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Analysis of the Factors That Contribute to the Germination of the Alfa (*Stipa tenacissima*) in Ras El Ma Region (Western Algeria) with the Design of Experiments Method

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Abstract: The Alfa (*Stipa tenacissima* L.) is a typically Mediterranean *Poaceae* whose main territory stretches over the Algerian-Morrocan highlands. Its regression threatens the equilibrium of the steppic ecosystem. This study, undertaken within the framework of the safeguard of this natural richness, is an attempt to determine the optimum conditions for its regeneration. Experiments of germination were carried out while varying three parameters: le treatment of the caryopses, the age of the caryopses and the mulching of the ground. The mathematical analysis of the results allows us to express regeneration by the following equation:

Y=14.12000+6.00500*traitment+5.45500*mulchinge+4.68000*age+0.92000*traitment-mulching +2.44500*traitment-age+1.59500*mulching-age+0,78000*traitment-mulching-age.

The coefficients of this polynomial show that the most influent factors are in a decreasing order:le chemical treatment, the mulching of the ground and finally the age of the caryopses. They also show that there is a very strong interaction between the age and the treatment of the caryopses. The germinative capacity of the caryopses of the alfa is enhanced by the synergy of these three factors

Key words: *Alfa, germination, caryopses, optimum*

Introduction:

Alfa **(***Stipa tenacissima* L)**,** from Arabic *halfa*, is a vivace herbaceous plant of the poaceaes family, originating in the arid areas of the western part of the Mediterranean basin; Its main territory extends along the large Algerian-Morrocan highlands. From there, it overflows on Western Morocco, southernmost Portugal, Eastern Spain, the Balearic Islands and Tripolitaine. In the south its natural limit is determined by the dryness. In the north and the west it is the increasing moisture of the climate that eliminates it from the flora. The territorial distribution of the alfa can be estimated as follows:

Algeria: 4,000,000 ha
Morocco: 3,186,000 ha
Tunisia: 600,000 ha
Libya: 350,000 ha
Spain: 300,000 ha

It is a plant of transition from a forest ecosystem towards the desert (Djebaili, 1984). Well adapted to the climatic conditions, it constitutes a natural barrier against the progression of the desert. There where the alfa ceases, the desert begins (Zériahène, 1987; Montana, 1992; Milton *et al.*, 1994). The study of the surface of the alfa extension in North Africa shows that it starts growing in areas where annual rainfall levels vary from 50 mm to 150 mm with an optimum of development between 200 mm and 400 mm of rain. The alfa is a very plastic plant with respect to the variations in temperatures; it is a characteristic which enables it to live in very hot steppic climates in summer and very cold winters. The alfa production depends closely on the climate.

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We can expect productions of 5 qx/ha/an if the year is rainy and 1.9 qx/ha/an if the year is dry. The energy value of the alfa is 0.3 ÚF/KG on average (UF: unit fodder). The digestive load factor is 50%. The alfa patches constitute a pastoral space for the domestic livestock as well as the wild fauna (gazelle, hare and tortoise) despite its low nutritive value. The contribution of the alfa varies according to the potentialities of the natural pastures and composition of the herd. Table 1 indicates the contribution of the alfa by type of pasture.

Table 1. Contribution of the alfa according to the type of pasture

Type of Pasture	Humid year UF/ha/year	Dry year UF/ha/year
Relatively dense forest	10	30
Clear forest and post-forest patches	20	60
Degraded patches	15	45
Pre-Saharan patches	5	15
Patches of sandy zones	10	30

(UF: unit fodder)

The quantities of herd consumption vary according to the zone and of the climate as shown in Table 2. In addition to its ecological role essential to the balance of the steppic ecosystem, it constitutes a source of richness for the local populations and was exported towards Europe until the first years of independence. Indeed the alfa leaf which contains 48% to 52% of cellulose is a first choice raw material for the manufacture of quality paper.

Table 2. Cattle grazing according to the zones and of the climate.

Zones	Humid year Qx/ha/year	Dry Year Qx/ha/year
Forest belt	0.5	2.1
Zone of highlands	0.7	1.28
Pre Saharian zone	0.2	0.72

However, overgrazing which results from the laxism and the lack of strict regulations aiming the protection of this vegetal cover, made its way (Bouabdellah, 1992; Aidoud *et. al.*, 1996). Fortunately, this situation is not irreversible. The insecurity due to natioanal political events that Algeria experienced, made some places dangerous thus little attended. This provoked a remarkable blossoming of the alfa which gained some of its territories back. What confirms that the pasturing is the principal destroying agent of this plant?

Within the frame of restoring this plant, researches aiming at helping its regeneration were carried out (Mehdadi *at. Al.*, 2004; Hellal *et. al.*, 2004; Hellal *et. al.*, 2007). Thus tests of germination of alfa caryopses were carried out by modifying the factors likely to influence their germinative capacity, such as the mulching or not of the ground, the chemical treatment or not of the caryopses (Mazliak, 1982), and their ages: 3 and 12 years.

The objective of this work is to interpret these results by using the method of the experimental designs in order to better evaluate the role of each factor intervening in regeneration and their possible interactions.

Materials and Method

The tests of germination of alfa were carried out in a station located 34°30 N and 1°02 W; at 1100 m altitude , 10 km away fron Ras-El-Ma, Wilaya of Sidi Bel Abbes, between the mounts of Tlemcen and those of El Aricha (Figure 1).

We used deep seed holes of 20 cm and 10 cm of diameter, with and without mulching of the ground. The caryopses are coming from eight various areas of Algeria. We used for each origin 25 seed holes, containing each one 5 caryopses. The results that we take into consideration are obtained from the averages of different experiences. There are several treatments likely to improve the germinatives capacities of caryopses (Mazliak), among which:

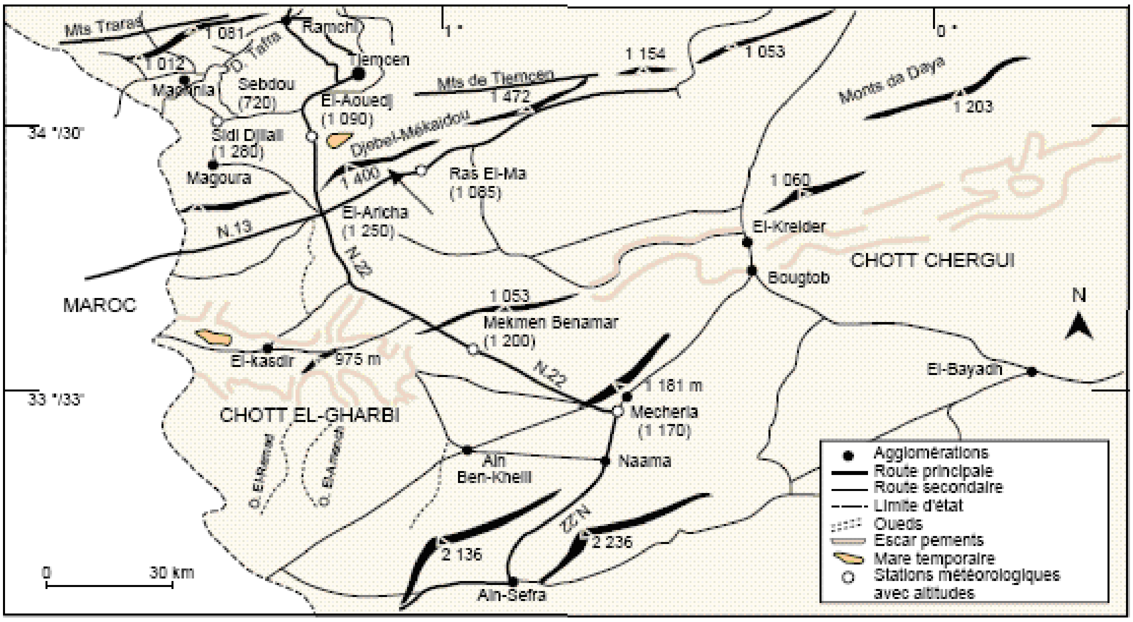

Figure1: Geographic situation of the experimental station

- The mechanical scarification which consists in removing the teguments of the caryopses.
- The chemical clarification: the caryopses are soaked in sulphuric acid during 5 mn, 10 mn, 15 mn, 20 mn, 25 mn, 30 mn, 35mn and 40 mn.
- The pre-soaking in distilled water: the caryopses are soaked in for 24 hours.

The results obtained express the germinative capacity (C G) representing the percentage of the caryopses having germs (Mazliak). Preliminary tests that were carried out allowed us to conclude that in the case of our study, the chemical treatment is the best suited for this investigation as it allows the best results.

Analysis of the Results by the Method of the Experiments Plans

Multiple parameters are likely to influence the performance of any studied system. The experimental designs (Benoit, 1995; Fischer, 1925; Goupy, 1988) are used to highlight and to quantify the influence of these parameters, with the obvious aim of an eventual optimization. In this particular case, we aim at studying and quantifying the importance of the chemical treatment of the caryopses, the mulching of the ground, the age of the caryopses as well as their possible interactions. We assign to each one of these parameters two levels: treated or not treated caryopsis; mulched or not mulched soil and 3 or 12 years aged caryopses and we obtain the matrix of all possible combinations, which contains as many columns as parameters and as many lines as experiments. The mathematical analysis of this matrix, allows us to obtain a first degree polynomial which represents the yield in the form:

$$Y = a_0 + a_1 X_1 + a_2X_2 + a_3X_3 + \ldots\ldots + a_{12}X_1X_2 + a_{13}X_1X_3 \ldots$$

Y represents the germinatif output and X_1 X_2 X_3 respectively the treatment of the caryopses, the state of the ground and the age of the caryopses. XiXj represents the interaction of Xi with Xj. Thus the matrix of the experiments is represented in Table 3.

Table3. Matrix of the germination experiments

EXP	x1:caryopses	x2:soil	x3:age	X1X2	X2X3	Germination %
1	-1	-1	-1	1	1	2.16
2	1	-1	-1	-1	1	9
3	-1	1	-1	-1	-1	9.6
4	1	1	-1	1	-1	17
5	-1	-1	1	1	-1	5
6	1	-1	1	-1	-1	18.5
7	-1	1	1	-1	1	15.7
8	1	1	1	1	1	36
Division	8	8	8	8	8	8

(Note: the lower level of the age parameter corresponds to older caryopses)

Results and Discussion:

The mathematical treatment of the results enables us to establish the equation of the germinatif output. The studied phenomenon can be represented by the model:

Y = +14.12000 +6.00500*traitement+5.45500*paillage+4.68000*age+0.92000*traitement-paillage+2.44500*traitement-age+1.59500*paillage-age+0.78000*traitement-paillage-age.

Table 4: Coefficients effects of the parameters and their interactions

Crary growth	Coeff. Sc	Std. Err	P	Conf.Inf (+/-)
Constant	14.0393	0.387907	3.47915e-006	1.07701
Cary	DF = 1			
Cary (low)	- 6.08569	0.387907	9.64166e – 005	1.07701
Cary (High)	6.08569	0.387907	9.64166e – 005	1.07701
Soil	DF = 1			
Soil (low)	5.53569	0.387907	0.000140053	1.07701
Soil (High)	5.53569	0.387907	0.000140053	1.07701
Age				
Age (low)	-4.76069	0.387907	0.000253164	1.07701
Age (High)	4.76069	0.387907	0.000253164	1.07701
Cary*soil	DF = 1			
Cary (low)*soil (low)	0.839311	0.387907	0.0964894	1.07701
Cary (low)*soil (High)	-0.839311	0.387907	0.0964894	1.07701
Cary (High)*soil (low)	-0.839311	0.387907	0.0964894	1.07701
Cary (High)* soil (High	0.839311	0.387907	0.0964894	1.07701
Cary* Age	DF = 1			
Cary (low)*Age (low)	2.36431	0.387907	0.00366494	1.07701
Cary (low)*Age (High)	-2.36431	0.387907	0.00366494	1.07701
Cary (High)*Age (low)	-2.36431	0.387907	0.00366494	1.07701
Cary (High)*Age (High)	2.36431	0.387907	0.00366494	1.07701
Soil* Age	D F= 1			
Soil (low)* Age (low)	1.51431	0.387907	0.0174853	1.07701
Soil (low)* Age (High	-1.51431	0.387907	0.0174853	1.07701
Soil (High)* Age (low)	-1.51431	0.387907	0.0174853	1.07701
Soil (High)* Age (low)	1.51431	0.387907	0.0174853	1.07701

This is obtained from the results reported in Table 4. The interest of this formulation is that it enables us to quantify the effects of the factors taken into account as well as their interactions. Previous works (Mehdadi *et al.*, 2004; Hellal *et al.*, 2004; Hellal *et al.*, 2007) investigated these effects but they are somehow truncated as they do not take into account the interactions of the parameters. This constitutes the originality of this work.

Figure 2 show the effects which are sorted from the largest to the smallest. When there is an interaction effect, the effect of one factor depends on the level of another factor. Interaction effect represents the synergy or antagonism of two factors.

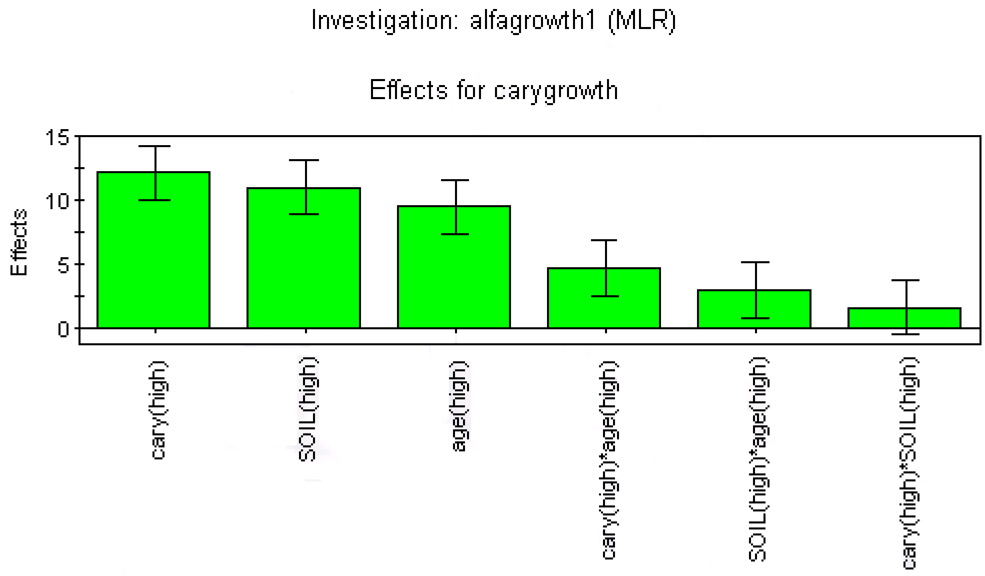

Figure 2. Effect of factors and their interactions.

Figure 3 displays the coefficients for all the responses. To make the coefficients comparable when responses (Y's) have different ranges, the coefficients are normalized, that is the coefficients are divided by the standard deviation of their respective response. This plot allows us to see how the factors affect all the responses.

Figure 4 displays the regression of coefficients with confidence intervals. This plot is used to interpret the coefficients. The scaling of the data makes the coefficients comparable. The size of the coefficient represents the change in the response when a factor varies from 0 to 1, in coded units, while the other factors are kept at their averages.

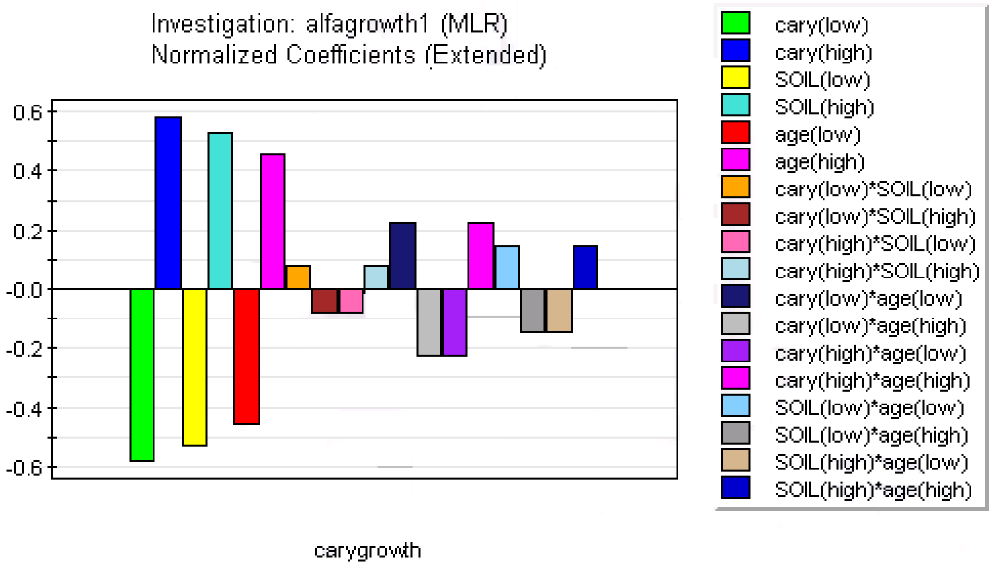

Figure 3. Parameters effects on the rate of growth

The plot of Figure 5 displays the predicted change in the response when one factor varies, and the second factor is set at its low and high level, all other factors being set on their centre. When the two lines are parallel there is no interaction between these two factors. In this case it is about the treatment of the caryopses and the soil. When the two lines cross each other there is a strong interaction.

Figure 6: The prediction plot is used for guiding us through the selection and specification of prediction plots. In the prediction plots the predictions of the selected responses are displayed for their low, centre, and high levels. The predictions of each subplot are adjusted for all the other factors.

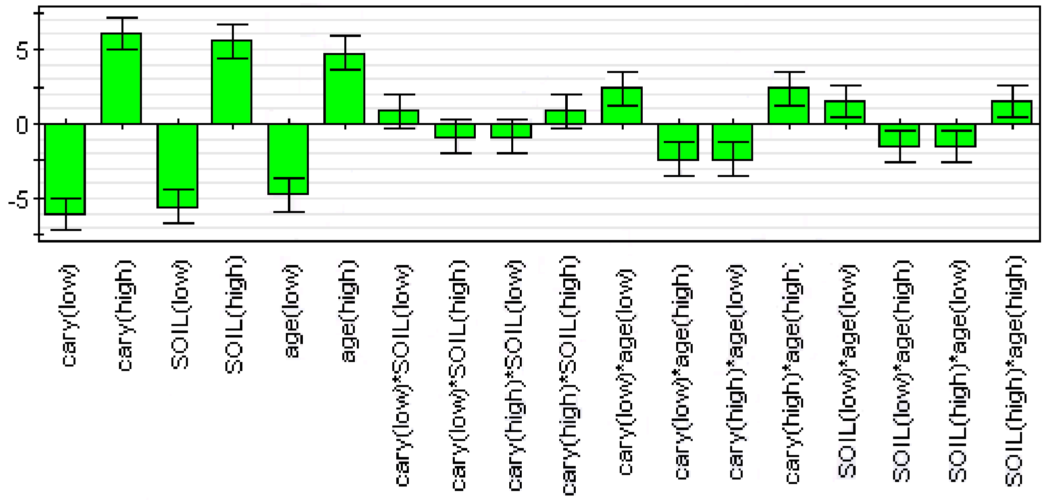

Figure 4. Scaled and Cantered Coefficients for caryopses growth

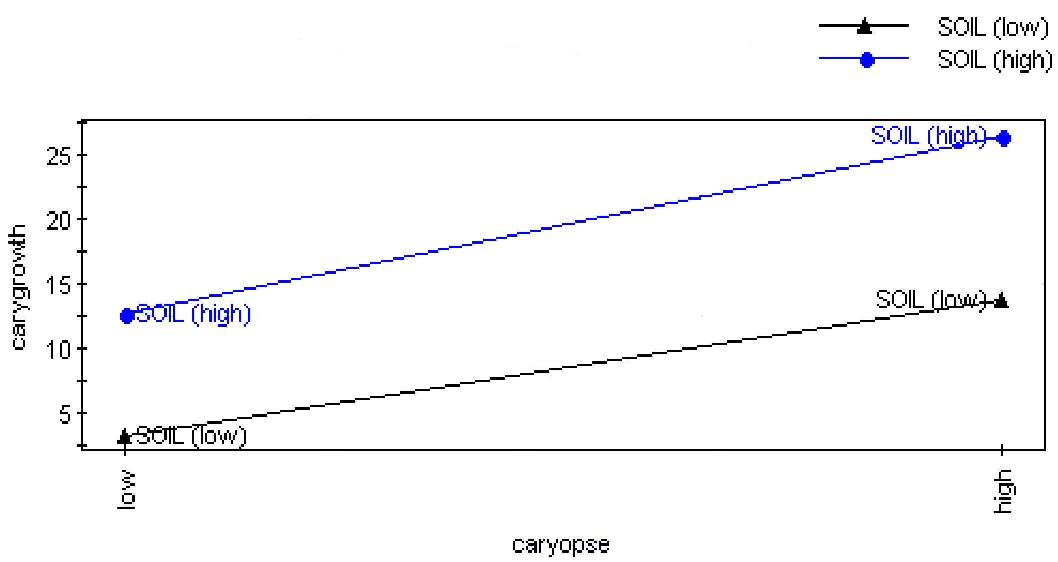

Figure 5. Interaction caryopses treatment / soil

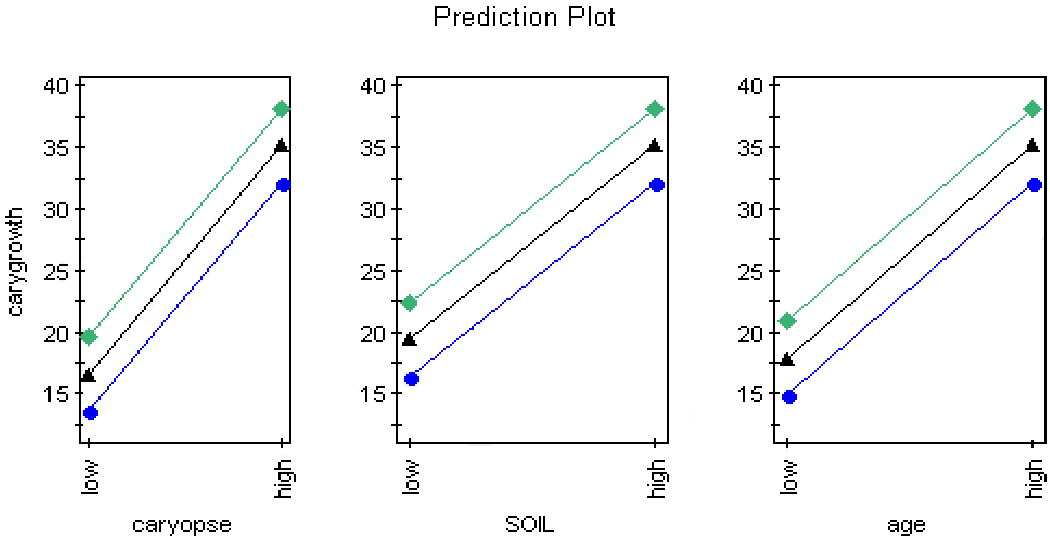

Figure 6. Prediction Plot

Figure 7 is used for optimization. It allows us to find an experimental area limited both by factor settings and response criteria. From all these results we can state that the important factors in decreasing order are the treatment of the caryopses, the soil mulching then the age of the caryopses. However none of these parameters can be neglected in order to obtain the best rate of regeneration as their influences are close to each other (6, 0, 5.4 and 4.6) . The second interesting aspect of this method of investigation is that it allows us to better understand the phenomena through the analysis of the interactions of the different parameters, by evaluating their influences. The most important interaction is that of the treatment and the age of the caryopses, as the value of its coefficient is 2. 3. The younger the seed, the better it responds to the chemical treatment.

The second effect of the interactions is due to the soil/age, with a coefficient of 1.5. This is quite expected as the rate of germination is higher with treated soil and younger caryopses. The last effect concerns the interaction of the treatment of the caryopses and the soil; this has no direct incidence on the growth of the caryopses.

In order to optimize the growth rate we use Figure 7. It is quite obvious that the optimal result is obtained with the high level of all the factors. In deed, the slopes of all the parameters confirm that in the prediction plot as well as the design plot.

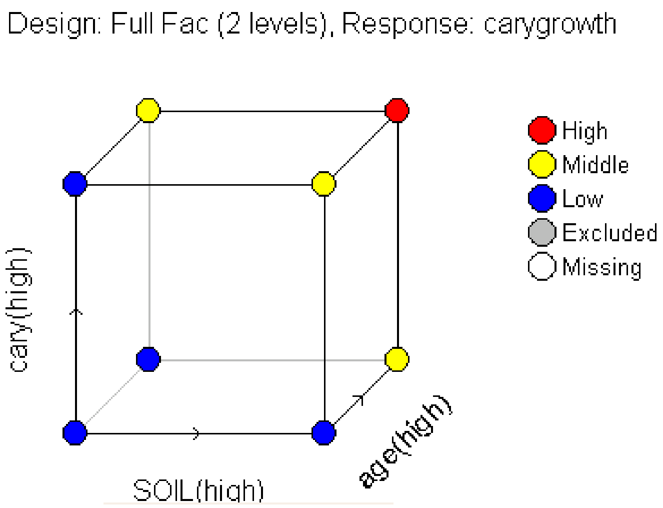

Figure 7. Optimisation of alfa germination

Conclusion

The purpose of this work was to get a better insight of the alfa germination in order to contribute to its restoration. Germination tests were carried out by varying parameters that intervene in the process. The use of the design of experiments method showed to be judicious as it allowed us to well interpret the obtained results.

We were able to quantify the role of all the parameters taken into account and their respective interactions.

The practical conclusion is that all of them should be given equal importance in order to optimize the regeneration process of this endemic plant as necessary to the local ecosystem as it constitute, beside its economical benefits, the natural barrier against the advance of the desert.

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