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Optimal economic return and rotation period of large scale *Acacia auriculiformis* plantations in Bangladesh

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ABSTRACT

Acacia auriculiformis (Akashmoni) has shown excellent performance under plantations and appropriate for quick economic return even on soil of low fertility. The present study highlighted on the maximum economic return and rotation period in different age series of A. auriculiformis plantations at different locations of Chittagong during May 2017 to April 2018. At 13% discounting rate, the study revealed maximum NPV (457,993 Tk), IRR (48%), BCR (6.20), and Le (277,425 Tk) in 10 years old strip plantations. Besides, negative NPV (-27535 Tk), IRR (-8%), and Le (-16888 Tk) were found in 4 years old block plantations. Here, both the plantation practices are profitable (BCR>1.00) except only for 4 years block plantation (BCR=0.6). However, if we consider only NPV, the rotation period should be fixed at 10 years and 14 years for strip and block plantations respectively. Therefore, the study revealed, if we consider IRR, BCR, Le to determine rotation interval of A. auriculiformis in Bangladesh, it should be fixed at 10 years and 12 to 14 years of strip and block plantations respectively. Hence, a large amount of production losses every year as crook and lean formation takes place due to use of low quality seeds and planting materials. However, different management practices is also required immediately for large-scale plantation programs of different regions of the country.

Key Words: *Acacia auriculiformis, Net present value, Internal rate of return, Land expectation value and Benefit cost ratio*

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I. Introduction

Globally Forests play a leading role in development activities where they also provide products for persistent way of life and livelihood facilities for an estimated over 1.6 billion people (Belcher 2005). However, the sustainable forest management practices of developing countries tropical forests are really poor where many forests have been clearcut followed by poorly regenerated and rapidly converted to other landforms (Salim and Ullsten, 1999). Nowadays, with increasing rate of deforestation, plantation programme have been suggested to promote woody undergrowth regeneration, improve overall productivity, ecosystem stability and therefore overall biodiversity enrichment within degraded areas (Lee *et al.* 2005). Several studies have denoted that land recovery occurs because of plantations where it allows inauguration of succession as well (Ang 1994; Khemnark,

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1994; Shepherd 1994; Singh *et al.* 2002). About seven percent of the world's forest covered by plantations and till now these plantations contribute almost 37% of necessary timber (Petit and Montagnini, 2004). However, determination of rotation period is one of the most important and oldest problems in such plantations (Pearse 1967). The harvesting or rotation age of a plantation depends mainly on growth rate of species and intended uses of the trees after clear felling (Islam *et al.* 2013). Social forestry and plantation forestry is playing an important role for the evolution of structural composition of forest cover that is benefiting thousands of insolvent people in Bangladesh where traditional forest management is responsible for net loss (Muhammed *et al.* 2011). Therefore, *A. auriculiformis* was first imported as a shade and ornamental tree about 40-45 years ago in Bangladesh (Das 1986; Das and Alam, 2001) but later on became popular as fast growing tree species in homesteads, social and forest department plantations (Hossain 2015). It is an evergreen, heavily branched, forked bole, exotic and are also planted on roadsides and railway embankments, in parks and gardens in Bangladesh (Doran and Turnbull, 1997; Turnbull and Awang, 1997, Islam *et al.* 2013).

Kibria *et al.* (2002) revealed the economic analysis and optimal rotation of Akashmoni growing in different region of Bangladesh. Muhammed *et al.* (2000) suggested that it should be used in short rotational plantation programmes in denuded forest areas. Latif *et al.* (2001) conducted their study for 1 to 25 years mixed plantations where they found Akashmoni is suitable for 10 years of rotation. Sarkar *et al.* (2008) done a comparative economic analysis between strip and block plantations where they found maximum economic return from 10 years strip plantations. Recently, Islam *et al.* (2013) found that the plantation aged between 5 to 17 years in Bangladesh, the optimal rotation interval for timber and fuel wood was 15 and 8 years respectively. Besides, a lot of *Acacia* plantations allowed better survivality including growth rate in different regions of the country where the highest yield (15-20 $m^3ha^{-1}yr^{-1}$) was found at 10-12 years rotation interval (Hossain 2015). In Indonesia, it has been found to produce 15-20 m^3ha^{-1} annually at a rotation of 10-12 years and 5-10 m^3ha^{-1} annually at a rotation of 10-15 years (Das 1986). Yield table in Java indicated that in a 10-12 year rotation, a total yield of over 20 m^3ha^{-1} annually can be achieved (Wiersum and Ramlan, 1982). In West Bengal (India) the rotation should be fixed to produce 15-16 m^3ha^{-1} annually (Banerjee, 1993). Now-a-days, fast growing *A. auriculiformis* enormously planted as plantation species because of its wider adaptability in various site conditions (Rahman *et al.* 2018; Islam *et al.* 2013). But, there are no sufficient studies on economic analysis of Akashmoni in strip and block plantations in Bangladesh. Besides, Akashmoni has been blamed for poor undergrowth vegetation as well as pollen allergy, though there is not any scientific report about it. Therefore, the aim of the study is to discuss maximum economic return and rotation period in different age series of Akashmoni plantations in Bangladesh.

II. Materials and Methods

The survey was conducted in May, 2017 to April, 2018 in established existing strip, and block plantations of Akashmoni in two forest divisions of Chittagong (Baroiyahdala National Park, Sitakundu, Ichamoti, Rangunia (Sheikh Rasel Aviry Park), Rauzan, Fashyakhali range, Ukhia, and Chittagong University Campus). From each survey area 3 plantations of 4, 6, 8, 10, 12, and 14 years old were selected subjectively to get economic information.

Analytical method for rotation period and economic return

To determine the economic information the costs of raising seedlings in the nursery, plantation initiation, weeding procedure, gap filling, selection thinning, and overall management cost were collected from the specific forest offices and plantation unit of Institute of Forestry and Environmental Sciences, University of Chittagong (IFESCU). To determine the rotation interval and economic parameters of Akashmoni in strip and block plantations, various indicators such as Net Present Value (NPV), Internal Rate of Return (IRR), Benefit Cost Ratio (BCR), Efficiency Index (EI) and Land Expectation value (Le) for each age group using formulas in Equations 1-3 (Gittinger 1974).

$$\text{NPV (Net Present Value)} = \sum \frac{Rn}{(1+i)\hat{}n} - \sum \frac{Cn}{(1+i)\hat{}n} \quad [1]$$

$$\text{IRR (Internal Rate of Return)} = \sum \frac{Rn}{(1+i)\hat{}n} - \sum \frac{Cn}{(1+i)\hat{}n} = 0 \quad [2]$$

$$\text{Benefit Cost Ratio (BCR)} = \frac{\sum \frac{Rn}{(1+i)\hat{}n}}{\sum \frac{Cn}{(1+i)\hat{}n}} \quad [3]$$

Here, Rn indicates returns every n year, Cn indicates cost every n year, n means number of years, and i indicate the interest rate. Equation 4 (Gunter and Haney, 1984) and Equation 5 (Gunter and Haney, 1984) was also used.

$$EAE = NPV\left[\frac{i(1+i)\hat{}t}{(1+i)^t-1}\right] \quad [4]$$

Where, EAE = Equal Annual Equivalent, NPV = Net Present Value, i = interest rate and t = rotation period, where t= 1, 2, 3…….n.

$$\textbf{Le} = \frac{Yr+Tb\,(1+i)^{r-b}+I\left[\frac{(1+i)^r-1}{i}\right]-Cc\,(1+i)^{r-c}-e\left[\frac{(1+i)^r-1}{i}\right]}{(1+i)^r-1} \quad [5]$$

Here, Y_r = net yield at the age of rotation, T_b = net value of halfway cutting, b = age at which revenue is received, I = annual income, C = net value of halfway cost, c = age at which cost is incurred, e = annual expenses, r = length of rotation, and i = rate of interest as a decimal.

Assumptions

The lending rate of the Bangladesh Bank was used to determine an appropriate discounting rate where the rate remained constant at 13% since 2012 to till now (Tradingeconomics 2015). Thus, it allows discounting all future costs and benefits to the present.

III. Results and Discussion

Economic analysis of *Acacia auriculiformis* in plantations

Both the strip and block plantations were surveyed to get available economic information of Akashmoni. Table 01 shows the NPV, IRR, BCR, EI, Le and two types of EAE value was different for different aged strip plantations.

Table 01. Economic information of Akashmoni strip plantations.

Age(Year)	NPV(Tk)	IRR (%)	BCR	EI (Tk)	Le (Tk)	EAE_{Le}(Tk)	EAE_{NPV}(Tk)
4	232830	24	1.28	0.28	36929	12415	2659
6	144095	27	1.72	0.72	88375	22106	23627
8	186954	37	3.18	2.18	114661	23893	27699
10	457993	41	6.2	5.20	280894	51765	64195
12	435489	36	5.95	4.95	267092	45134	59152
14	452336	33	6.14	5.14	277425	37005	60336

*Here, NPV =Net Present Value, IRR= Internal Rate of Return, BCR= Benefit Cost Ratio, EI= Efficiency Index, Le= Land Expectation Value, EAE= Equal Annual Equivalent; US $ 1.00= Tk. 84.517 in 2018-2019. Source: www.exchangerates.org.uk.

Generally, expenditure with a positive NPV will be representing profitable investment and expenditure with a negative NPV will representing in a net loss. It is seen that almost all the economic parameters are negative at the age of 4 for block plantation (Table 02).

Comparison of Net Present Value (NPV) in strip and block plantations

The maximum NPV (312816 TK.) was found at the age of 14 year old block plantations. It indicates that the rotation age is fixed at 14 years for block plantation (Figure 01). The NPV is always positive for strip plantations since its establishment and it is higher than block plantations in almost every year. Maximum NPV found for strip plantation 457993 (TK) at the age of 10 while, it also indicates that the rotation age is fixed at 10 years for strip plantation. It has been observed that the NPV is negative at the age of 4 for block plantations (Figure 01). Therefore, the fact NPV is negative for 4 years old plantations that the growth is inadequate than the investment cost of operations.

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Table 02. Economic information of Akashmoni block plantations

Age (Year)	NPV (Tk)	IRR (%)	BCR	EI (Tk)	Le (Tk)	EAELe (Tk)	EAENPV (Tk)
4	-27535	-8	0.6	-0.4	-16888	-3378	-9257
6	25518	21	1.33	0.33	12255	2010	6383
8	86900	23	1.51	0.51	32687	20900	18108
10	209523	33	3.67	2.67	61722	11374	38612
12	309363	34	4.94	3.94	71370	12060	52278
14	312816	32	4.98	3.98	56517	8967	496333

*Here, NPV =Net Present Value, IRR= Internal Rate of Return, BCR= Benefit Cost Ratio, EI= Efficiency Index, Le= Land Expectation Value, EAE= Equal Annual Equivalent; US $ 1.00= Tk. 84.517 in 2018-2019. Source: www.exchangerates.org.uk.

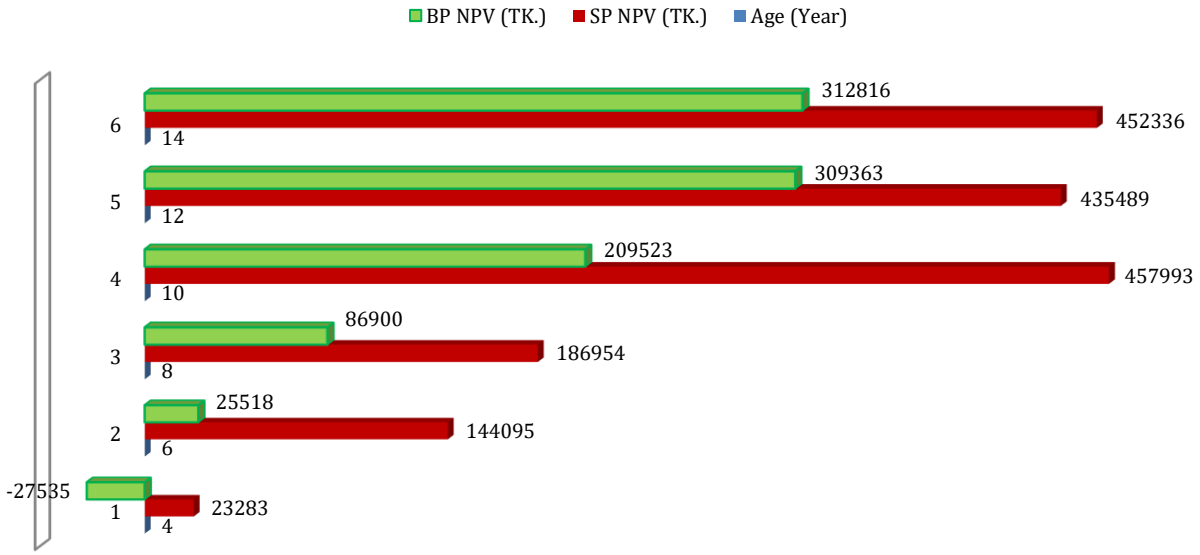

Figure 01. Tree age on Net Present Value (NPV) in Strip Plantations (SP) and Block Plantations (BP).

However, the NPV of akashmoni in strip and block plantation is closely supports the findings of Sarkar *et al.* (2008) except the negative NPV for block plantations. The findings are very different from Kibria *et al.* (2002) where they found the highest NPV (TK. 1157769) for 15 years old plantation. According to Islam *et al.* (2013), a study conducted in akashmoni strip and block plantations in almost all forest divisions of Bangladesh, found that the NPV was negative for the plantation age of 5, 6 and 7 years. Considering only NPV, they found the rotation interval fixed at age 15 years whereas present study is almost similar with their findings.

Comparison of Internal Rate of Return (IRR) in strip and block plantations

For 10 years old strip plantation, the IRR is maximum 41% and minimum (24%) value is found at 4 years old plantation (Figure 02). Besides, IRR value negative (-8%) for 4 year old block plantation and maximum 34% is found at 12 years old plantations. The study reveals that the rotation period on the basis of IRR for strip plantation would be fixed at 10 years. However, for block plantation, the rotation period would be best at 12 years. Result of present study is an agreement with the findings of Sarkar *et al.* (2008). According to Islam *et al.* (2013), the maximum IRR was found at 13 years old Akashmoni plantations and it seems very close to present findings. On the other hand, current IRR study does not match with the results of Kibria *et al.* (2002).

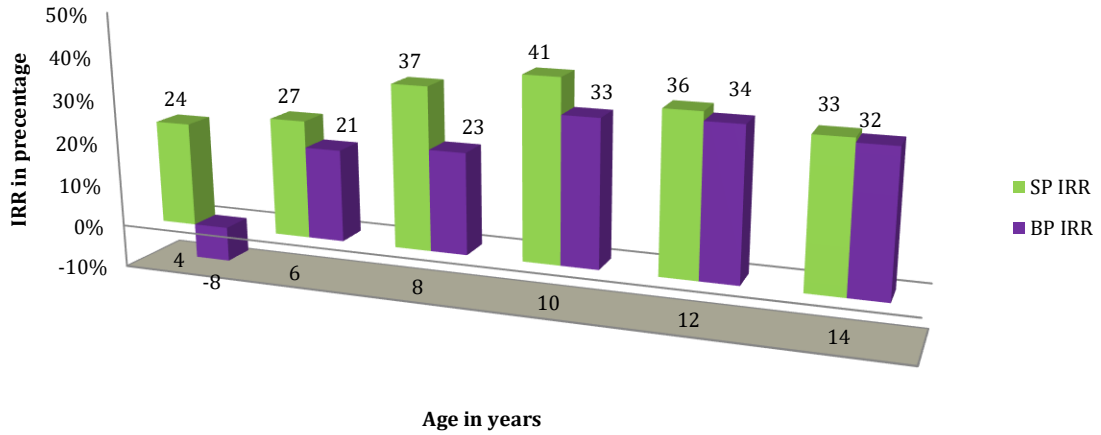

Figure 02. Tree age on Internal Rate of Return (IRR) in Strip Plantations (SP) and Block Plantations (BP).

Comparison of Benefit Cost Ratio (BCR) in strip and block plantations

The study revealed economic analysis of BCRs in strip and block plantation of Akashmoni at different ages (Figure 03). The study found that the maximum BCR (6.2) and EI (Tk 5.2) are found for strip plantation at age of 10 years. On the other hand, for block plantation maximum BCR (4.98) and EI (Tk 3.98) is found for strip plantation at 14 years. However, both the plantation practices are profitable (BCR>1.00) except only for 4 years old block plantation (BCR=0.6). In such case, if BCR is considered, than the rotation period would be fixed at age 10 years and 14 years for strip and block plantations respectively. Sarkar *et al.* (2008) found maximum BCR (3.09) for 10 years old strip plantations. In contrary, present study revealed almost double (BCR 6.20) in same aged plantations where, similarity is found for block plantation only.

However, Islam *et al.* (2013) found BCR 5.81 and 5.92 at the age of 10 and 14 years akashmoni plantation respectively where the present finding is very close to their results. Moreover, Kibria *et al.* (2002) revealed benefit cost ratio (6.51) and Efficiency Index (Tk 5.11) at the age of 17 years which is not accepted by the current findings.

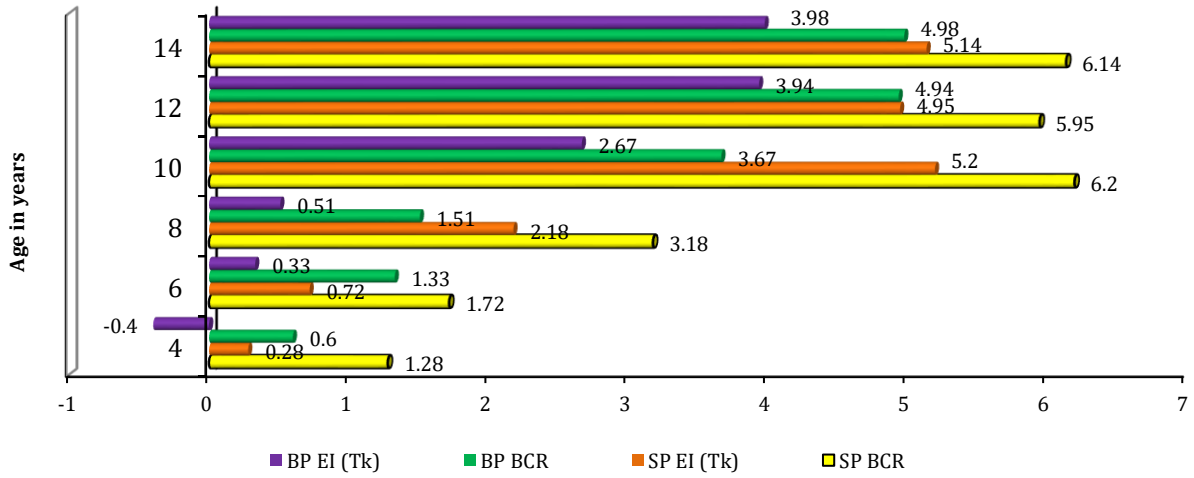

Figure 03. Tree age on Benefit Cost Ratio (BCR) and Efficiency Index (EI) in Strip Plantations (SP) and Block Plantations (BP).

Comparison of Land expectation value (Le) in strip and block plantations

Highest Land Expectation value (Le) was found in 10 years old strip plantation (2,80,894 Tk) and the lowest (36,929 Tk) is recorded in 4 year old plantations (Figure 04). Besides, Le is maximum (71,370 Tk) for block plantation at the age of 12 year and the lowest one is in the plantation of 4 year (-16,888 Tk). However, if we want to find out the rotation age on the basis of Land Expectation Value (Le) then it will be confirmed at 10 year for strip plantations and 12 year for block plantations. According to Islam *et al.* (2013) Le was maximum (41,6471 Tk) for 13 years akashmoni plantation in Bangladesh which is reversely correlated with present

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study. Besides, Sarkar *et al.* (2008) revealed that the Le was maximum (2,85,252 Tk) for 10 years strip plantation and strongly supports the results of present study. Kibria *et al.* (2002) found the Le value was 4,16,471 Tk for 13 years old plantation and is closely related to present findings.

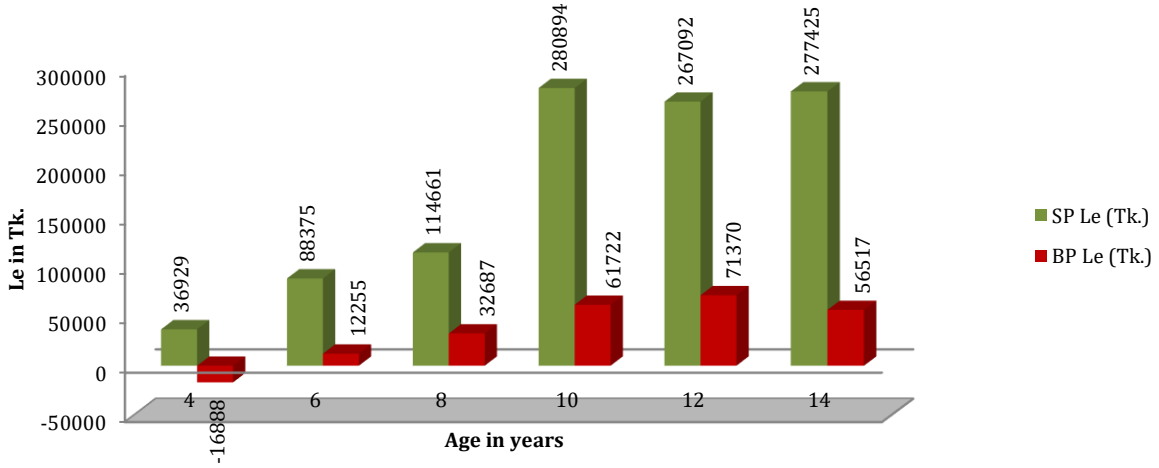

Figure 04. Tree age on Land Expectation Value (Le) under Strip Plantations (SP) and Block Plantations (BP).

Comparison of Equal Annual Equivalent (EAE_{Le} and EAE_{NPV}) in strip and block plantations

The study revealed that the highest EAE_{Le} (51,765 Tk) for 10 years old strip plantation and highest 20,900 Tk for 8 year old block plantations (Figure 05).On the other hand, EAE_{NPV} showed best (64,195 Tk) at the age of 10 year for strip plantation. Where, the value is maximum (52,278 Tk) at the age of 12 year for block plantation. Results of Islam *et al.* (2013) is close to present study, where they found highest EAE_{Le} (59,003 Tk) at 10 years Akashmoni plantation in Bangladesh. In contrast, they revealed the EAE_{NPV} is maximum (1,52,216 Tk) at 15 years old plantation which is totally different from current findings.

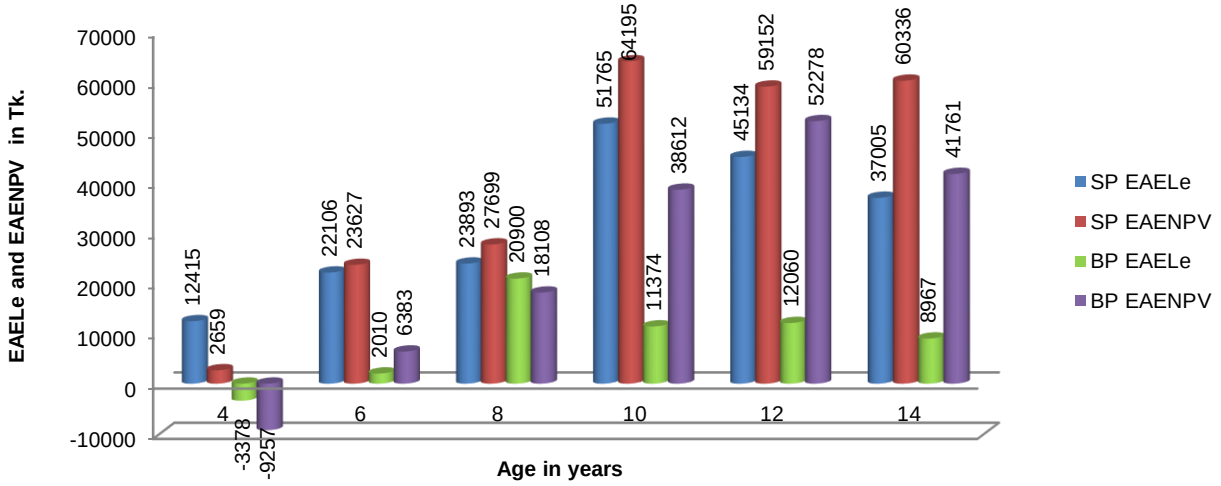

Figure 05. Tree age on Equal Annual Equivalent based on Le (EAE_{Le}) and Equal Annual Equivalent based on NPV (EAE_{NPV}) in Strip Plantations (SP) and Block Plantations (BP).

IV. Conclusion

With increased deforestation rate, huge amount of barren areas are available for plantation programme where people of our country not concerned about how to manage such infertile lands economically. Nowadays, *A. auriculiformis* is planted massively in some of the hilly and unproductive areas to get quick returns of investment. In general, strip plantation is the best option in comparison to block plantation. It was also clear that no single method of analysis could be considered to determine the rotation interval, as this parameter depends on the objectives of the study. Under the present forestry management system, considering the economic criteria, the rotation interval of akashmoni species in Bangladesh should be fixed at 10 years and 12 to 14 years for strip and block plantation respectively. Question is that whether we should plant hundreds of species in reforestations programmes or to concentrate on research work to find a few main plantation species? It is also recommendable that instead of keeping the vast lands barren or treeless,

Akashmoni can be used for plantations as it provides goods and economic benefits to the society in diverse way. However, same aspect of economical return for other fast growing species should be evaluated quickly.

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