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A COMPARATIVE SURVEY ON PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OF CAUCASIAN ALDER (ALNUS SUBCORDATA) SEED IN DIFFERENT ALTITUDES OF HYRCANIAN FORESTS

SUMMARY

In order to conduct a survey on trends of morphological (length & width), physical (humidity & weight of 1000 seeds) and physiological (germination capacity) changes, Alder seed/fruit were collected from six different altitudes (50, 400, 800, 1200, 1400 & 1600 meter above sea level) of Golband management Plan limits supervised by Nowshahr forestry Headquarters, Mazandaran province. The results show that there is a significant difference ($P<0.01$) between all characteristics coming under our scrutiny in altitudinal levels on which the study is carried out so that the maximum and minimum length and width of the seed and fruits have alternatively been observed at altitudes of 1400 and 50 meter above sea level Of the investigated attributes, weight of 1000 seeds has the widest variety. The humidity of all provided samples of various heights is less than 5% which is regarded as a proof of orthodox-natured seed of this type.

The study of Alder seed germination illustrated that the maximum and minimum amounts of the weight have been observed at altitudes of 1400 and 50 meter above sea level. The general findings of this study demonstrated that seed of Caucasian Alder (*Alnus subcordata*) did not go dormant and sprouted at once, regardless of altitudinal variation, after sowing. Additionally, the distinct effect of altitude gradient changes and consequently the changes of climatic conditions to the characteristics of Alder seed and fruit coincide with the findings of majority of researchers.

Keywords: *Alnus subcordata*, seed traits, fruit, altitudinal gradient

INTRODUCTION

Accounting for 7.75% of Hyrcanian forests, Caucasian Alder is considered as the forth species of these forests from density point of view (Resaneh et al., 2000). Located in the southern beaches of the Caspian Sea, the region of which

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this species spreads stretches from the westernmost limit to the easternmost limit of Caspian forests from one side and from lowlands to highlands from another side (Sabeti, 2002). The species is integral to the rehabilitation program of forests in the north of Iran. In such a manner that, according to seedling production statistics, it consisted about the continuance in reproduction (Etemad, 2002). Due to abundance of genetic impurity in species of forest trees, there is considerable differentiation in physiological and morphological characteristics of their seed.

Artificial regeneration of forests through planting requires high quantities of quality seeds for growing vigorous seedlings. These seedlings are raised in nurseries, where germination capacity (GC) and speed are the most important germination parameters. Inter- and intra-species variations in germination behaviour and seed quality and their influence on the development of unintentional directional selection of specific genotypes are implicated (Stoehr, and El-Kassaby, 2011). The result is a contributory factor in our awareness of potential of seed and consequently administering apposite rectifying and rehabilitation programs in forestall areas.

Several studies have been done on the interaction of habitat on seed characteristics. Study on altitudinal provenances of beech, conducted by Etemad (2002) and Rezaei et al. (2011). Effects of seed size and seed 10% of total broad leaves seedling production in hyrcanian region.

Continuance of biological reproduction of forest is one of the cardinal principles in the discussion concerning silviculture. Sufficient and good seed production of forest trees guarantees source elevation on chestnut-leaved oak germination, done by Ali Arab et al. (2009).

Ecological diversity existing along altitudinal slope of watersheds is a major factor in developing differentiation in seed characteristics (Turna and Guney, 2009). Located in an environment which is partially high and partly low-lying and affected by the humidity of the Caspian Sea, Golband forest management plan are influenced by factors such as altitudinal changes, geographical directions and micro slopes which have led to the formation of assemblages of botanical diversity. Caucasian Alder, originally regarded as one of the local species, is fast-growing and raised as a valuable species of forests in northern regions of the country. This type serves a prominent role in instauration programs of degraded forests as well as woodland expansion.

The current study lays its emphasis on the requisiteness of propagating this seed species and the incontrovertible role of consciousness of qualitative and quantitative characteristics of the seed in constructiveness of plans implemented to reproduce saplings.

The findings will produce a solution to existent unknowns concerning the diversity in chief characteristics of this species of seed in different heights of the northern forests of Iran.

MATERIAL AND METHODS

The Study area

The area through which the survey has been carried out is a part of Nowshahr Headquarters of Natural resources, Mazandaran province, called Golband Forest management Plan. The region lies at altitude 36° 26′ 01″ to 36° 38′ 18″ north and longitude 51° 22′ 51″ to 51° 37′ 30″ east. The altitudinal limit of this region at the lowest point is at an altitude 50 meters, e.g. Khanikan Forestry Plan and at the highest point is at an altitude of 2400 meters, located in the northern crest of Nimevar village.

Research Methodology

In order to collect samples of Alder seed through Golband Forestry Plan limits, some stations in the specific heights, where there is a dense mass of Alder, were identified. Fruit needed for our study were randomly gathered from a minimum of 10 seed trees with 40-50 centimetre diameter class, located at six various altitudinal points (50, 400, 800, 1200, 1400 & 1600 m) in the northern slope of the limit, at a time interval of 20 days. To negate the effect of seed position in the tree crown, seeds were collected from different parts of the tree. Maintaining the quality of fruit while they were being transported to the laboratory necessitated the use of appropriate bags. Therefore, jute sacks which are well-ventilated were employed to preserve their quality. Furthermore, the fruit were kept in cold store before carrying out of experiments. At first, we made respective measurements of Alder fruit. Then, seeds were extracted from fruits and the other properties of the purified seeds were measured. Physical and morphological changes, alternatively, including size (the length and diagonal of fruit and seed), weight of 1000 seeds (multiply number by kilogram), purity, the seed humidity and germination, were studied according to International seed testing association manual (ISTA, 2008).

In order to specify dimensions of the fruit/seed, 4 replicates of 50 seeds were taken at random in every height under study, and then their length and diameter were measured by Caliper (with accuracy of 0.01). The other characteristics were determined applying the following formulae and methods (table.1).

Table.1. Formulas used to measure the characteristics in the study

Treats	Formula
Purity	(Weight of pure seed / total weight of sample) * 100
1000 SW	(Mean of 8 replicates of 100 seeds)*10
Moisture content %	[(Weight of fresh sample – Weight of dry sample) / Weight of fresh sample] * 100
Germination	Total germination in all replicates / Number of replicates

Conduction of the experiment was based upon a completely randomized design, hence at first an investigation into normality of the data was carried out by performing Kolmogorov-Smirnov test. Afterwards, F-test was utilized to normalize variance of the data. One-way ANOVA test was applied to make an analysis of the data, and the comparison of medians was performed with the help of Duncan's test through running SPSS17 software

RESULTS

The ultimate outcomes of comparing the data have demonstrated that the difference observed between fruit and seeds, collected from various heights, was significant considering the characteristics under study (table.2).

Table 2. Analysis of variance characteristics of the seed / fruit Alder

Source variation	**SS**	**df**	**MS**	**F**	**Sig.**
Seed length	2.1	5	0.43	68.5	0
Seed width	0.6	5	0.12	84.3	0
Seed MC%	20.7	5	4.1	345.4	0
1000 SW	0.06	5	0.013	1930.9	0
Fruit Length	351.3	5	70.2	78.6	0
Fruit width	99.9	5	19.9	148.4	0
Germination	6123.5	5	1224.7	152.5	0

The maximum length of seed (3.03 mm) was observed at an altitude of 1400 meters, then altitudes of 1600, 1200, 800, 400 respectively. Finally, the minimum one (1.83 mm) went to a point at an altitude of 50 m.a.s.l. The trend of change increase indicates a regular pattern of rise in accordance with an increase in height within altitudes of 50 to 1400 m, though it reflects a modest reduction at an altitude of 1600m, compared to its equivalent at an altitude of 1400m. Regarding the width of seed, the maximum one (0/89 mm) was observed at an altitude of 1400 meters. The trend of variation in width shows an approximate sinusoidal pattern within the limits of the plain to the highest measured elevation (1600 m), so that a strain of increase runs through altitudes of 50 m to 800 m. There is a slight downturn at an attitude of 1200 m, though its reduction is of no account to its counterpart at the elevation of 800 m; thereafter, it reaches its highest point at an the heights of 1400. Finally, it declines anew at an altitude of 1600 m (figure 1). In general, it can be stated that variations in length are proportional to the ones in width.

The results generated from measuring seed humidity level have illustrated that the humidity of Alder seed is minimal overall. Moreover, regarding the humidity it can be concluded that its humidity has born close resemblance to its equivalent in seeds of Orthodox category. The utmost humidity of the seed (4/49) was observed at an altitude of 800 m. This property would vary along the altitudinal gradient so that seed humidity was rising from an altitude of 50 m to an altitude of 800 m and hereafter, its descending trend was ongoing by an elevation of 1400 m.

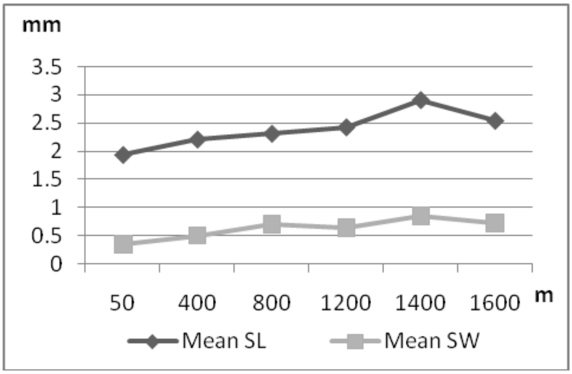

Figure 1. Trend of variation in length and width of seeds with seed source elevation change

Afterwards, the trend remained constant, though a marginal rise, which was negligible comparing to its counterpart at a height of 1400, could be seen by an altitude of 1600 (figure 2).

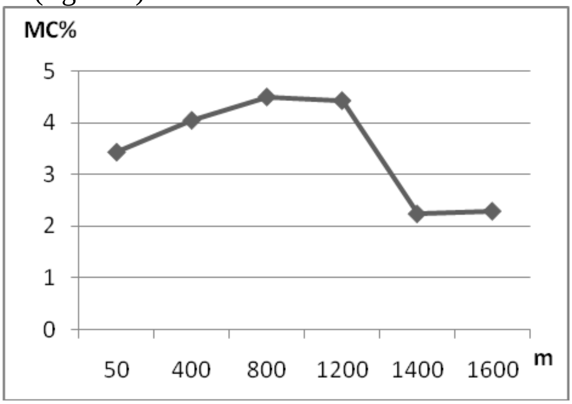

Figure 2. Trend of variation in seed moisture, with seed source elevation change

In the case of weight of a thousand seeds, the maximal weight of seed (0.28 gm) was observed at an altitude of 1400 m. With an upward movement in weight changes, the trend followed a regular basis in accordance with increase in height from altitudes of 50 m to 1400 m., in other words, the more the height rises, the larger the size of seeds gets. The upward trend shows a gentle slope within altitudes of 50 m to 400 m, but a sharp one from a height of 400 m to a height of 1200 m, then, it was slowing down and from then on the weight of seed decreased by an altitude of 1600 m (figure 3).

The results of the comparisons made between the lengths of the fruit have revealed that the maximal length of fruit (28.8 mm) could be seen at an altitude of 1400. This property would swell on a regular basis from an altitude of 50 m to an altitude of 1400 m, then, there has been a small fall in seed length at an elevation of 1600, compared to its equivalent at an altitude of 1400 m.

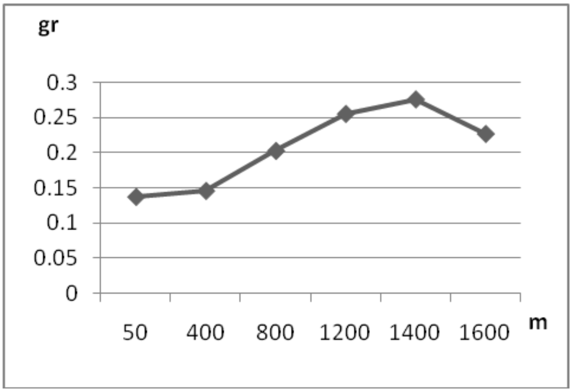

Figure 3. Trend of variation in weight of a thousand seeds, with seed source elevation change

The notable point is that how the length of fruit alters, is exhaustively in proportion to changes in seed length. The outcome of the comparison performed between the fruit diameter has been that the uttermost diameter of fruit (14.60) could be found at an altitude of 1400. The alteration in fruit breadth was also proportional to seed length, whereas the preceding one varied with considerably greater regularity in comparison to the succeeding one; it means that the upward trend of width kept on growing, in accordance with a rise in height, on a regular basis from an altitude of 50 m to an altitude of 1400 m, Although there was a slight fall at an elevation of 1600 m compared to its equivalent at a height of 1400 m (figure 4).

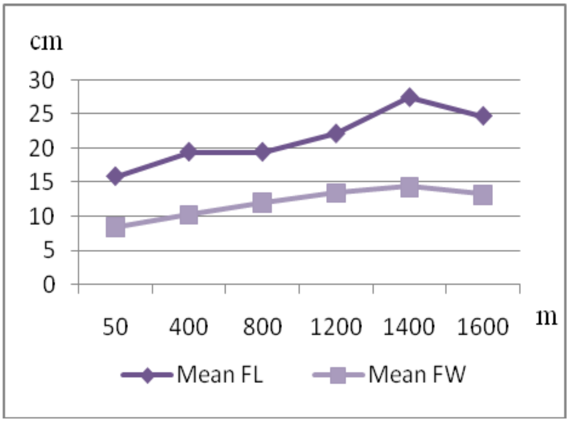

Figure 4. Trend of variation in length and width of fruit with seed source elevation change

The outcome of comparing seeds from the germination capacity point of view has determined that seeds germinated at maximum capacity (72%) at an altitude of 1400 m. The variation in germination capacity followed the aforementioned trend- in other words; having a gentle slope, the trend maintained rising regularly according to the increase in height so that it moved upwards within an altitudes of 50 m to an altitude of 1400 m (figure 5).

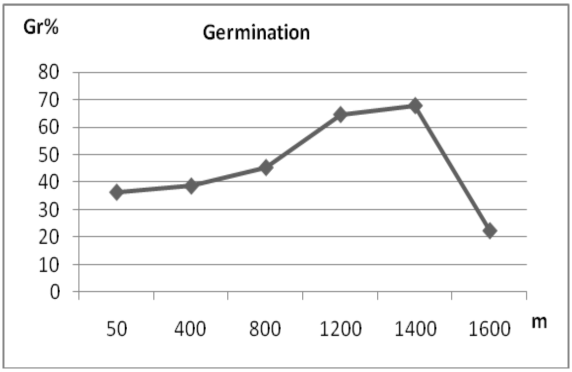

Figure 5. Trend of variation in germination of seeds with seed source elevation change

DISCUSSION

The results of the present research have suggested that the morphological (length & diameter), the physical (moisture/purity/weight of 1000 seeds) and the physiological (germination capacity) characteristics of Alder seed and fruit were sensible ($P<0.01$) along the altitudinal gradient.. Variations in seed characteristics were on the basis of changes of altitudinal gradient. In a study conducted by Turna and Guney (2009), some morphological qualities of Pinus sylvestris seed at the heights of turkey were investigated. The outcome of the aforesaid study, which was a reflection of how influential some geographical parameters (elevation) are, has manifestly indicated that the variation occurring in the characteristics of seed and cone of this species is as a consequence of differences found along altitudinal gradient of separate watersheds. The findings corresponded to the ones found by Seyfolahian (1988), Etemad (2002) and Rezaei et al. (2012) in their research on qualitative and quantitative changes in the characteristics of beech seed in the forests situated in the north of the country; they reported the most quality seed at an altitude of 1500 m, which is identical to the general findings of the current study.

Considered as a preponderant factor in the size and growth of achieved saplings for ensuring the establishment of optimal afforestation, seed size serves an instrumental factor incarrying out rehabilitation projects with success. In the current study, precipitation and temperature have been in inverse proportion to elevation. It means that the more the height increased the greater reduction in precipitation and temperature was observed (according to nearest meteorological data, Anonymous, 2010). All seed dimentions show a steady rise by increasing of elevation to ensure the establishment of saplings more appropriately and to deal with change of condition which is becoming harsher. Thus the length of seeds 1.51 times (from 1.93 mm at the altitude of 50 m to 2.91 mm at the altitude of 1400 m), the diameter of seeds 2.5 times (from 0.34 mm at the altitude of 50 m to 0.85 mm at the altitude of 1400 m) and their weights 3.18 times (from 0.27 gm at the altitude of 50 m to 0.85 gm at the altitude of 1400 m) have increased. The greatest variation of seed traits along different elevations can be observed in the weight of thousand seeds

Isik (1986) in his survey on effect of elevation changes on seed characteristics and sapling of Pinus brutia concluded that there was a positive and direct correlation between the weight of a thousand seeds and the increase in elevation. Their findings have been corroborated appropriately in the current study. Singh et al. (2006) in their survey on seed and sapling features of Celtis australis species showed that in comparison with other morphological traits, the weight of seed demonstrated the uttermost difference between various communities. Both of the above-mentioned findings are substantiated in the current study. Comparing the dimensions of the seed at altitudes of 1400 m and 1600 m illustrates that there is a slight decrease in the dimensions of the seed, which alternatively include 12% in the length, 15% in the width and 18% in the weight of a thousand seeds, at an elevation of 1600 m. Note that the diversity of changes in seed characteristics is also in proportion to the dimensions of fruit; this means that all characteristics of fruit (length and width) which we measured were increased from the plains to an elevation of 1400 m and then it decreased (the elevation of 1600). In a study conducted by Pluess et al. (2005), the effects of height increase on seed weight of different species in the Alps, located in Swiss, were examined. In this survey, a heterogeneous collection of 29 species (a species in a plain and the other one in a high elevation) was compiled and studied. The findings revealed that Seeds of Swiss Alp species (altitudinal) are 28±8 % larger than plain seed species ($P < 0.01$). The Alps species include 55% heavier seeds, 3% lighter seeds and 44% equiponderant seeds in comparison to plain seed species. The results of the present study have also reflected that the increase in dimensions of the seed and fruit is appropriate with the increase of altitude.

Humidity considered as one of the main indices of physical quality of seed is measured in the standard test (ISTA, 2008). The trend of variations in humidity of altitudinal gradient is proportionate to changes in precipitation. Thus by the altitude of 1200 m, the increase of seed humidity level is proportional to the upswing in precipitation (from 3.42% to at the altitude of 50 m to 4.92% at the altitude of 1200 m). Then, with an increase of altitude, it begins its downward trend (at least 2.23% at the altitude of 1400 m which is of no account to its counterpart at the elevation of 1600 m). In their study on the seed and sapling characteristics of Celtis australis species, Singh Prasad (2006) pointed out that the altitude is in inverse relation to the level of seed humidity, which is consistent the results of the present study.

Germinating is known as one of the qualitative characteristics of seed in relation to rehabilitation activities. In this study, changes in the germination occur with a steady and appropriate trend of increase along the altitudinal gradient so that the trend begins rising with a steady slope (37%, 39%, 46%, 65% and 68%) from the altitude of 50 m to the altitude of 1400 m and afterwards, its amount reduced with a substantial fall (23%: the least possible amount). Incidentally, the trend of changes in germination is in proportion to the trend of other seed characteristics. There is correspondence between these findings and the ones found by internal researchers, for instance, Etemad (2002) and Rezaei et al. (2012) on Fagus orientalis seeds, Alvaninezhad et al. (2009), and Ali Arab et al.(2010) on chestnut-leaved oak seed. Of the foreign researchers whose findings in the altitudinal gradient and also between the provenances existing at different longitude are in accordance with the results of this paper, are alternatively Angosto and Mattila (1993), who conducted a study on seeds of three legume species, Loha et al.2006 who carried on a study on Cordia africana seed and Uniyal et al., (2003), who did a study on Grewia oppositifolia seed. Ton et al. (1990) have stated that larger seeds are a demonstration of a better quality of the germination and genetic potential. In addition, the reports provided by Negi and Todaria,1997., Navarro, and Guitián.,2003., illustrated that there are direct relationships between seed size, seed germination and sapling growth of species of forest trees.

Etemad (2002) revealed that late frosts in spring, which results in flowers frost and creates an obstacle to complete pollination, is the main reason of increase of empty seeds percent at the elevation of 2200m. Such a phenomenon is considered as the probable factor in the dramatic decrease of Alder seeds germination at the altitude of 1600 m. Scholten et al., (2009) have expressed that the difference in environmental conditions and the elevation of seed collection which affects seed germination are the causes of this issue. According to study, Roach and Wulff (1987), Gutterman (1992) and Lopez et al. (2003), the differences existing between various provenances, especially in terms of seed germination, can be affected by environmental heterogeneity among different areas of seeds collection. Reduction of precipitation and sever environmental conditions due to increase of height are of the environmental heterogeneity which have a significant effect on germination changes. In this study, this environmental heterogeneity and its impact on all other features under study have been observed thoroughly.

CONCLUSIONS

According to overall results of this research, it can be concluded that Alder seeds gathered from different elevations has no dormancy. Incidentally, the trend of variations in characteristics of this seed species is approximately in direct proportion to altitudinal changes to an elevation of 1400 m-in other words, its rise is in equilibrium with the increase in elevation and in most cases, it comes to the maximum amount at an elevation of 1400 m. An exception to the upward trend in variation of height and seed characteristics was traced at the elevation of 1600 m, so that most of the seed features have declined and in some cases they have come to their minimum amount, regardless of the increase in elevation. Extreme environmental conditions at this elevation as the main cause to explain this situation. Regarding the meteorological data found in the current study, such a claim is substantiated.

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KOMPARATIVNO ISTRAŽIVANJE FIZIČKIH I FIZIOLOŠKIH KARAKTERISTIKA SJEMENA KAVKASKE JOVE (ALNUS SUBCORDATA) NA RAZLIČITIM NADMORSKIM VISINAMA HIRKANIJSKIH ŠUMA HYRCANIAN FORESTS

SAŽETAK

Kako bi se sprovelo istraživanje trendova morfoloških (dužina i širina), fizičkih (vlažnost i težina 1000 komada sjemena) i fizioloških (kapacitet klijanja) promjena, sjeme/plod jove je sakupljeno na šest različitih nadmorskih visina (50, 400, 800, 1200, 1400 & 1600 m.n.v.) u okviru ograničenja Golband plana upravljanja (riječno područje br. 45) pod nadzorom Uprave za šumarstvo Nowshahr, provincija Mazandaran. Rezultati pokazuju da postoji značajna razlika ($P<0.01$) između svih karakteristika koje smo posmatrali na svim nadmorskim visinama gdje je istraživanje vršeno tako da su maksimalne i minimalne dužine i širine smjemena i ploda alternativno posmatrane na nadmorskim visinama od 1400 i 50 metara iznad nivoa mora (m.n.v.). Vlažnost svih obezbjeđenih uzoraka različitih visina je manja od 5% što se smatra dokazom istinskog prirodnog sjemena ove vrste. Istraživanje klijanja sjemena jove je pokazalo da su maksimalni i minimalni iznosi težine dobijeni na nadmorskim visinam od 1400 i 50 m.n.v. Generalni nalazi ovog istraživanja su demonstrirali da sjeme Kavkaske jove nije bilo dormantno i nije brzo klijalo nakon sijanja, bez obzira na variranje nadmorske visine. Pored toga, vidiljivi efekti promjena nadmorske visine, te stoga i klimatskih uslova, na karakteristike sjemena i ploda jove se podudaraju sa nalazima većine istraživača.

Keywords: *Alnus subcordata*, osobine sjemena, gradient nadmorske visine