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Regeneration status of *Dodoneae viscosa* in malakand division

Siraj Ahmad*, Nasrullah Khan

Department of Botany, University of Malakand, Khyber Pakhtunkhwa, Pakistan

Key words: Dodoneae viscose, Seedling, Sapling regeneration, Environmental variables, Regression.

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Abstract

The regeneration status of *Dodonaea viscosa* communities was investigated in Malakand division. It lies in Hindukash 71.43^{o} South to 73.85^{o} North and 36.07^{o} West to 36.40^{o} East. Seedling and sapling data was collected using quadrat method. Various physical and chemical factors were measured. Density/ha of seedling, sapling and mature plants of *Dodonaea were* calculated. Pearson's correlation and regression analysis were performed. In protected area the high density of seedling, sapling and mature plants observed respectively which show the normal regeneration, however overgrazing and anthropogenic activities delimits natural regeneration of Dodoneae. Highest density of seedling and sapling at altitude (1083) m observed in group III and then decrease gradualy. Pearson's correlation co-efficient showed a positive relationship between sapling and seedling densities ($p > 0.001$), sapling and organic matter ($p > 0.05$) seedling and organic matter, while a negative significant relationship was found between sapling and soil pH ($p > 0.05$), seedling and soil pH ($p > 0.001$), as well as sapling and elevation ($P > 0.01$). Regression analysis showed positive relationship between Seedling and Sapling ($r = 0.919$ at $P > 0.001$), sapling /organic matte ($r=0.457$ at $P > 0.05$). The Seedling/Elevation showed a negative significant relationship ($r = 0.525$ at $P > 0.01$). The R-values of regression analysis of seedling/soil pH and sapling /pH was $r = 0.529$, $r = 0.386$ respectively, which shows a negative significant relationship of pH with seedling and sapling at the p-values $P > 0.01$, $P > 0.05$.

* **Corresponding Author:** Siraj Ahmad ✉ sirajyousafzai@yahoo.com

Introduction

Dodoneae viscosa L. is a perennial evergreen shrub species of Sapindaceae family (Nasir and Ali, 1972). Though, it is Australian in origin but also distributed in the tropical (Rani *et al.,* 2009), subtropical and temperate region of the world (Little and Skolmen, 1989; Prakash *et al.,* 2012). The species is mostly grow in sandy or rocky, loamy soil, windy area in the drought habitat and mostly favor east facing slope (Rani *et al.,* 2009). The regeneration of seedling and sapling of forest vegetation is mostly affected by the destruction of habitat and high density of livestock (Tilghman 1989; Frelich and Lorimer 1985; McCormick *et al.,* 1993). Very little literature is available on the factors which promote the regeneration of seedling (keeley, 1977) however, factors which mostly influence the regeneration of seedling of shrubby species are latitude, altitude, topography, slope, aspect, and the pattern of weather condition (Hanse, 1971). The natural regeneration of seedling and sapling depends on existing mature vegetation which produces seeds and generates new forests (Colombo, 2005). Nutrition, space, humidity, sunlight, soil nature, physical properties of soil, climate, topography and anthropogenic activities also limit the regeneration of seedling and sapling (Colombo, 2005; Noor and Khatoon, 2013). The stage of seedling recruitment is the first step for the determination of future stand structures, condition of habitat as well as vulnerability to disturbance (Christopher *et al.,* 2005). Cutting for fuels, local and commercial purposes, grazing of animals and expansion of cultivated field are the main causes of disturbance of vegetation communities (Noor and Khatoon, 2013). The sequential pattern of seedling recruitment positioned the stage for the subsequent developmental pattern of the vegetation (Christopher *et al.,* 2005).

Many species regenerate after particular type (fire or tree-fall) or size gap initiating disturbance while other establish beneath intact forest canopies (Taylor and Halpern, 1991). Usually *Dodonaea viscosa* regenerates through seeds though its propagation is also practiced successfully through cutting of twigs (Gilman, 1999). The seeds of *Dodonaea viscosa* are drought tolerant, remain viable for a long time and germinate successfully after rainfall. It is also investigated that for the survival of seedling of *Dodonaea viscosa* early rainfall is more necessary (Gilman, 1999). Much has been discussed about the regeneration potential of seedling and sapling of different plants species (Bekele 2000; Natalie *et al* 2005., Bace *et al.,* 2011; Christopher *et al.,* 2011; Khan 2011; Rahman, 2013), but little is known about the natural regeneration of seedling and sapling of *Dodonaea viscosa* in Malakand division. Therefore, the present study aims to investigate the natural regeneration of seedling and sapling of *Dodonaea viscosa* community's in Malakand division. Therefor the study is helpful in sustainable use and conservation.

Materials and methods

Field survive, design of quadrat and data collection

The area of Malakand division was survived for the seedling and sapling of *Dodonaea viscosa* communities in the years. Quadrat method was applied for the sampling of seedling and sapling of *Dodonaea viscosa* following Cox (1990). At each sampling site a total of ten quadrats were placed randomly and the size of quadrat was selected as 10×10m for sampling. Inside each quadrat the number of seedling and sapling along with Juvenile plants of *Dodonaea viscosa* were counted following Hussain (1984). Elevation of the sampling stand was measured in meter through GPS (global positioning system) and aspect was determined through magnetic compass while, clinometer was used for the measurement of slope angle (Khan, 2012; Khan *et al.,* 2013; Shariatullah, 2013; Rahman, 2013).

Collection of soil samples

For the collection of soil samples polythene bags were used. 1kg Soil samples were collected at each sampling stand up to a depth of 30 cm from four different places and mixed to form a composite sample. The bags were labeled and taken to the agricultural research center Takhta band Mingora Swat for further analysis.

Seedling and sapling data analysis

The density/ha of seedling and sapling of *Dodonaea viscosa* was calculated and compared with the density/ha of mature plants using the formulas:

$$\text{Density (D1)} = \frac{\text{Number of individual of a species in all quadrats}}{\text{Number of quadrats taken}}$$

$$\text{Density/ha (D2)} = \frac{\text{Density of a species}}{\text{Area of quadrat} \times \text{no of Quadrats}} \times 10{,}000$$

Soil analysis

Soil was analyzed for physical and chemical parameters such as soil water holding capacity, organic matter, soil pH, lime contents, soil texture (silt, sand and clay particles) and inorganic nutrients such as N.P.K in agriculture research Centre Takhtaband (Swat). 1:5 soil water suspensions were used for the determination of soil pH following Black (1965). Silt, sand and clay) % were analyzed through hydrometer following (Bouyoucos, 1936) while, the % age of organic matter was determined following Walkley (1947). Bingham (1994) method was used for the determination of phosphorus. Nitrogen and potassium was determined following Sultan-pur and Schwab (1977). M.No3, and AB-DTPA was used for the extraction of N and K from basic soil (Sultan-pur and Schwab 1977). Soil water holding capacity was determined following (Harding, D.E. and Ross, D.J. 1964), while acid base neutralization method was used for lime contents of the soil following Rahman *et al.,*(2012).

Statistical analysis

Pearson product movement correlation and regression analysis were applied for the interpretation of soil, environmental variables, with seedling and sapling density/h of *Dodonaea viscosa* following (Khan *et al.,* 2011; Rahman, 2013). The data was analyzed by Excel 2003.

Results

Regeneration potential of D. viscosa

The density/ha mean values of seedling, sapling and mature plants of *Dodonaea viscosa* in different groups is given in table (1).

Table 1. Density/ha mean values of seedling, sapling in comparison to mature *Dodonaea viscos.*

D/ha	Group I	Group II	Group III	Group IV	Group V	Total
Parameter	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	
Seedling	2439 ± 773	3454 ± 941	2808 ± 145	2744 ± 136	1296 ± 389	12741
Sapling	2061 ± 568	2271 ± 694	2392 ± 83	2363 ± 131	1208 ± 414	10295
Mature plants	928.67 ± 129	864.85 ± 60	1524.39 ± 26	605.10 ± 95.6	605.57 ± 105	4348.6
Total	5428.67	6409.85	6724.39	5712.1	3109.6	27384.58

The highest mean value of seedling density/ha, (3454 ± 941) is found in group II followed by group III (2808 ± 145 /ha) and group I (2439 ± 773 /ha) while, less number of seedling/ha were present in communities of group V. the sapling density/ha of *Dodonaea viscosa* was 2061 ± 568 in group I, 2271 ± 694 in group II, 2392 ± 83, 2363 ± 131 and 1208 ± 414 density/ha in group (III, IV and V) respectively which indicating that the sapling density was high in communities of group III. The mature plants of *Dodonaea* were also more in group III as compared to other groups. A large difference is observed among the density/ha of seedling, sapling and mature plants of *Dodonaea viscosa* with in the communities groups.

In all groups the density/ha of seedling is high followed by sapling and mature plants which indicating the normal regeneration potential but the anthropogenic disturbance and demand for fuels purposes has reduced the population of *Dodonaea viscosa*.

Table 2. Inter-correlation among Seedling, Sapling and environmental variables.

	Sapling	Seedling	El	Sl	As	Whc/10g	pH	%OM	%Lime	N(g/kg)	P(mg/ kg)	K(mg/ kg)	Sa%	Cl %	Si %
Sapling	1														
Seedling	0.910***	1													
El	-0.371	-0.525**	1												
Sl	-0.105	-0.016	-0.226	1											
As	-0.077	-0.225	0.234	-0.039	1										
Whc/10g	0.010	0.021	0.077	-0.048	0.12	1									
pH	-0.386*	-0.529***	0.425*	-0.031	0.27	0.126	1								
%OM	0.458*	0.380*	0.06	-0.047	-0.177	0.221	0.057	1							
%Lime	-0.016	-0.175	0.236	0.121	0.358	-0.168	0.513**	-0.015	1						
N (g/ kg)	0.242	0.134	0.013	-0.183	-0.129	0.269	0.063	0.854***	-0.076	1					
P(mg/ kg)	-0.214	-0.230	0.599***	-0.408*	-0.269	0.083	0.052	0.195	-0.207	0.249	1				
K (mg/ kg)	-0.006	-0.134	0.394*	-0.544**	-0.196	0.036	0.182	0.397*	-0.108	0.456*	0.734***	1			
Sa%	-0.234	-0.095	-0.175	0.145	-0.165	0.208	-0.31	-0.246	-0.684***	-0.192	-0.06	-0.144	1		
Cl %	0.107	-0.090	0.182	-0.256	0.465*	-0.154	0.418*	0.029	0.640***	0.043	-0.084	0.2	-0.673***	1	
Si %	-0.059	-0.265	0.517**	-0.252	0.367	-0.003	0.553**	0.243	0.641***	0.291	0.269	0.359	-0.811	0.631***	1

Key: Sapling = sapling density/ha, seedling = seedling density/ha, El = Elevation, Sl = Slope, As = Aspect, Whc/10g = water hc/10gm, pH. % OM = Organic matter, % Li = %Lime, N (g kg-1) = Tot.N (g kg-1), Phosphors = P (mg kg-1), K (mg kg-1), = Potassium (mg kg-1),Sa = Sand %, Cl = Clay %, Si = Silt %.

Cross correlation of seedling and sapling with environmental variables

A strong positive inter-relation is found between sapling and seedling densities ($p > 0.001$), sapling and organic matter ($p > 0.05$) while a negative significant relationship is found between sapling and soil pH at the probability level $p > 0.05$. A negative significant relationship was found between seedling density and elevation at the probability level ($P > 0.01$).

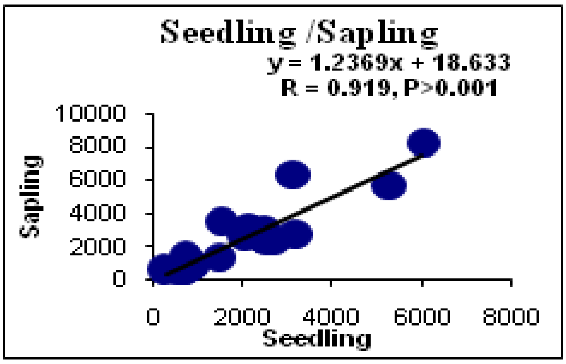

Fig. 1. Seedling /Sapling.

Similarly soil pH was also found in negative significant relation with seedling density at probability level ($p > 0.001$). There was found a positive significant relationship between soil organic matter and seedling (Table 2).

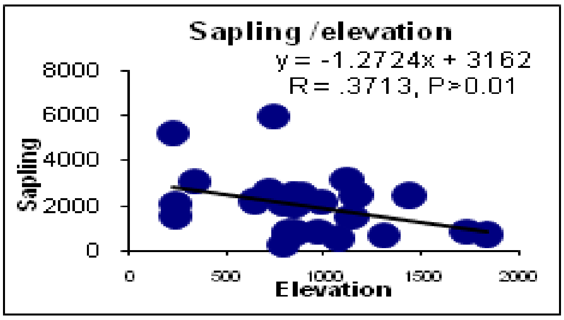

Fig. 2. Sapling /elevation.

Regression analysis

The results regression analysis of *Dodonaea viscosa* indicating a strong positive significant relationship between Seedling and Sapling ($y = 1.2369x + 18.633$, $r = 0.919$ at $P > 0.001$, sapling /organic matter ($y = 1397.8x + 271.07$), $r = 0.457$ at $P > 0.05$ probability level.

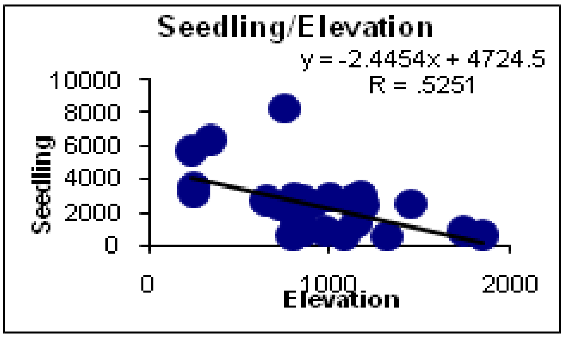

Fig. 2. Seedling/Elevation.

The Seedling/Elevation showed a negative significant relationship ($y = -2.4454x + 4724.5$), $r = 0.525$ $P > 0.01$.

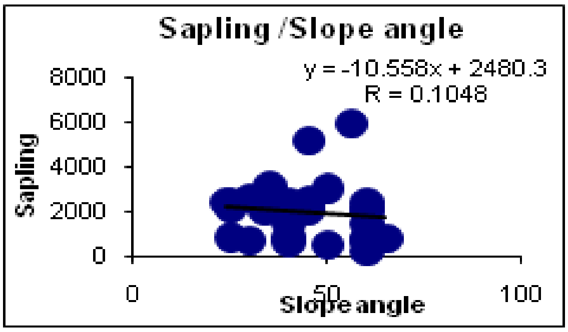

Fig. 3. Sapling /Slope angle.

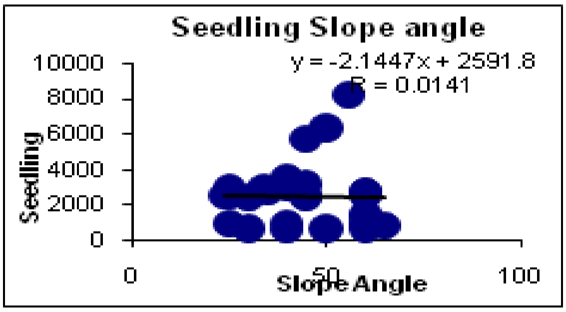

Fig. 4. Seedling Slope angle.

The R-values of regression analysis of seedling/soil pH and sapling /pH was $r = 0.529$, $r = 0.386$ respectively, which shows a negative significant relationship of pH with seedling and sapling at the probability values $P > 0.01$, $P > 0.05$. It means that among the studied parameters soil pH, organic matter and elevation mostly affect the regeneration of *Dodona viscosa* (Fig. 1-27).

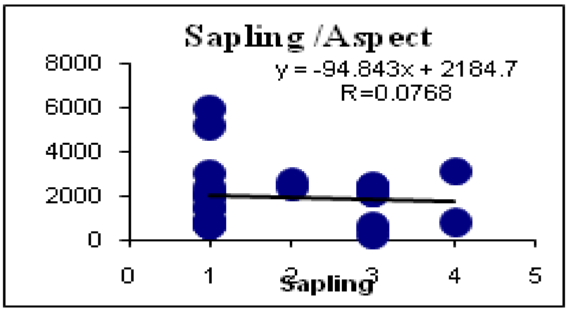

Fig. 5. Sapling /Aspect.

Discussion

All the sampling stands contain seedling and sapling of *Dodonaea viscosa* but a large difference is observed between the seedling and sapling densitiey in different stands which is dueto the difference in the parameters such as soil pH, soil water holding capasity, organic matter, Nitrogen, Phosphorus ,Potassium contents, altitude, aspect and slope angle of the sampling sites. Our finding is in correlation with Hanse (1971) stated that latitude, elevation, topography, slope, aspect, and the pattern of weather condition of an area mostly influence the seedling regeneration of shrubby species.

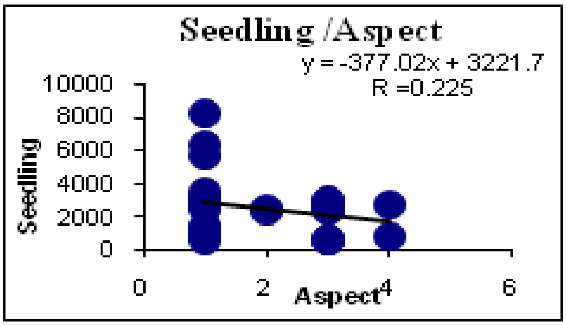

Fig. 6. Seedling /Aspect.

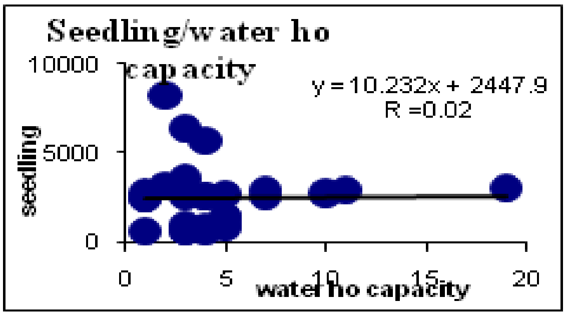

Fig. 7. Seedling /water ho capacity.

Though in all the sampled sites, seedling density of *Dodonaea viscosa* was high than its sapling and sapling than mature plants density. Similar study was conducted by Rahman (2013) recorded high sapling density than seedling and argued the abnormal regeneration of the plant species.

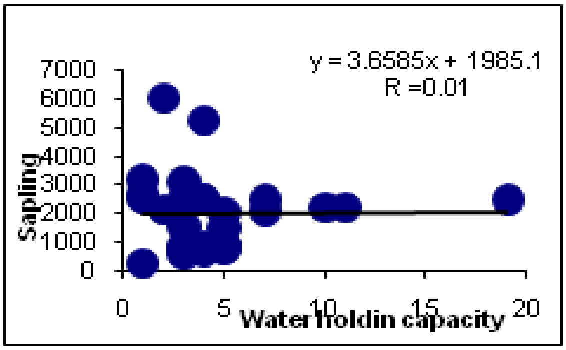

Fig. 8. Sapling /Water holding capacity.

Khan *et al.* (2011) also reported less density of seedling as compared to choped stems of *Monotheca buxifolia* and associated tree species which is also the abnormal regeneration as reported by West *et al.* (1981).

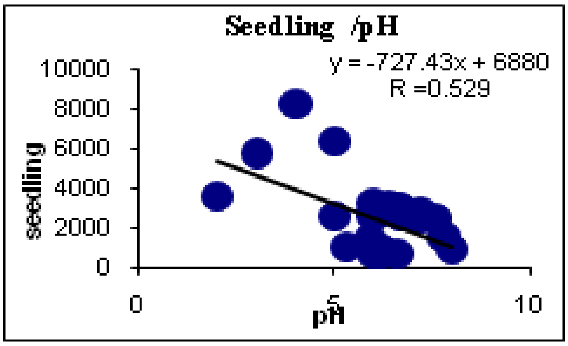

Fig. 9. Seedling /pH.

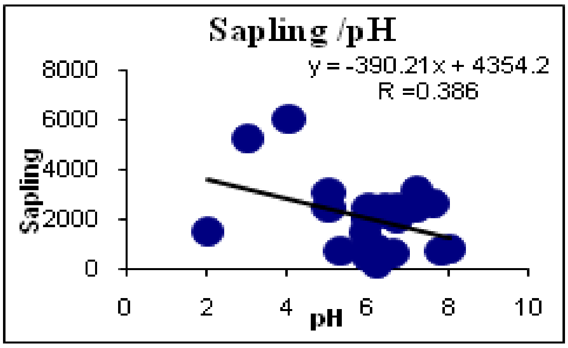

Fig. 10. Sapling /pH.

Our finding is not correlated with them because in our finding the seedling and sapling density in relation to mature plans of *Dodonaea* indicating the good and normal regeneration of seedling and sapling. Our result is strongly supported by Khan *et al.* (1987) and Manoj *et al.* (2008) who reported that the regeneration of a species depend upon the seedling and sapling density and good regeneration will be that in which seedling density is more than sapling and that of the sapling is greater than mature plant's density

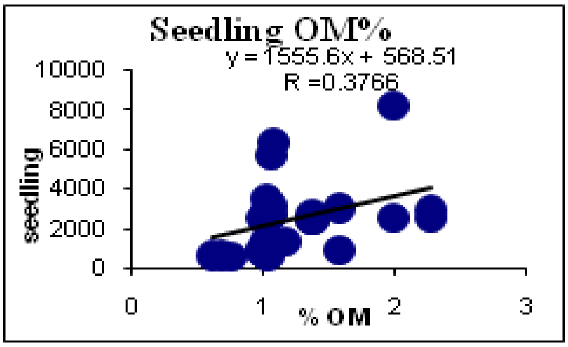

Fig. 11. Seedling OM%.

The result also indicated that although the regeneration is normal while anthropogenic disturbance, grazing of livestock and demand for fuels purposes has greatly affected the density of seedling and sapling of *Dodonaea viscosa communities*.

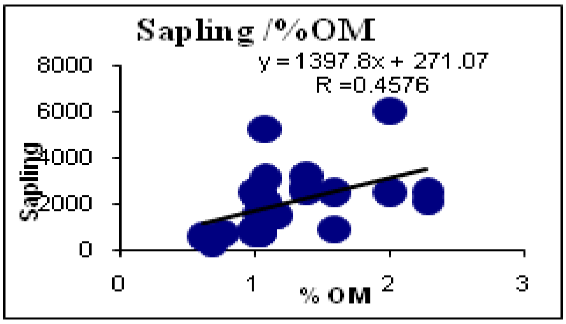

Fig. 12. Sapling /%OM.

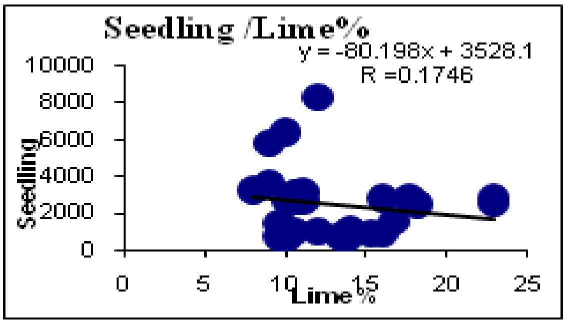

Fig. 13. Seedling /Lime%.

The seedling and sapling density of *Dodonaea* was high in the communitie's of group III which is situated at high altitued as compared to the other communities groups obtained through Ward's cluster analysis this community was highly disturbed and comprised of only six species which shows that *Dodonaea* can establish communities on degraded land (Bekele, 2000).

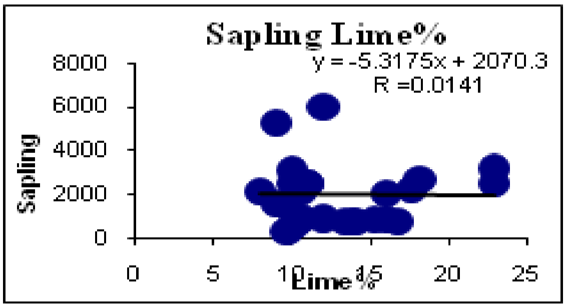

Fig. 14. Sapling Lime%.

The stands of group III of *Dodonaea viscosa* communities were situated at (1083) m elevation, slope angle (53°) was high as compared to other groups which shows that the density of seedling and sapling of *Dodonaea viscosa* increase upto certain height (1083) m and then decrease gradualy. Similar study was also conducted by Rahman (2013) to study the regeneration potential of *Seriphidium brevifolia* (Wall ex. DC) and Khan *et al.,* (2011) for the regenration capasity of *Monothica buxifolia* in district Dir *(Lower)*.

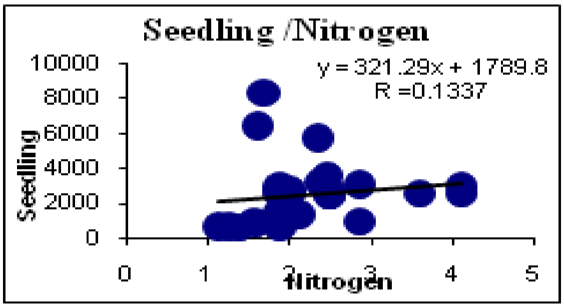

Fig. 15. Seedling /Nitrogen.

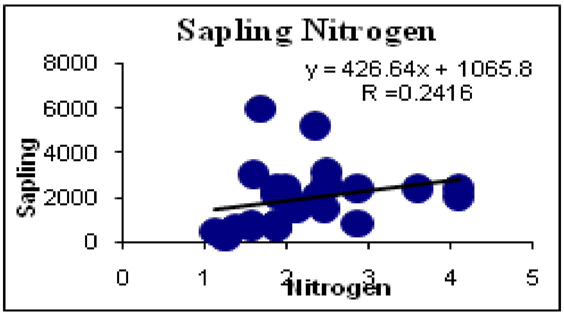

Fig.16. Sapling Nitrogen.

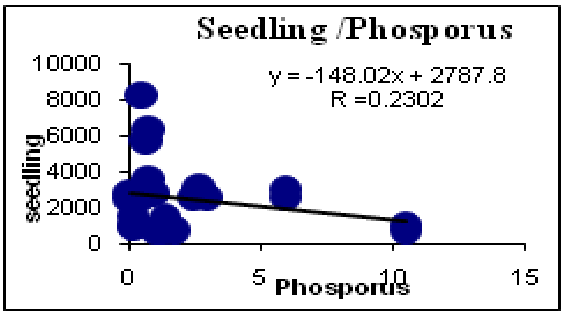

Fig. 17. Seedling /Phosporus.

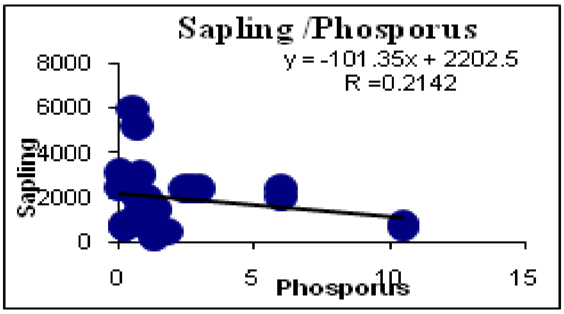

Fig. 18. Sapling /Phosporus.

The soil water holding capasity, organic matter and nitrogen contents were high than all the remaining group. Our result is supported by Singh (1986) who stated that the colloidal nature of organic matter consequently increase the water holding capacity of soil. It is also reported that Seedling generally preferred less content of potassium in soil (Rahman 2013).

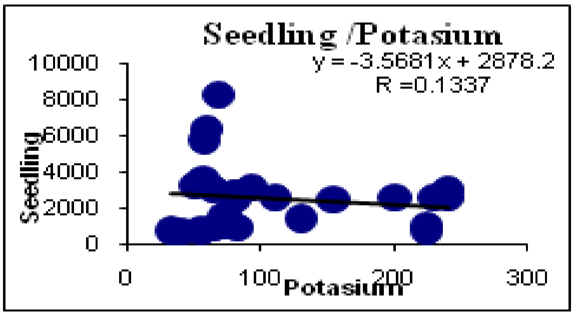

Fig. 19. Seedling /Potasium.

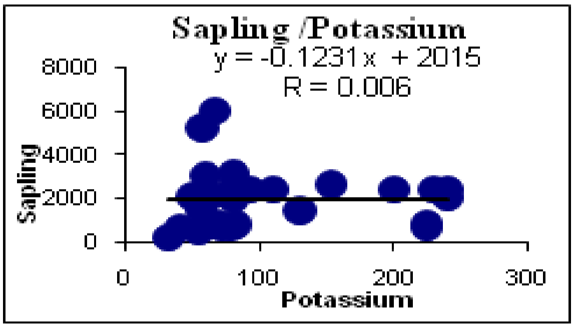

Fig. 20. Sapling /Potassium.

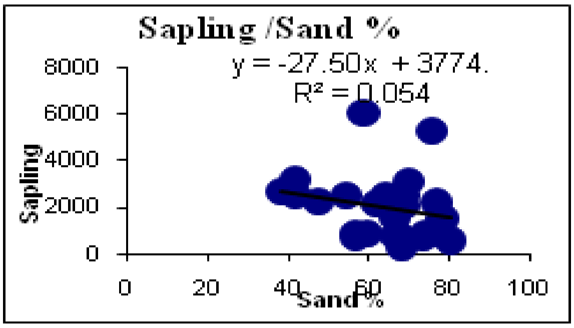

Fig. 21. Sapling /Sand %.

The results obtained through Pearson's correlation co-efficient showed that there was strong positive relationship between sapling and seedling densities ($p > 0.001$), sapling and organic matter ($p>0.05$) and seedling and organic matter of the soil, while a negative significant relationship was found between sapling and soil pH ($p > 0.05$), seedling and soil pH ($p > 0.001$), as well as sapling and elevation ($P >$

0.01) while the remaining factors don't shows significant relation with seedling and sapling density of *Dodonaea viscosa*. Cribb and cribb (1963), reported that in an undisturbed area density is closely related to slope of the sampling site.

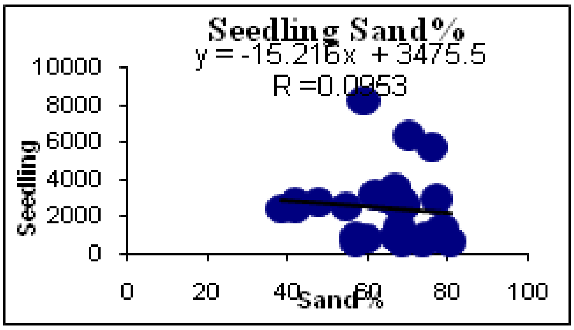

Fig. 22. Seedling Sand%

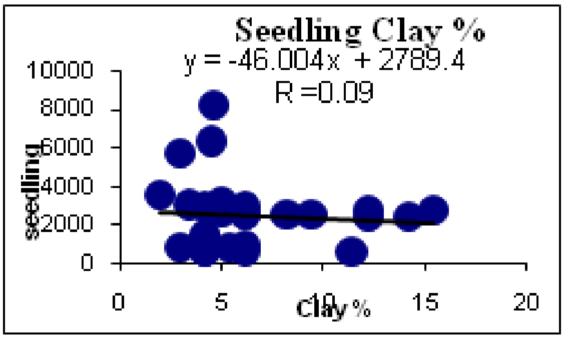

Fig. 23. Seedling Clay %

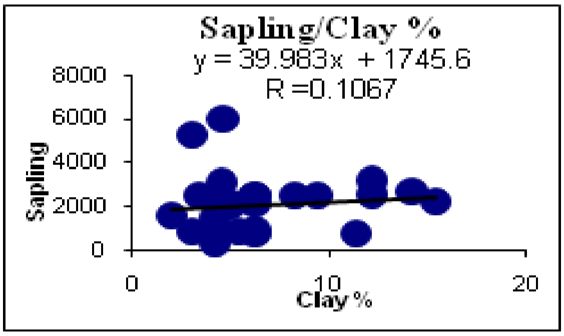

Fig. 24. Sapling/Clay %.

Barnes *et al.*, (1997) reported that slope, aspect, and soil characteristics are the factors which determining the structure of vegetation. Khan *et al.*, (2011), and Shariatullah (2013) documented that low slope, high elevation promote the organic matter of the soil and lime content which finally have an effect on all the ecophysiological process of a species. Bekele (2000) reported that seasonal rainfall is a dominant factor which regulating and establishment, recruitment, survival and growth at seedling stage.

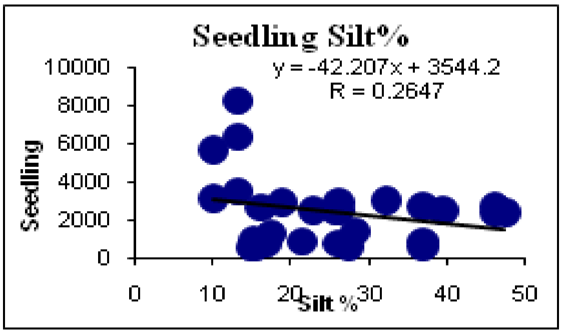

Fig. 25. Seedling Silt%

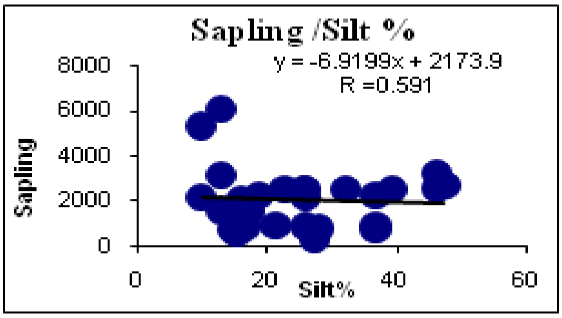

Fig. 26. Sapling /Silt %

Conclusion

The above finding indicate that alternative sources should be used to reduce the pressure on the collection of *Dodonaea viscosa* for fuels purposes as well as further study is needed to investigate the status of natural regeneration of *Dodonaea viscosa* communities in other parts of the country. The community of the area should be educated for sustainable use and conservation of plant resources.

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