)}[z(x_i) - z(x_i + h)]^2 \quad (1)$$

where: N – the number of sample point pairs separated by a standard distance called the h-offset; $z(x_i)$ – the value of the variable z at the location of x_i.

The presence of a spatial structure where observations that are close to each other are more similar than those that are far apart (spatial autocorrelation) is a prerequisite for the application of geostatistics (Asfaw et al., 2018; Yahiaoui et al., 2015; Tripathi et al., 2015).

Prediction by the IDW method

The prediction of conductivity and pH by the IDW method is calculated by the following equation (Rahul et al., 2019; Seyedmohammadi et al., 2016):

$$z(x_o) = \frac{\sum_{i=}^{n}\frac{x_i}{h_y^{\beta}}}{\sum_{i=1}^{n}\frac{1}{h_y^{\beta}}} \quad (2)$$

where, $z(x_0)$ – the interpolated value, n – representing the total number of sample data values, x_i – the i-th data value, hi – the separation distance between the interpolated value and the sample data value, and denotes the weighting power.

Performance evaluation criteria

To evaluate the accuracy of the predictive ability of the developed models, three types of standard statistical performance evaluation criteria were used. These are the correlation coefficient (R), the root mean square error (RMSE) and the mean error (ME) (Hammam and Mohamed, 2020; Abidine, et al., 2018). The performance evaluation criteria used in this study were calculated using the following equations:

$$R = \sqrt{1 - \left[\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}\right]} \quad (3)$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{i-}\hat{y}_i)^2} \quad (4)$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i| \quad (5)$$

where: y_i – indicates the measured value; i – the predicted value, $\hat{y}_i$ – the average of the measured value and n the total number of observations.

Data processing

All static calculations were performed using Microsoft Excel. Geostatistical analysis and development of soil EC and pH prediction maps were performed using ArcGis10.8.

Germination methodology

Objective

The purpose of this work was to evaluate the effect of salinity (50 and 100 mM) on the germination process of three species (*Medicago sativa*, *Acacia senegal* and *Dolichos lablab*) on three different environments (dune, dune slope, Interdune).

Plant material

The plant material used was composed of the seeds of three species studied (Table 1). The seeds were provided by Awleigatt National Park.

Experimental protocol of germination

The seeds used were provided by PNA. The authors take this opportunity to express their sincere thanks to them for the spirit of collaboration of the whole team and for the great and voluntary help they have provided throughout the development of this work. NAP purchased the seeds from the foreign market. The appearance of the seed lots used, with the exception of the Acacia, shows that the seed was freshly harvested. The *Acacia* appears to be from an older harvest season. However, sorting was carried out to recover only healthy seeds. A preliminary test showed very high germination in *Dolichos lablab*, acceptable in *Medicago sativa* and no germination in *Acacia* before dormancy was broken.

Disinfection of seeds

The seeds of the three species were sorted and disinfected with sodium hypochlorite (bleach) for 5 minutes then washed thoroughly with tap water and rinsed three times with distilled water to eliminate elements harmful to germination.

The lifting of dormancy

Pre-treatment of *Acacia* seeds which showed germination inhibition was done. According to Yougouda et al. (2020), pre-treatments are necessary for species with hard seed coats. It allows satisfactory germination by breaking seed dormancy. Unlike quiescence, pretreatments do not cause seeds to germinate, but make them capable of germinating later when all the required conditions are met. There are two types of dormancy breaking:

- The scarification: it consists in altering the rigid integuments in order to make the embryo accessible to water and oxygen. It can be done mechanically or chemically.
- The stratification: it is made by a stay of seeds in the cold (5°C). This pre-treatment aims at lifting the dormancy of embryonic origin.
- In the adopted protocol, the authors opted for the chemical pretreatment using sulfuric acid (95%) for 3 minutes.

Sowing of seeds for germination

Once disinfected *Medicago sativa* and *Dolichos lablab* and treated *Acacia*, the seeds are sown on the soils taken from three different areas (Dunes, dune side and inter dunes). Germination was carried out in the lower part of the mineral water bottles of capacity 75 ml and perforated at the bottom. This part of 7 cm height was well washed and disinfected. After draining, the device, described above, lined with a double layer of filter paper was filled to half of each type of soil. The soil taken from the Interdune zone with certain opacity was crushed and ground to have the same texture as the soil taken from the other two zones. In each pot, 10 seeds were sown. Three treatments per species were used (0, 50 and 100 mM NaCl), for a total of 450 seeds for each species and 50 seeds per treatment. Once buried in the soil, the seeds were watered every two days. Temperatures varied between 25°C and 30°C. The photoperiod was 16 hours during the day and 8 hours at night. The germinations were carried out during the months of October and November 2022. The kinetics of germination was followed daily for two weeks.

The studied parameters

The kinetics of germination corresponds to the variations in time of the rate of germination of seeds under the conditions of the experiment. It is a parameter that enables to better understand the ecological significance of the germinative behavior of the varieties studied as well as the set of events that begin with the stage of water absorption by the seed and end with the elongation of the

Table 1. Names of species and their families

Scientific name	Vernacular name	Family	Color of the seeds
Acacia senegal	Gommier	Fabaceae	Brown
Lablab dolichos leblab	Cowpea	Fabaceae	Black and red
Medicago sativa	Alfalfa	Fabaceae	Green, yellow, brown

embryonic axis and the emergence of the radicle (Benidire et al., 2015). Monitoring germination kinetics allowed identifying three parameters:

- germination lag time – the latency time is the time needed for the imbibition of seeds. According to Hampson and Simpson (1992); this time corresponds to the time necessary for the germination of 10% of the grains capable of germinating;
- germination index – the germination index (GI) represents the speed of germination. A low index reflects a slow germination (Baba Sidi Kaci, 2020). It is calculated according to the Association of Official Seed Analysts (1990) by the following formula:

$$Germination\ index = G1/1 + G2/2 + ... + Gn/n \quad (6)$$

where: G1 – the germination percentage on the first day; G2 – on the 2nd day, etc.; n – the number of days of the germination time.

- germinative capacity – it presents the physiological limit of seed germination (Brahima et al., 2018). It is expressed as the ratio of the number of germinated seeds to the total number of seeds capable of germination (Benidire et al., 2015).

RESULTS

Reminder of the experimental data

Germination is the most critical stage of the plant development cycle. It conditions the installation of the plant in its environment. It is strongly dependent on edaphic conditions. The seeds placed on an inadequate soil cannot germinate even if all the climatic conditions are satisfied. In what follows, the germination of three forage species, heavily used at the PNA, will be studied on three types of soil in the absence of salt "Control" and in its presence 50 and 100 mM NaCl. The use of salt is justified by the salinization of soils, after several successive crops, by fertilizers and irrigation water. Thus, it seems imperative to specify the limits of tolerance to salinity of the three species studied.

The adopted approach consists in characterizing, first, the soil and then following the germination behavior of the three species on a control and saline medium. The conducted study focused on two major edaphic parameters characteristic of soils: electrical conductivity (EC) and pH. The adaptability and ecophysiological behavior of the three species are assessed by studying the effect of three substrates taken from the soil enriched or not with 50 and 100 mM NaCl on three germination parameters: latency time, germination index and germination capacity.

Edaphic characterization

The two studied parameters EC and pH were used in order to realize the characteristic interpolation maps of the studied area possibly representative of the ANP soil.

Soil conductivity

Table 2 presents the electrical conductivity measurements of the three types of soil studied (dune, dune slope, inter-dune). The results show that the electrical conductivity is low on the dune, very high on the inter-dune and occupies an intermediate position on the dune slopes. Thus, the inter-dune appears to be more affected by salinity than the other areas studied.

Soil pH

Table 3 shows that the pH of the three areas studied is basic. However, a slight difference is observed. The pH of the flank and the Inter-dune (8.19 and 8.24) are slightly higher than that of the dune (7.92). Thus, it turns out that the soils of the flank and Interdune are the most basic.

Interpolation maps

The mapping of electrical conductivity and soil pH is an important tool. It allows the generalization of individual data over the study area (Table 4), thus giving an idea of the soil of Awleigatt National Park. The predicted data (EC and pH) were used to construct the interpolation maps following the IDW and OK “ordinary kriging” models.

The case of electrical conductivity

The interpolation maps of the predicted EC data of the study area show a slight difference for both IDW and OK methods, where the electrical conductivity is high in the east and more clearly in the middle and low in the northwest for both methods. It should be noted that this middle of the map corresponds to the inter-dune area (Figures 2 and 3).

Table 2. Electrical conductivity of the studied soils

	Dune	Dune flank	inter dune
AVE	0.03	0.06	0.80
E.T	0.01	0.01	1.07
I.C	0.003	0.004	0.26

Note: AVE – average; S.D – standard deviation; C.I – confidence interval.

Table 3. The pH of the studied areas

	Dune	Dune flank	inter dune
AVE	7.92	8.19	8.24
E.T	0.21	0.24	0.30
I.C	0.07	0.06	0.07

Note: AVE – average; S.D – standard deviation; C.I – confidence interval.

Table 4. The area and perimeter of the study area (ANP)

Site	Area		Perimetre	
Study area	3859003.31m²	385.900331 ha	9341.92 m	9. 34194 km

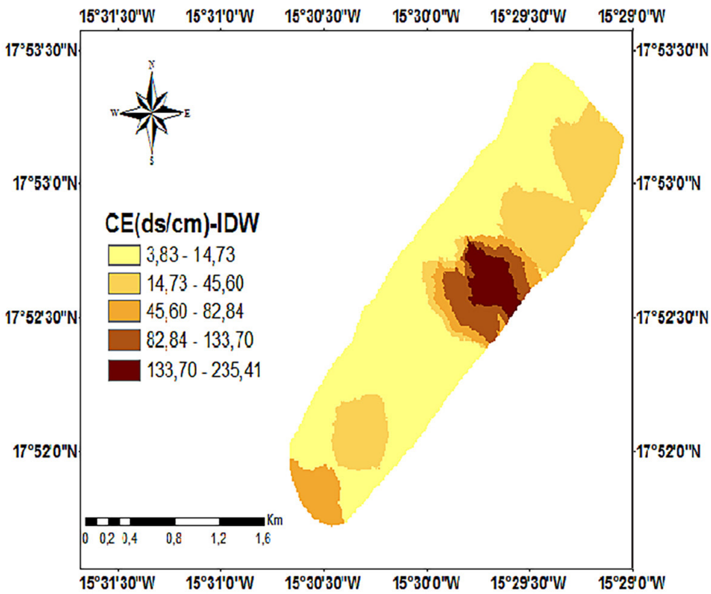

Figure 2. EC interpolation map of IDW

The pH case

The interpolation maps of the predicted pH data are more homogeneous in the study area with a slight variation from one method to another. For both methods, the area is more basic in the southeast than in the northwest (Fig. 4 and 5).

Method validation

In order to generalize the data over the entire study area, IDW and OK extrapolation methods are used. The most appropriate method for a given site is the one with the highest correlation coefficient R and the lowest errors RMSE and MAE.

The case of electrical conductivity

Table 5 presents the performance evaluation parameters for electrical conductivity interpolation following the two methods IDW and OK. The results show that the IDW method has higher correlation coefficient and the RMSE and MAE errors are lower for IDW. As a result, the IDW method reflects the salinity status of the area.

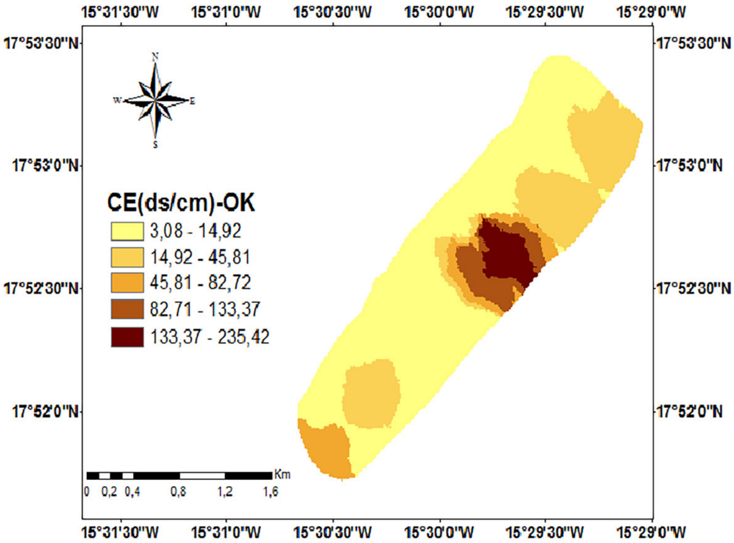

Figure 3. EC interpolation map by OK

Table 5. Predicted ECs for the study area

Parameter	IDW	OK
R	0.99	0.38
RMSE	3.17	9.02
MAE	0.0001	6.62

The case of pH

Table 6 shows the performance evaluation parameters for pH interpolation following the two methods IDW and OK. The results show that the IDW method gives a higher correlation coefficient. The RMSE and MAE are lower. It was concluded that the IDW method is more representative of the pH of the explored area.

In summary, the IDW method is the most valid method for developing interpolation maps for ANP. Germination is the critical stage for the species to settle in its environment. Salinity affects the germination of many species. Monitoring germination in different environments allowed characterizing some aspects of germination behavior

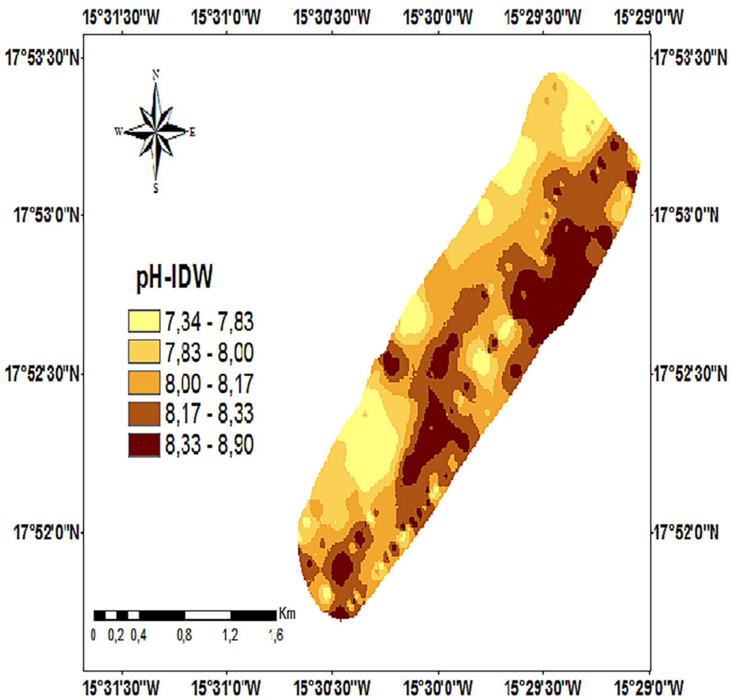

Figure 4. pH interpolation map by IDW

Table 6. Predicted PH of the study area

Parameter	IDW	OK
R	0.99	0.63
RMSE	0.018	0.63
MAE	0.004	0.60

in the three species and their adaptability to salinity. To better elucidate the germinative behavior of the three species with respect to substrates and salinity, germinative capacities, germination index and latency times were compared.

The germination capacity of Medicago sativa

Figure 6 shows that the highest germination capacity of *Medicago sativa* grains was recorded on the substrate taken from the Dune flank in the absence of salt and in the presence of 50 mM NaCl (10 to 50%). The lowest germination capacities were observed on the substrate of the inter-dune (0 to 25%). The germinative capacities on the dune substrate occupied an intermediate position (5 to 35%). A slight stimulation of the germination capacity was noted on this last substrate in the presence of 50 mM NaCl.

Germination capacity of Acacia senegal

Figure 7 shows that the highest germination capacity of Acacia 30% was observed in seeds sown on the dune in absence of salt. The presence of salt in the germination medium strongly inhibited germination capacity by half on 50 mM NaCl and by two thirds on 100 mM NaCl. On the dune flank, germination capacity was higher in the presence of salt 20% than in its absence 13%. The seeds sown on the inter-dune have a low germination capacity overall; it hardly exceeds 5% in the absence as well as in the presence of NaCl.

Germination capacity of Dolichos lablab

Figure 8 shows that the germination capacities of *Dolichos lablab* grains grown on the three substrates were high 82–98%. The presence of salt in the germination medium slightly affected the germination capacity on the substrates taken from the dune and the dune slope and more severely that of the seeds grown on the inter-dune substrate.

Germination index of the three species

Table 7 shows the germination index of the three species (*Medicago sativa*, *Acacia senegal* and *Dolichos lablab*) on the different germination media. The highest index are observed in *Dolichos lablab* grains both in the presence and absence of NaCl. Nevertheless, on the Interdune substrate, the index was affected by the presence of salt. Medicago sativa had the highest germination index at low NaCl concentration 50 mM

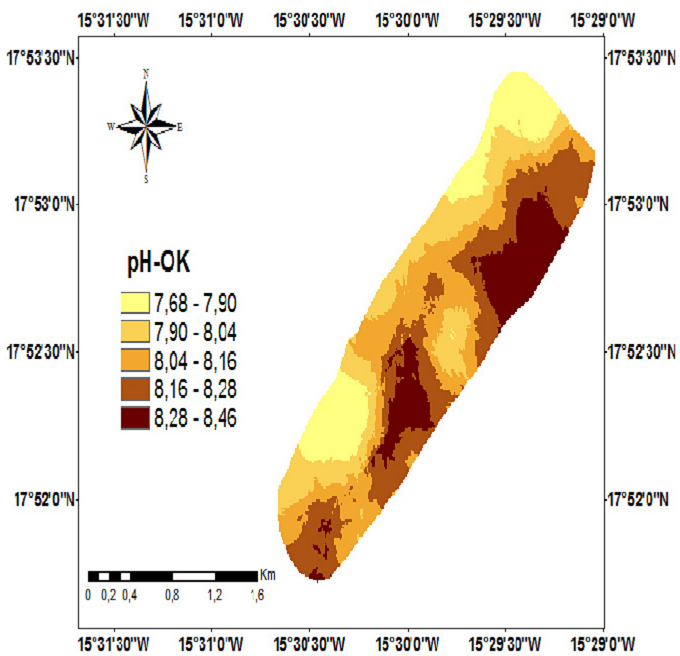

Figure 5. ph interpolation map by OK

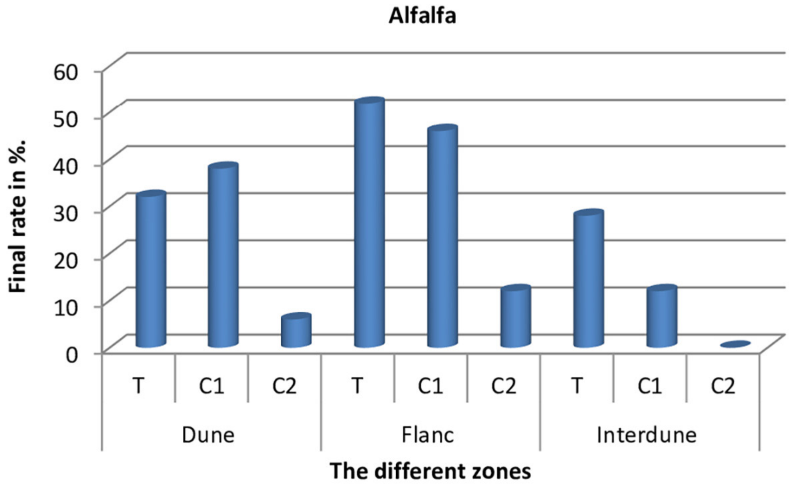

Figure 6. Germination capacity of *Medicago sativa* seeds sown on three substrates taken from the Dune, Flancdunaire and Interdune in the presence of different concentrations of NaCl (0, 50 and 100 mM)

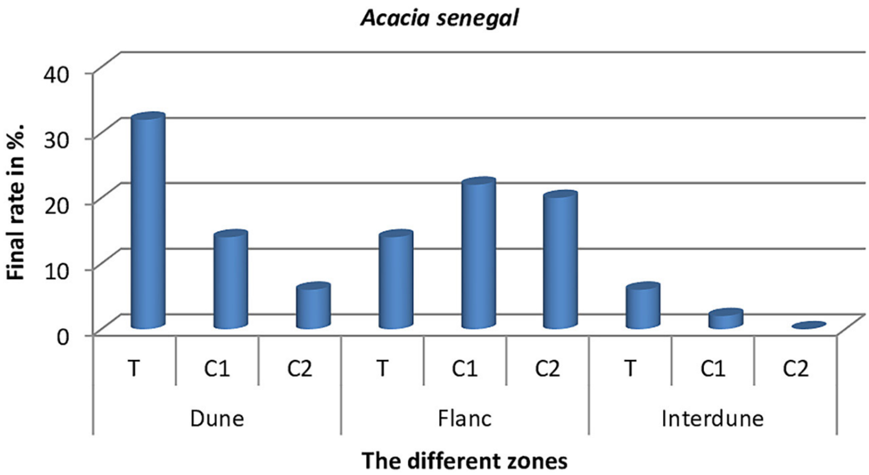

Figure 7. Germination capacity of *Acacia senegal* seeds sown on three substrates taken from the Dune, Dune flank and Interdune in the presence of different concentrations of NaCl (0, 50 and 100 mM)

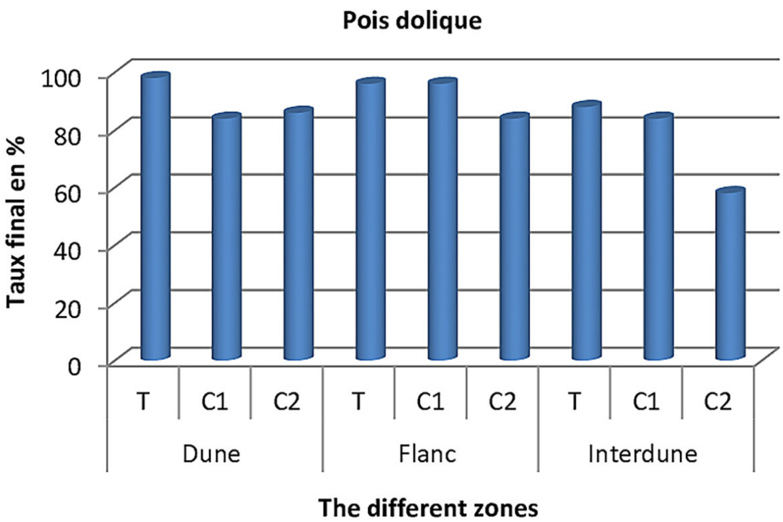

Figure 8. Germination capacity of *Dolichos lablab* seeds sown on three substrates taken from the Dune, Dune flank and Interdune in the presence of different NaCl concentrations (0, 50 and 100 mM)

Table 7. Germination index (in seeds/day) of the seeds of the three species sown on the three substrates collected on the Dune, Dune flank and Interdune in the presence of different concentrations of NaCl (0, 50 and 100 mM)

Substrat	Treatment	Species		
		Alfalfa	*Acacia senegal*	*Cowpea*
Dune	T	5.52	6.75	20.8
	C1	14.29	2.41	13.53
	C2	0.5	0.82	10.42
Dune flank	T	9.75	2.75	16.83
	C1	6.34	6.16	14.91
	C2	0.92	3.33	12.61
Interdune	T	4.17	0.83	12.82
	C1	1.57	0.25	8.88
	C2	-	-	5.06

on the dune substrate. On the other substrates, the index was affected by the salinity of the germination medium. *Acacia senegal* showed two high index on the dune substrate in the absence of salt and the dune flank in the presence of 50mM NaCl. The high 100mM concentration affected germination severely on the inter-dune substrate in all three species.

Germination lag time of the three species

Table 8 presents the germination lag time for the three species (*Medicago sativa*, *Acacia senegal* and *Dolichos lablab*) on the different germination media. The shortest germination lag time was noted in the control grains grown on the dune substrate and the dune slope. That of the controls sown on the interdune substrate was longer. The presence of salt in the medium increased relatively the latency time on all the germination media. A particular case was noted in *Acacia senegal* which presents low values or a failure of germination.

DISCUSSION

Mapping of electrical conductivity and pH of Awleigatt National Park shows that its soil is more saline and basic in the inter-dunes. The soils on the dune flank and dune are less saline (Figures 2 to 5). These prediction results are validated by using the IDW method. Some studies attest to the compatibility of this method with soils in arid and semi-arid regions (Bhunia et al., 2018; Sahu et al., 2021).

The study of the germination behavior of the three forage species, in the laboratory on substrates taken from the three zones, showed that they germinate better on the dune (figures 6 to 8). *Medicago sativa* was found to have a higher germination index in the presence of the low concentration of 50 mM NaCl (Table 7). This stimulating action of salt during the germination stage is observed in different glycophytes (Guerrier, 1981; Benmahioul et al., 2009). However, the major effect of salt on germination is inhibitory. It

Table 8. Latency time (in days) of seeds of the three species sown on the three substrates taken from the Dune, Flancdunaire and Interdune in the presence of different concentrations of NaCl (0, 50 and 100 mM)

Substrat	Treatment	Species		
		Alfalfa	*Acacia senegal*	*Cowpea*
Dune	T	2	2	2
	C1	4	3	3
	C2	-	-	4
Dune flank	T	2	2	2
	C1	3	3	3
	C2	9	4	4
Interdune	T	3	-	3
	C1	6	-	4
	C2	-	-	5

is reflected by an increase in the lag time, a slowing of the germination rate germination index and a decrease in germinative capacity (Anaya et al., 2018). Pigeonpea, which has a very high germination capacity 82 to 98% only shows sensitivity to salinity when the dose of NaCl becomes relatively high 100 mM on the Interdune substrate. This decrease in germination capacity may be attributed to the additional salinity characteristic of the Interdune substrate. Several authors postulate the toxic effect of Na^+ and possibly Cl^- ions on the embryo (Brahima et al., 2018; (Benmahioul et al., 2009).

The depressive effect of salinity on germination in legumes, like all glycophytes, is well documented (Benidire et al., 2015; Anaya et al., 2018). If only the germination rate is retained, expressed in this study by the germination index (Table 6), it can be observed that all the species studied are affected by the salinity of the environment. Thus, the salt of the medium – if does not decrease the germinative capacity in certain cases (Figures 5 to 8) –delays the germination by spreading it out in time. This slowing down of germination is not only due to the emergence of the radicle, but also to the latency time. Indeed, Table 7 shows that the time required for seed imbibition is longer in the presence of salinity. The detrimental effect of NaCl on seed water uptake was observed in glycophytes (Essemine et al., 2007) and also halophytes (Naidoo and Naicker, 1992).

As a result, the depressive effect of salinity on germination in the three species was manifested on several levels. A toxic effect affecting the germinative capacity and the speed of germination was observed, in addition to an osmotic effect which leads to a difficulty of imbibition and consequently a delay of the emergence of the radicle.

CONCLUSIONS

The study of the electrical conductivity and soil pH of the three environments (dune, dune slope and the Interdune) of Awleigatt National Park showed that all three substrates are basic. The highest electrical conductivity was observed in the inter-dune substrate and the lowest in the dune substrate. The dune flank soil occupies an intermediate position. The method of interpolation of the predicted data, the most suitable for this study, was the IDW method. Indeed, it presents the results that corroborate the experimental ones. The germination behavior of three species (*Medicago sativa,* Acacia and *Dolichos lablab*), in the absence of salt, on the different media shows that *Dolichos lablab* has the highest germination power. In the presence of salt (100 mM NaCl), *Dolichos lablab* is more resistant to sodium chloride than the other species on the different media. Moderate concentrations of NaCl (50 mM) show a contrasting effect in different species and substrates.

Acacia and *Medicago sativa* are more sensitive to salinity. Acacia is sensitive to salinity on the dune and inter-dune, while *Medicago sativa* is sensitive to salinity on the dune flank and inter-dune. A slight stimulation of germination capacity was observed in Acacia on the dune flank and *Medicago sativa* on the dune substrate. The parameters calculated on the germination kinetics curve confirm the same depressive effect of salt on germination capacity. As a result, the back of the dune and the dune slope have the most favorable soils for germination of the three species.

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