Efficiency of seed production and cone size of *Abies numidica* De Lannoy in the plantation in Algeria

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Abstract: Total seed number /cone, proportion of filled seeds/cone, cone size (diameter, length) and weight are used to evaluate the seed production of *Abies numidica*.
Total number of seeds/cone ranged between 572 - 98 (2000), 410 - 223 (2001) and 459 -251 (2002). The filled seed rate varying between 70 -194 (2000), 72 - 205 (2001) and 58,18 -233 (2002). The number of reproductive equivalent N (27.56) is the highest in 2000 and the production is high but the proportion of filled seed is the lowest. The SEF (47, 37) is highest in 2002.
Seed production is variable between years and trees, the production is continuous on 03 years or there is an alternation in years or the production is limited to 2000.
Cone length, cone weight and total seed /cone and weight of filled seed are significantly correlated. The diameter of cone is significantly correlated with the rate of filled seed

Key words: Cone, efficiency, seed production, year, tree.

1-INTRODUCTION

Abies numidica De Lannoy is an endemic forest species in Babors mountains (Algeria), it covers an area of 300 ha [1]. It is a kind of mountain, like all Mediterranean pines for which the natural area is located in areas beyond the 2000m with cold, very cold winters [2], it is met from 1650m and goes up to 2000m [3]. *Abies numidica* is a genetic resource that is important to maintain, it is indeed threatened because of the small number of individuals in the natural population and its endemism. maintains its starts with its capacities of seed production, seed quality and natural regeneration.

Cone–seed contents is a reliable and simple tool in monitoring forest trees seed crops in seed orchards [4]. In artificial stands settled for breeding programs an understanding of trees reproductive processes and their biology is essential for maximizing genetic gain obtained from tree breeding [5]. Reducing seed loss is a major concern in seed production and tree breeding program [4].

In flowering plants, low seed production can result from low availability of resources, low pollen transfer and flower or seed predation [6]. The low efficiency may be due to large distances between conspecifics, low pollen production by individuals, and poor pollen dispersal. These conditions are assumed to affect both ovule fertilization and seed production negatively [7]. Predicting pollen cone production as well as seed-cone production is required because pollen levels determine rates of fertilization and degree of panmixia [8].

Year is suggested to cause a significant variation in reproductive componments such as the number of cones and the number of seeds per cone [9], [10]. Of the reproductive traits examined at cone level seed efficiency is the most common one. It measures the filled seed produced per cone as percentage of the seed potential (number of fertile ovule per cone [11], [4] and [12].

2- Materiel and Methods

The cones were collected from the plantation located in the forest of Serraïdi. This forest is located between 7 ° 54' Nord and 36 ° 38' Est at a distant from the sea of about 7km, average altitude of 856m, in the variant bioclimatic humid, with Q_2 calculated equal to 148,06. The average annual rainfall is 984.25 mm. *Abies numidica* has been introduced in 1968, from seeds from natural stands of Babors.
The cones were harvested on 30 trees, the sample is realized on three (03) consecutive years with a follow on same trees on which we collected a variable number of cones (5and8). In laboratory, these cone were disjointed manually, seeds were separated by tridensimetric in ethanol 90°C to separate filled seeds (good seeds) and empty seeds.

On each cone we measured : the length, diameter, with a caliper and Weight with precision scales. We counted total number seed/cone (TNS), Number and the average weight of filled seeds (FNS/C and W) and proportion of filled seed/ cone (PFS/C) we have calculated:

-the equivalent number reproductive N: it corresponds to the number of trees that produced seed out of trees.

-The Seed efficiency, (SEF) is defined as the number of filled seeds to the total number of ovule initiated on the fertile scales or total seed production.

3-RESULTS

3-1-Cone seizes and weight

Table 1: Basic statistics Analysis

	Année 2001					Année 2002				
	Mean	Min	Max	ET	CV (%)	Mean	Min	Max	ET	CV (%)
Pc	109,40	31.09	167,83	40,08	37,15	60,35	18,51	116,40	27,42	46,11
Lc	14,20	7,92	21,29	3,21	22,68	12,23	8,51	16,36	2,22	18,12
Dc	4,35	3,74	4,64	0,33	7.62	3,48	2,75	4,21	0,51	14,64

Legend: -Pc: cone weight**,** cone length (Lc), cone diameter (Dc), Min : Minimum, Max: Maximum.

The average length of cone is 14.20 cm ranging between 7.92 -21.29 cm, with a coefficient of variation of 18.12% for 2001, and 12.23 cm ranging between 8.51 -16 36 cm with a coefficient of variation of 22.68% for 2002.
The average diameter of 3.48 cm ranging between 2.45-4.21 cm for 2002 and, 4.35 cm ranging between 3.74-4.64cm for 2002 (tab.1)
The average weight of cone is 109.40 g ranging between 31.09 - 167.83 g with a CV of 37.15% for 2001 , and ranging between 18.51 -116.4 g with an average of 60.35 g and a CV of 46.11% for the year 2002.

Table2 : variance Analysis

	Year 2001					year 2002				
Variables	ddl	SCE	CM	Fobs	P	ddl	SCE	CM	Fobs	P
Pc	26	186383	32,606	5,723	0.00	19	63114.41	3321.81	29.67	0.00
Lc	26	1197,10	2,284	3,935	0.00	19	413.55	21.77	18.27	0.00.
Dc	26	12,964	0,260	5,953	0.00	19	19.74	1.04	51.83	0.00

The differences between trees are significant at the 5% level, there is a significant heterogeneity within the same population, the effect of tree is important every year (table 2).

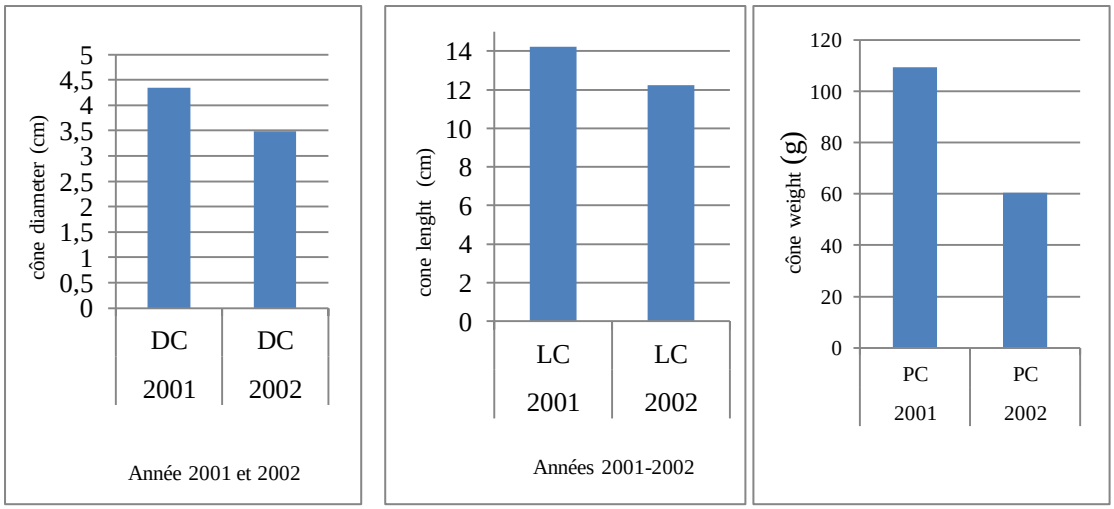

Figure 1: cone size and weight variation between years 2001 and 2002

Diameter and length of the cone do not vary greatly from year to year, they mark a stability, however the weight of the cone seems more variable, cones of 2001 are heavier and there was a decrease in the weight of cones the following year. The variation in each population or between trees is also important, given the coefficients of variation obtained, this variation is more important for the year 2002 regarding the size of cones. The weight of the cone is the character that showed a net change inter year, the effect of the tree is also significant each year (Fig.1).

3-2- Seed production

3-2-1- Average number of seeds per cone and average number of filled seeds per cone

The average number of seeds per cone is 293.83 for 2000 ranging between 97.75- 572 seeds, 325.54 in 2001 ranging between 194.33 -432.66 and, 383.94 in 2002 ranging between 251.50 -520.20. For the year 2000, we find that the rate of filled seeds is not very important not exceeding 32.34%, in contrast to two years, an inter-individual variation is very important (Table 3,4,5) .

3-2-2-Average weight of seeds per cone

There is a significant change in the average weight of filled seeds between two years, in fact it is 80.85 g and 248.00g respectively for 2000 and 2001. The change is also important among trees for a year with a maximum of 392 g and a minimum of 43 g for the year 2001. The results of the analysis of variance showed significant differences (0.05) between trees within a population (Table 3,4,5).

Table 3 : Basic statistics Analyses (2000)

	Year 2000				
Variable	Mean	Maximum	Minimum	ET	CV
TNS/C	293.83	572.00	97.75	75	40
FNS/C	97.15	195.00	39.00		
PFS/C (%)	32.34	54.08	12.60	25	45
W (g)	80.85	104.97	14.37		
SEF	33.06				
N	27.56				

Table 4: Basic statistics Analyses (2001)

Year 2001					
Variable	Mean	Maximum	Minimum	ET	CV
TNS/C	325.54	432.66	194.33	70	22
FNS/C	152 .06	217.66	39.66		
PFS/C (%)	47.12	63.75	20.44	16.4	35.5
W (g)	248.00	392.00	43.00	0.82	32.12
SEF	46.71				
N	8.68				

Table 5: Basic statistics Analyses (2002)

Year 2002					
Variable	Mean	Maximum	Minimum	ET	CV
TNS/C	384.94	520.20	251.50	66	17
FNS/C	182.96	296.5	83.29	55	30
PFS/C (%)	47.52	57.00	33.11		
W (g)	-		-		
SEF	47;37				
N	22.26				

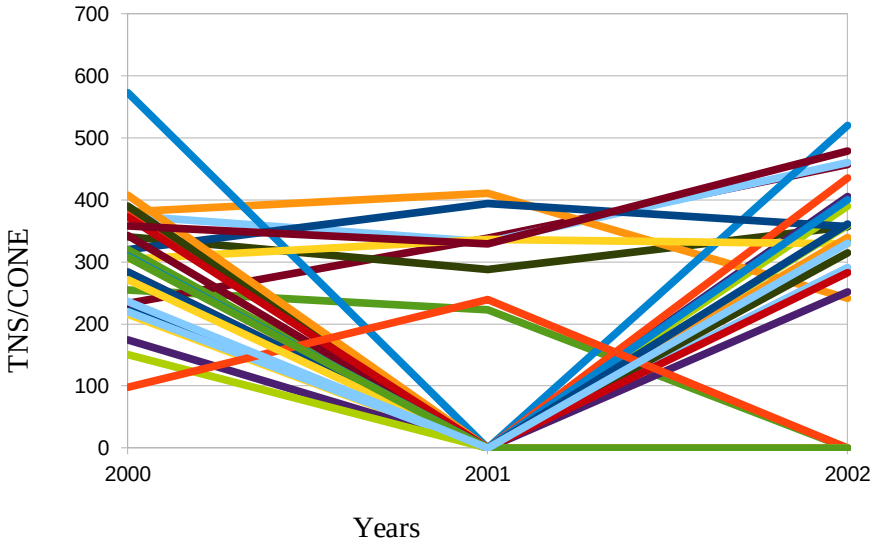

Figure 2 : variation of cone seed production between years

There is a variation between years (Figure 2), reflecting the effect of year on seed production, explaining the reproductive behavior of trees. Indeed, three groups of trees emerge: trees produce seeds in three consecutive years, others against produce seeds every two years to know a good production in 2000 but not in 2001, followed by a good production in 2002 and finally, a group of tree that produce successively in 2000 and 2001.

The year 2000 is considered as a reference year because all the trees have produced the cone and the equivalent number reproductive N is 27.56 on a total of 30 trees, followed in 2002 with N equal to 22.26 (Table 3), but the year 2001 is the year when the number of trees that produced seed is the lowest, N do not exceeding 8.68, however, the rate of filled seeds is most important for the year 2002 followed by 2001.

In 2000 SEF is 33.06 while it was 46.71 and 47.35 respectively for the years 2001 and 2002, this years have better production filled seeds than 2000. The SEF indicate That seeding in a good year, as in 2002 where 47.35% of egg fertile initiated on the scale of the cone to may develop fully filled seed, Whereas relatively lower seeding years in the proportion of eggs all which fulfilled such development was lower.

Table 6 : Correlation between cone size and cone seed production

Variables	Lc	Dc	Pc	TNS/C	PFS/C	W
Lc	1.000					
Dc	0.141	1.000				
Pc	0.738***	0.335	1.000			
TNS/C	0.777***	0.140	0.775***	1.000		
PFS/C	0.229	0.425**	0.223	0.075	1.000	
W	0.604***	0.274	0.583***	0.512***	0.688**	1.000

There is a very highly significant correlation between length and weight cone and total number seeds per cone (Table 6).

The diameter of the cone is significantly correlated with the rate of filled seeds, which explains the location of such seeds to this part of the cone. There is no correlation between the total number of seeds produced by tree and the rate of filled seed, which is largely explained through the results as the change of SEF.

4-Discussion

The dimensions and weight of cones are allowed to discriminate against them trees and explain the heterogeneity within a population. The weight of cones appeared more variable between years [11] and [4] observed the same results in *Cedrus atlantica.*

The number of seed corresponding to ovule initiated per cone, revealed proportionate to cone length (r= 0.777), this is logical since a bigger cone may contain a larger number of scales which in turn may support a larger number of ovules [4]. An important seed production does not necessarily correspond to an important production filled seeds, [13] observed in populations of *Pseudotsuga menziesii* with wide cones an important grain production and heavier seeds but not necessarily high seed efficiency.

We observed in this study a significant correlation between cone size and seed production and the weight of seed. All cone and seed traits showed a highly significant variation between years and trees. [14] propose that the number of seed per cone was more related to cone size, in the same results [15] observed that the number of seed per cone and the number of filled seed per cone varied significantly between geographical regions and among population. The character weight appears to be the most variable character from one year to another it depends on the weather conditions throughout the period of development of the flowering natural to cones disarticulation [16], [17] and [9].

The stand effect is considered as a factor responsible of variation in parameters of reproductive success and seed efficiency of coniferous species [11] and [4]. [18] observed on *Abies pinsapo* a seed crop viability which was four times greater in the high density population than in the low density one, they suggest in a previous study [19] the lower number of viable seeds per tree in low density area to be a direct consequence of lack of pollen. [20] and [12] found different values of seed efficiency among sites of *Abies amabilis*, [4] found the same results in *Cedrus atlantica* they linked this to differences in pollen availability. [7] found mean pollen production and mean nearest neighbor distance were recorded for several populations of *Taxus canadiensis* and correlated with the proportion of ovules pollinated and, seed set was correlated most strongly with pollination success and mean ovule production. Seed production is limited by pollen supply or by resource available to the mother plant maturing seeds. [21] proposed a model showing that natural selection may often act to bring the female's allocation of her reproductive effort to a point where seed production is limited by both pollen supply and provisioning resources, the |[21] model indicate that seed production could be expected to respond to a decrease in pollen supply but not to an increase. In the same results [6] suggested a strict dichotomy between pollen limitation and resource limitation of female reproductive success in plants.

Year effect in the present study caused for its part substantial variation in the number of seed per cone with higher seed efficiency and higher cone production in 2002, [22] found an inter annual variation in seed efficiency among plantation of *Picea mariana*, [23] found a lower pollen crop and lower filled seed yield in two different years and suggested limited pollen supply as the main cause of the filled seed yield in cone year comparatively to the other in population of *Tsuga hatarophylla*, in the same results [11] and [4] observed a significant variation among years for the reproductive parameters on *Cedrus atlantica*.

There is an important variation in cone production per tree between years, so the cone production is lower in 2001 where N= 8.68 corresponding to number of tree produced a cone, than to 2001 with N= 27.56 and 2002 with N= 22.2. [8] Observed a relationship between the production of cone pollen and seed cone with age of trees, the rate of growth cones varies between good and bad years of production, the annual fluctuations in the production of cones can be affected by the production of anterior years and environmental factors [9], [8] and [14].

Conclusion

In the present study we calculated the total number seed per cone and the proportion of filled seed, measured the cone size and weight and the tree reproductive number.

We examined the effect of year and tree on variation on cone-seed contents, seed number / cone and related SEF (Seed efficiency).

Year showed a global influence on seed production resulting in low and high seeding years, variation between trees is so important there is an important heterogeneity, the tree reproductive number is low in 2000 but high in 2002.

Cone weight is the trait which showed the retest variation among trees and years. There is a correlation between cone size and weight, this indicate that total number of seed/cone is sensitive to variation of cone weight and size tendency substantiated by the positive correlation between this parameters, this showed that there is a relation between resource allocation and environmental factors. These allometric relationship suggest the number of ovule initiated per cone to be proportionate to cone weight.

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