IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals
HUMAN

Human Journals
Research Article
February 2018 Vol.:8, Issue:4

Altitudinal Fertility Variation in Natural Populations of Anatolian Black Pine [*Pinus nigra* Arnold. Subsp. *Pallasiana* (Lamb.) Holmboe]

IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals
HUMAN

Mahmut Cercioglu[1], Nebi Bilir[2,]*

[1]*Golhisar Vocational School of Mehmet Akif Ersoy University, Golhisar, Burdur, Turkey*

[2]*Faculty of Forestry, Suleyman Demirel University, Isparta, Turkey*

Submission:	27 January 2018
Accepted:	3 February 2018
Published:	28 February 2018

HUMAN JOURNALS

www.ijsrm.humanjournals.com

Keywords: Strobili, Fertility, Effective Number, Cone, Seed

ABSTRACT

Anatolian Black pine [*Pinus nigra* Arnold. subsp. *pallasiana* (Lamb.) Holmboe] is an important forest tree species for Turkish forestry and the "National Tree Breeding and Seed Production Programme" by 4.7 million ha natural distribution. Fertility data (i.e. reproductive success) estimated based on numbers of reproductive characters has important roles in success of plantation forestry and breeding programme. In this study, fertility variations were estimated based on number of strobili, cone and seed in three populations sampled altitudinal range (1300 m. <, ≤1300-1600 m.<, 1600 m. ≤) for two years) of the species for two years to contribute for genetic-breeding and other forestry practices. Large differences supported by results of analysis of variance were found among populations and within populations, and also between years for the reproductive characters, while average of number of strobili, cone and seed was the highest in low altitude (1300 m. <). The fertility variations (Ψ) estimated by number of reproductive characters were generally similar and close to (Ψ<3) ideal population.

INTRODUCTION

Anatolian Black pine [*Pinus nigra* Arnold. subsp. p*allasiana* (Lamb.) Holmboe] is an important forest tree species and national breeding programme (Koski and Antola, 1993) because of its commercial wood production of Turkey by 4.7 million natural distributions of which 45% to be unproductive [1]. Forest establishment is the most important way in conversion of unproductive forest to productive forest. Forest establishment is also getting importance of the species because of its widely used in afforestation and higher unproductive forest area.

It is known that fertility data (i.e. reproductive success) estimated based on the number of reproductive characters have important roles in economical and biological success of forest establishment and breeding programme. Variation in fertility is also one of the major factors used for different purposes in forest tree breeding [2 to 8]. While many studies which most of them on estimation practices have been carried out on fertility variation based on strobili production, estimation based on combination of reproductive characters and the species [8 to 11] was very limited. It could be also said, it has not been studied in natural populations of the species, yet. The main objective of this study is to estimate the fertility variation among individuals in a natural population of Anatolian Black pine based on strobili, cone and seed productions to contribute for genetic-breeding and other forestry practices (i.e., plantation forestry) of the species.

MATERIALS AND METHODS

Three populations were sampled as an altitudinal range (1300 m. <, ≤1300-1600 m. <, 1600 m. ≤) for two years) at southern part of Turkey (Table 1).

Numbers of female (**N**♀) and male(**N**♂) strobili were counted using branch numbers of each individual multiplied by the average numbers of strobili per branch from 90 trees randomly chosen from each altitudinal range in end of 2015 and 2016. Numbers of mature cone ($\mathbf{N_C}$) and filled seed ($\mathbf{N_S}$) data were collected at the same numbered trees fort the years.

Table 1. Geographic details of the sampled plantations

Range	Latitude (N)	Longitude (E)	Altitude (m)
1300 m. <	37° 01' 16''	29° 22' 08''	1196
≤1300-1600 m.<	36° 56' 44''	29° 26' 18''	1472
1600 m. ≤	36° 56' 36''	29° 23' 87''	1708

The female fertility (ψ_f) and male fertility (ψ_m) variation or also called gametic fertility variations could either be estimated by a measure suggested [12] or by coefficient of variation (*CV*) as:

$$\psi_f = N\sum_{i=1}^{N} f_i^2 = CV_f^2 + 1\,;\, \psi_m = N\sum_{i=1}^{N} m_i^2 = CV_m^2 + 1$$

Where, N is the census number, f_i is the female fertility of the i^{th} individual, m_i is the male fertility of the i^{th} individual and CV_f and CV_m are the coefficients of variation in female and male fertility among individuals, respectively.

Total fertility variation (Ψ) is calculated by Bilir *et al.* [13] as:

$$\Psi = \left(\frac{CV_f{}^2 + CV_m{}^2}{4}\right) + 0.5\left(N\sum_{n=1}^{N}\frac{f_n m_n}{\sum f \sum m} + 1\right)$$

Where, N is the census number, CV_f is the coefficient of variation in female fertility, and CV_m is the coefficient of variation in male fertility, f_n and m_n are the numbers of female and male strobilus of the n^{th} individual; f and m are used as index for the female and male strobilus, respectively.

Cone fertility (Ψ_C) and seed fertility (Ψ_S) variations or also called zygotic (cone & seed) fertility variation was estimated based on individual cone and seed productions as [14]:

$$\Psi_C = N\sum_{i=1}^{N} Con_i^2 = CV_C^2 + 1 \quad ; \quad \Psi_S = N\sum_{i=1}^{N} Seed_i^2 = CV_S^2 + 1$$

Where N is the census number, Con_i/$Seed_i$ are the cone and seed fertility of the i^{th} individual, respectively. CV_C and CV_S are the coefficients of variation in cone and seed fertility. In this paper, the fertility of i^{th} individual was estimated by the proportion of cone/seed productions in the population.

The effective number of parents and the relative effective number of parents (N_r) (N_p) was estimated as [7]:

$$N_p = \frac{N}{\Psi_C}\,;\quad N_r = \frac{N_p}{N}$$

RESULTS AND DISCUSSION

Averages of number of strobili, cone and seed was the highest in lowest altitude (1300 m. <), while large differences supported by results of analysis of variance ($p<0.05$) were found among populations, and also between years for reproductive characteristics (Table 2).

Table 2. Average and ranges of reproductive characteristics in the populations and years.

	1300 m. <		≤1300-1600 m.<		1600 m. ≤	
Characteristics	**Average**	**Min - Max.**	**Average**	**Min - Max.**	**Average**	**Min - Max.**
2015						
N♀	32	8 – 55	89	27 – 165	111	33 - 180
N♂	321	80 - 500	268	80 - 500	336	100 - 500
N_C	119	12-335	91	10-250	107	25-400
N_S	6092	626-16750	4280	355-13550	5526	1296-20687
2016						
N♀	181	20 – 400	55	3 – 130	69	3 - 165
N♂	536	60 - 1200	165	10 - 400	206	10 - 500
N_C	87	12-335	61	10-251	67	10-230
N_S	649	12-3125	309	18-1854	1045	75-5500

There were large differences among individuals within population for the reproductive characters (Table 2). Large differences in fertility were reported among trees in natural populations of different forest tree species [e.g., 2, 3, 6, 7, 11, 13, 15 to 18]. The results could be used in selection and establishment of improved seed sources. It was known that differences in age and environmental variation, mainly in soil properties, may have influenced the observed variation in reproductive characters in the natural forest [15, 19].

The fertility of the reproductive characters among trees was moderate (Table 3). Herewith, the cone and seed fertility means the contribution of zygotic parents (i.e., total fertility). Estimated fertility variations (Ψ) as the proportion of the numbers of strobili, and cone and filled seeds counted from individuals in the population were generally close to ideal population (Ψ<3) (Table 3). It was suggested that the sibling coefficient (Ψ) of natural stands as a heuristic rule of thumb could be set to three (Ψ = 3) and that of seed orchards could be set to two (Ψ = 2) [20].

Table 3. Female and male fertility and total fertility variation (Ψ), and cone (Ψ_C) and seed (Ψ_S) fertility in the populations.

	1300 m. <		≤1300-1600 m.<		1600 m. ≤	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**
	Female (ψ_f) and male (ψ_m) fertility and total fertility variations (Ψ)					
ψ_f	1.14	1.24	1.18	1.37	1.09	1.45
ψ_m	1.14	1.24	1.18	1.38	1.09	1.45
Ψ	2.56	2.79	2.65	3.09	2.45	3.27
$N_{p(f)}$	78.97	72.37	76.35	65.47	82.64	61.86
$N_{p(m)}$	79.11	72.73	76.42	65.42	82.93	62.07
N_p	35.16	32.22	33.96	29.11	36.78	27.54
$N_{r(f)}$	87.74	80.41	84.84	72.74	91.82	68.74
$N_{r(m)}$	87.90	80.81	84.91	72.69	92.15	68.97
N_r	39.07	35.80	37.73	32.35	40.87	30.60
	Cone (Ψ_C) and seed (Ψ_S) fertility					
ψ_c	1.41	1.40	1.25	1.64	1.40	1.43
ψ_s	1.42	1.85	1.32	2.29	1.40	1.87
$N_{p(c)}$	63.88	64.06	72.12	54.73	64.09	63.07
$N_{p(s)}$	63.38	48.65	68.35	39.28	64.25	48.13
$N_{r(c)}$	70.97	71.18	80.13	60.82	71.21	70.08
$N_{r(s)}$	70.42	54.05	75.94	43.65	71.38	53.47

The effective number of parent (N_p), was mirrored to the fertility variation, ranged from 27.54 (68.74 % of census number) for total fertility variation (Ψ) of the highest altitude of 2016 to 82.93 (92.15% of census number) for male fertility of the highest altitude of 2015 (Table 3). It was between 39.28 (43.65% of census number) for seed fertility of middle altitude of 2016 to 72.12 (80.13% of census number) for cone fertility of middle altitude of 2015 (Table 3).

The production of cones, flowers, pollen, fruits and seeds have been used to estimate fertility and fertility variation in many plant species [e.g. 5, 13, 21, 22]. However, data collection on cone and seed productions was easier, cheaper and more accurate than that of strobilus count. Besides, the tree keeps the cone in longer period than strobili in a year. So, data collection period is longer in cone than strobilus counts as also emphasized [8, 9, 11, 18]. The results showed cone production should be also used for estimation of fertility in the species.

ACKNOWLEDGEMENT

This study was a part of Ph.D. thesis, prepared under supervision of Prof. Dr. Nebi Bilir. Authors thank to the "Scientific Research Projects Coordination Unit of Suleyman Demirel University, SDU-BAP" for financial support (Project No: **4466-D1-15**).

REFERENCES

1. Anonymous. Forest inventory of Turkey. General Directorate of Forestry of Turkey, pp. 28, 2017, Ankara, Turkey.
2. Bila AD. Fertility variation and its effects on gene diversity in forest tree populations. Ph.D. Thesis. Swedish University of Agricultural Science, 2000, Umeå, Sweden.
3. El-Kassaby YA.Evaluation of tree-improvement delivery system: factors affecting genetic potential. Tree Physiol, 1995, 15:545-550.
4. Griffin AR. Clonal variation in radiata pine seed orchards. I. Some flowering, cone, and seed production traits. Australian Forest Research, 1982, 12:295-302.
5. Shea KL. Effects of population structure and cone production on outcrossing rates in Engelman spruce and subalphine fir. Evolution, 1987, 41:124-136.
6. Xie CY, Knowles P. Male fertility variation in an open-pollinated plantation of Norway spruce (*Picea abies*). Canadian Journal of Forest Research, 1992, 22:1463-1468.
7. Kang KS, Bila AD, Harju AM, Lindgren D. Fertility variation in forest tree populations. Forestry, 2003, 76: 329-344.
8. Yazici N, Bilir N. Aspectual fertility variation and its effect on gene diversity of seeds in natural stands of Taurus cedar (*Cedrus libani* A. Rich.). IJ. Genomics, 2017, 2960624:1-5.
9. Bilir N, Kang KS. Estimation of fertility variation by strobili and cone productions in Taurus cedar (*Cedrus libani* A. Rich.) populations, IUFRO Forest Tree Breeding Conference August 25–29, 2014, Prague, Czech Republic.
10. Özel HB, Bilir N. Fertility variation in two populations of taurus cedar (*Cedrus libani* Rich.). *PJB*., 2016, 48: 1129-1132.
11. Bilir N, Ozel HB. Fertility variation in a natural stand of Taurus cedar (*Cedrus libani* A. Rich.). International Forestry and Environment Symposium (IFES), 2017, 7-10 November, Trabzon, Turkey.
12. Kang KS, Lindgren D. Fertility variation and its effect on the relatedness of seeds in *Pinus densiflora*, *Pinus thunbergii* and *Pinus koraiensis* clonal seed orchards. Silvae Genetica, 1998, 47:196-201.
13. Bilir N, Kang KS, Lindgren D. Fertility variation in six populations of Brutian pine (*Pinus brutia* Ten.) over altitudinal ranges. Euphtyica, 2005, 141:163-168.
14. Bilir N. Fertility variation in Wild rose (*Rosa canina*) over habitat classes. International Journal of Agriculture and Biology, 2011, 13:110-114.
15. Bila AD, Lindgren D. Fertility variation in *Millettia stuhlmannii*, *Brachystegia spiciformis*, *Brachystegia boehmii* and *Leucaena leucocephala* and its effects on relatedness in seeds. Forest Genetics, 1998, 5:119-129.
16. Almqvist C, Jansson G, Sonesson J. Genotypic correlations between early cone-set and height growth in *Picea abies* clonal trials. Forest Genetics, 2001, 8:197-204.
17. Bilir N, Kang KS, Zang D, Lindgren D. Fertility variation and effective number in the seed production areas of *Pinus radiata* and *Pinus pinaster*. Silvae Genetica, 2003, 52:75-77.
18. Bilir N, Ozel HB. Variation in strobili and cone production among clones in a *Pinus nigra* seed orchard. The International Conference on Agriculture, Forest, Food Sciences and Technologies (ICAFOF). Cappadocia, 2017, May 15-17, Turkey.
19. Bilir N, Prescher F, Lindgren D, Kroon J. Variation in seed related characters in clonal seed orchards of *Pinus sylvestris*., New Forests, 2008, 36:187-199.
20. Kang KS. Genetic gain and gene diversity of seed orchard crops, Ph.D. Thesis. Swedish University of Agricultural Science, 2001, Umeå, Sweden, Acta Universitatis Agriculturae Sueciae, Silvestria 187.

21. Savolainen O, Karkkainen K, Harju A, Nikkanen T, Rusanen M. Fertility variation in *Pinus sylvestris*: a test of sexual allocation theory. *American Journal of Botany*, 1993, 80:1016-1020.
22. Roeder K, Devlin B, Lindsay BG. Application of maximum likelihood methods to population genetic data for the estimation of individual fertilities. *Biometrics*, 1989, 45:363-379.