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Modeling the Distribution of the Height of Chestnut Trees in the Forests of Gilan

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Abstract: ***Variables of total height can be considered the main variables morphometric of forest trees. The purpose of this study was to investigate the probability distribution of the height of chestnut trees in the forests of Gilan province. In this study, 30 samples of dimensions 50 × 50 m as selectively were sampled and heights of 213 trees of chestnut trees were measured. Probability distribution function that investigated was beta, gamma, normal, lognormal and Weibull. Characteristics of each of the functions were estimated using the maximum likelihood method. In order to fit probability distribution functions that were studied, fitting chi-square and Kolmogorov-Smirnov was used. Kolmogorov-Smirnov test results showed that the beta distribution in compare to the other distribution of power is more explanation. So, is a suitable model for chestnut trees in the forests of Guilan.***

Keywords: fitting test, Modeling, probability distribution, height, chestnut

1. Introduction

Variables such as tree height in forest biometrics, in some case, such as determining the volume, height curve, calculate the coefficients of shape and slenderness were used application, but should consider general understanding and explaining the behavior of these variables, because these are as the random variable. To explain the behavior of these variables can be used of modeling the distribution. Modeling of frequency distribution parameters such as diameter and height in various branches of forests science such as silvics, forestry and forest biometrics, is considered by scientists. The first attempt to modeling of frequency distribution variables of trees was performed in 1898 by Baily (Baily, 1980). The first study was conducted in the context in Iran, related to the diameter distribution of trees in the forest of Gorazbon district in Kheiroudkenar, Noshahr (Namiran, 1990). In this study, beta distribution, Weibull, and negative binomial were used. The results of fitting chi-square test and Kolmogorov-Smirnov test showed that the Weibull distribution and beta can describe the diameter distribution of trees. Motaji et al, (2000) conducted another study to determine the diameter distribution of mass uneven-aged trees in the forest of Gorazbon in district Kheiroudkenar. In this study, beta distribution, Weibull and normal were fitting to relevant data. Kolmogorov-Smirnov test and chi-square results show that in beta and Weibull distribution can explain the distribution of size data, but a normal distribution cannot have this performance. Fallah et al, (2005) to study the diameter structure of mass uneven-aged of beech trees in Shastkalateh and Sangkadeh, used multiple regression model. Motaji et al, (2000) investigated distribution of trees according to tree height classes in the forests. In this study, beta, Weibull and normal distribution were used to determine the abundance of trees in height classes that named modeling of frequency distribution random variable of high in mathematic. The results of the chi-square test and Kolmogorov-Smirnov showed that one of the above distribution model was not suitable for this purpose. Mohammadalizadeh et al, (2000) investigated modeling of frequency distribution tree height in mass uneven-aged trees in the forest of Gorazbon in district Kheiroudkenar. Four distribution, Weibull, gamma, normal and log-normal for modeling frequency distribution of variable height were chosen. Andrsvn- Darling test results showed that the distributions of Weibull, gamma, normal or log-normal are more suitable respectively and lognormal distribution is not an appropriate model for modeling of the distribution of tree height frequent. In Iran, studies of the structure and tree height and also using mathematical and statistical methods to do this studies are in their early stages. However, more studies have been done in European and American countries, most of these studies have been done on the mass of the same age. On the other hand, due to the importance of variable diameter, more these modeling are about variable diameter and less attention has been paid to the variable height. It should be noted that basically requires to modeling distribution of variable height is a new requirement that is considered along progress of the increasing importance of forests.

The aim of this research is comparing the statistical model distribution of trees in high class to select the appropriate distribution function for modeling the distribution of height in the Gilan province and also determine the most appropriate distribution function of height for the chestnut species. Chestnut tree as a forest species endemic, rare and precious in some forest habitat of Gilan naturally appear, Chestnuts in the

Gilan has four main habitat, Visrud (most sites), Siah Mazgi, Ghalehroodkhan and Shafarood and are relatively close together. So far 9% of the trees in the original habitat have been destroyed dry feet (Hedayati, 2003). All sites are faced with grazing and habitat destruction and gradually the number of acres of habitat for this species has been reduced (Hedayati et al., 2003). Therefore, in this study, the distributions of beta, gamma, normal, lognormal and Weibull to check the height data were fitted, to best distribution between above distributions selected to fitting height data.

2. Material and Methods

Information needed for the study of three sites of chestnut trees of this species in the province were obtained as follows:

Zone 1: The habitat area of 350 acres from 200 to 600 meters above sea level is located in the Emamzadeh Ebraham forest plan. Distance between the habitat and Shaft city and Rasht are 10 km and 30 km respectively. Geographical location is 37° 10'N to 37° 15'N of latitude and 49° 10'E to 49° 15'E of longitude that is located in No. 17 of watershed.

Zone 2: The habitat as spotted at an altitude of 320 meters above sea level and in 55 to 75% slope on the western edge of the Dahane village, after tea gardens in Fouman city is located. Distance between the habitat and Shaft city and Rasht are 23 km and 46 km respectively. Geographical location is 37° 5'N of latitude and 49° 14'E of longitude that is located in No. 14 of watershed.

Zone 3: This series (Series 17 Shafarood) is one of series of 17-fold Shafarood domains that is located near the Pounel village. Distance between this habitat and wood and paper factory in Gilan is 5 km. Geographical location is 37° 28' 10"N to 37° 15' 10"N of latitude and 49° 5' 10"E to 49° 15' 10"E of longitude.

3. Research Methodology

In this study, the selective sampling was used with dimensions of 50 × 50 m (Pourbabaii, 2008). To carry out this study with regard to the extent of regions, a total of 30 samples from areas with chestnut trees in the Gilan province (Shaft, Fouman and Shafarod) as shown in Table 1 were measured. Required characteristics of trees including diameter and height were measured.

Table 1: Samples of trees measured in different regions

Regions	Number of samples	The number of measured trees
Shaft	13	115
Fouman	7	38
Shafarod	10	60
Total	30	213

The cases of distribution

Frequency distribution or probability distribution shows the distribution of individuals in the different categories. Distribution in real-world phenomena is different and varied. Hence to probability distribution, so far, several theoretical models have been presented that called function (Johnson *et al.*, 1994). Probability distribution functions can be divided in to two categories discrete and continuous. In this study, due to the continuous random variable of height, the continuous probability distribution models were used. One of the characteristics that influence the flexibility of functions is the number of characteristic. In general, Increase parameters, will cause increase the flexibility of the model to fitting probability distribution of the data. But more number of characteristic means difficult and more complex calculation method of the parameters. In this study, the probability distribution models, such as beta, gamma, lognormal, normal and Weibull were investigated (Table 1).

Table 2: Probability distribution functions and their characteristics (Johnson *et al.*, 1994)

distribution	Characteristic function	Probability distribution function
Beta	The characteristic of shape α_1 and α_2 ، Characteristic of littoral a and b	$f(x) = \frac{(x-a)^{\alpha_1-1}(b-x)^{\alpha_2-1}}{\beta(\alpha_1,\alpha_2)\,(b-a)^{\alpha_1+\alpha_2-1}}$
Gama	Characteristic of shape α ، Characteristic of position β	$f(x) = \frac{x^{\alpha-1}}{\beta^{\alpha}\Gamma(\alpha)}\, e^{\left(-x/\beta\right)}$
Normal	Characteristic of scale σ ، Characteristic of position μ	$f(x) = \frac{1}{\sigma\sqrt{2\pi}}\, e^{\left[-(x-\mu)^2/2\sigma^2\right]}$
Lognormal	Characteristic of scale σ ، Characteristic of position μ	$f(x) = \frac{1}{x\sigma\sqrt{2\pi}}\, e^{\left[-(\ln x-\mu)^2/2\sigma^2\right]}$

Weibull	Characteristic of shape α Characteristic of position β	$f(x) = \frac{\alpha}{\beta^{\alpha}} x^{\alpha-1} e^{-(x/\beta)^{\alpha}}$

Method of analyzing of the data

In this study, to estimate the parameters of the distribution, maximum likelihood method was used. Maximum likelihood method is usually had complex calculations and lead to numerical methods**.** So that in classical statistics the maximum likelihood estimators to be known as the best estimators. There are several ways to assess the fitting. Test comparing the frequency distribution observed with the frequency distribution expected obtained from the frequency distribution model of goodness of fit tests are known. The null hypothesis in these tests is: there not differences the observed probability distribution and probability distribution of expected.

In this study for comparison distribution of observed the diameter classes with the expected, Chi-square goodness of fit test (X2) and the Kolmogorov-Smirnov (KS) was used. Calculation of various parameters and also goodness of fit the distribution of statistical software Easy Fit Professional Version 5.5 was used.

4. Results

Overall, the distribution of 213 species of chestnut trees in Elevational classes was measured. The obtained results of preliminary calculations on the data of chestnut trees height are presented in Table 3.

Table 3. Descriptive statistics of the chestnut tree height (m)

Statistic	Rank	Statistic	Rank
Count	7	Minimum	213
Average	8	First quarter	9.754
Standard error	9	Middle	0.1687
Standard deviation	11	third quarter	2.46
Variance	20	Maximum	6.065
Coefficient of Variation	8.97	Range	0.2525
Coefficient of skewness	2.4148	Elongation factor	1.346

The estimated values of the parameters of the distribution, beta, gamma, normal, lognormal and Weibull are presented in Table 4.

Table 4: The estimated Parameter values distributions

Distribution function	The values of Characteristic Functions
Beta	$\hat{a}$ = 7 , $\hat{b}$ = 22.001 = 0.773 , $\hat{\alpha}_2$ = 2.878 , $\hat{\alpha}_1$
Gama	, $\hat{\beta}$ =0.621 $\hat{\alpha}$ =15.68
Normal	, $\hat{\mu}$ =9/754 $\hat{\sigma}$ =2.46
Lognormal	, $\hat{\mu}$ =2.24 $\hat{\sigma}$ =0.231
Weibull	=4.92 , $\hat{\beta}$ =10.6 $\hat{\alpha}$

Goodness of fit test results to check the appropriate probability distribution function of the height of chestnut trees according to the Kolmogorov-Smirnov and Chi-square tests are presented in Table 5.

Table 5: The values of the statistical tests of goodness of fit

Distribution function	X^2			K.S		
	Significant	Statistic	Rank	Significant	statistic	Rank
Beta	Ns	11.74	1	*	0.145	1
Gama	*	60.155	2	*	0.149	5
Normal	*	37.09	4	*	0.169	2
Lognormal	*	54.43	3	*	0.168	4
Weibull	*	40.73	5	*	0.189	3

In figures 1 to 4, P-P diagrams related to the probability distributions.

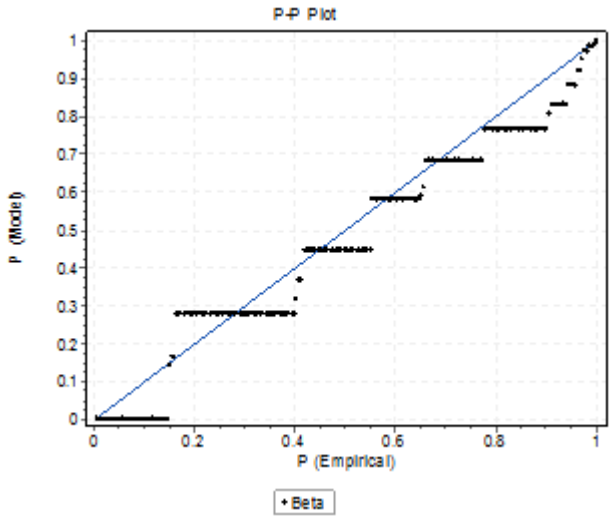

Figure 1: P-P diagram Beta distribution

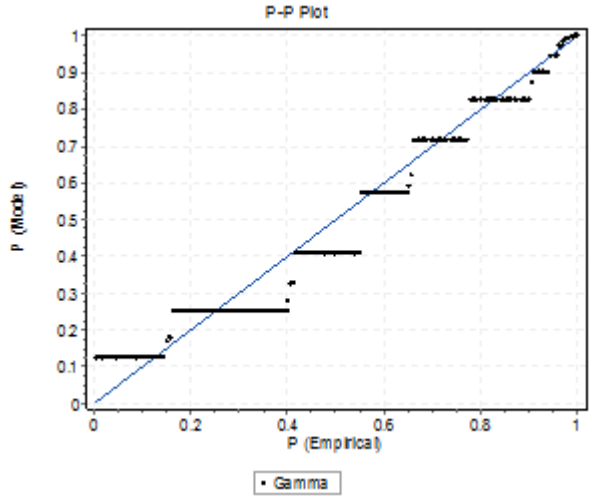

Figure 2: P-P diagram Gama distribution

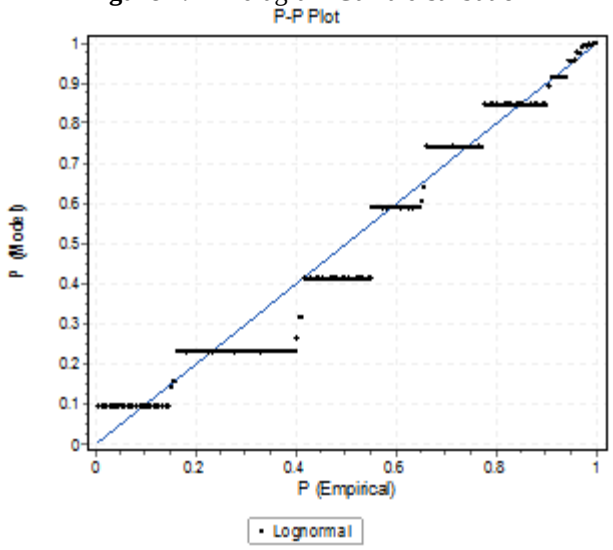

Figure 3: P-P diagram normal distribution

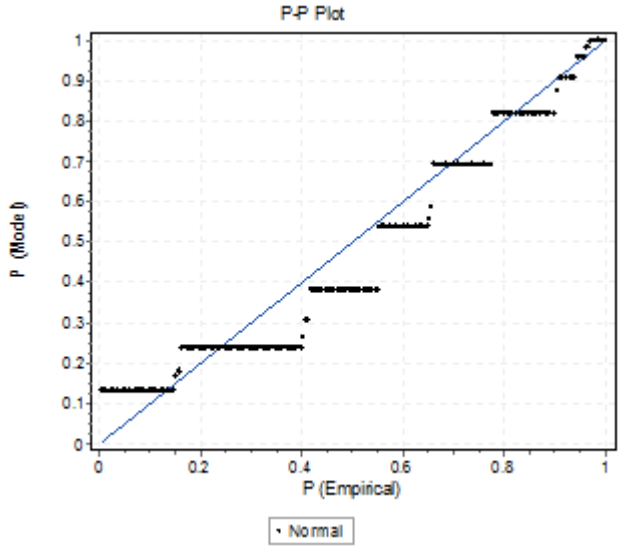

Figure 4: P-P diagram Lognormal distribution.

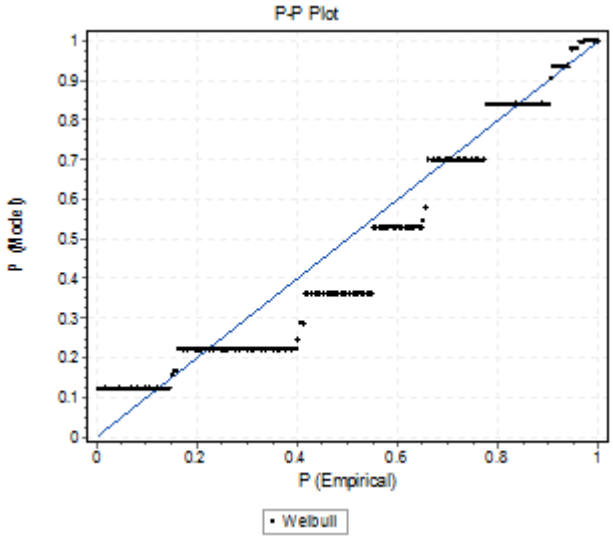

Figure 5: diagram Weibull distribution

5. Discussion

Given the importance of height as the main variable biometrics forest**,** study on that is very important**.** This variable is highly correlated with variable diameter, volume and other size of the tree. This variable is highly correlated with variable diameter, volume and other size of the tree. Thus, in studies of height curve, curved volume, table size, form factor and slenderness ratio plays an important role (Amaro et al, 2003). Nanang (1998) suggest that use of appropriate probability theory, to predict the distribution of the number of trees in a forest stand not only is important in estimating the production of different ages, but also can also be useful in the planning of forest thinning methods and optimal biological, economic productivity and also mass stability guaranteed. In this study the average equal to 4.754, variance equal to 6.065, skewness coefficient equal to 1.346 and Slenderness coefficient to equal 2.41448. Measure the goodness of fit together with Kolmogorov-Smirnov test, chi-square test and P-P diagram was performed. Results showed

Kolmogorov-Smirnov test in compare to chi-square test has more power. So, between the two tests the Kolmogorov-Smirnov test was used to measure the goodness of fit. As well as magnitude of test statistic indicates that the observed frequency distribution was far from statistical distribution that tested in the study. That means that greater test statistic followed by increase difference between observed frequency distribution and statistical distribution. Goodness of fit test results showed that according to Kolmogorov-Smirnov test all values were significantly ($p < 0.05$). Between the distribution, Beta, Gama, Normal, Lognormal and Weibull respectively showed the highest power explanation. This result may due to the beta distribution is more flexible than other distributions. This result is in contrast with results of Mohammadalizadeh et al, (2014) and Motaji (2000). But according to the chi-square test, the beta distribution is not significant and hasn't processing power. These results are similar with result that Motaji (2000) obtained. As well as estimation method used in this study is maximum likelihood method. This method due to the high properties is considered as the most desirable method. This method is similar to method that used in previous study (Mohammadalizadeh, 2010).

6. Conclusion

In the end it is necessary to express, the comparison between these results with results of internal and external study showed that of the various aspects, the present study is different from those, because in this study, there is no possible to having comprehensive comparison. Such studies about the statistical distribution based on the height in Iran have not been repeated and there is not much knowledge about this issue.

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