Incident photosynthetically active radiation under and outside the canopy of *Acacia nilotica* (Linn.) for agroforestry system

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**Abstract**

The important factor to be considered in biomass production is the maximum light use efficiency. The capture of radiation and its use in dry matter production depends on the fraction of the incident photosynthetically active radiation (PAR). An experiment was conducted in the campus of Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola, Maharashtra during 2018-2019 with the objective to study microclimatic effect under Babul (*Acacia nilotica* L.) for checking the suitability of Babul to match the under story agricultural crops and pasture grasses on the basis of microclimatic parameters recorded under and outside the canopy of Babul. Collected data were statistically analyzed with descriptive statistics by calculating mean and standard deviation. Observations on microclimatic parameters Photosynthetically active radiation were recorded from October to December (Rabi Season). Observations were recorded under and outside the canopy of Babul by selecting ten trees from the 15x15 m plot of Babul plantation site and data were recorded during (9 am, 2pm, and 4pm) in a day by weekly intervals for three months. The results revealed that the microclimatic parameter such as photosynthetically active radiation (PAR) showed lower values under the canopy and higher value outside the canopy, and from West and South direction highest PAR was recorded. In comparison, average PAR values under the canopy from all the three months were lower for the outside canopy PAR value. On the basis of this farmer can chose the suitable understory agricultural crops and pasture grasses.

**Keywords:** Microclimate, photosynthetically active radiation, canopy

**Introduction**

Agroforestry as the land use system that integrates tree crops and animals in a way that, scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farming communities. In this way agroforestry may be defined as the concurrent use of land for agriculture, forestry, horticulture and also for raising livestock. It represents the optimum use of land (Negi 1999) [4]. Agroforestry plays an important role to overcome the problems of global climatic change and also it reduces the pressure on natural forest. Vidarbha region of Maharashtra categories into three eco-zones mainly eastern, western and central Vidarbha zone. The area of Akola district falls under western part of Vidarbha region of Maharashtra. As our study concern with Vidarbha region the information about different agroforestry system should be known. Farmers in Vidarbha region practicing different agroforestry system in their field namely: bund plantation, boundary planting, agri-silviculture, horti-silviculture, agro-silvopastural, agri-horti-silviculture, plantation along irrigation canal, kitchen garden, plantation near water resources, block plantation and scattered plantation (Arpit Deshmukh et al., 2016) [2]. An important effect of tree in agroforestry system is the modification of the microclimate for annual crop or livestock (Ong et al., 2000) [5]. Compare to an open environment the modified microclimate under trees is characterized by reduced solar radiation, more moderate temperature regime, higher humidity, lower rate of crop transpiration and higher soil moisture level (Singh et al., 2012) [6].

*Acacia nilotica* (L.) commonly known as Babul has been recognized worldwide as a multipurpose tree. It grows about 15-18 m in height and grows under climatic conditions ranging from sub-tropical to tropical (Bargail and Bargail, 2009) [3]. It is a relatively fast growing, drought resistant multipurpose leguminous with the ability of biological nitrogen fixation and can intensively exploit soil column for nutrients and moisture.
This species has been considered as one of the fast-growing species of the wastelands and agroforestry systems throughout India providing strong timber, fodder for goats and sheep and high-quality fuel wood apart from enriching the soil with nitrogen (Bargil and Bargil, 2007).

Materials and methods
Study was conducted in the campus of Dr. Panjabrao Deshmukh Krishi Vidyapeeth Akola. Akola is situated in subtropical region between 22° 42’ N latitude and 77° 02’ E longitudes. The altitude of the place is 304.42 m above mean sea level. Climate of Akola is semi-arid and characterized by three distinct seasons viz., hot and dry summer from March to May, warm humid rainy season from June to October and mild cold winter from November to February. Average annual precipitation on the basis of last fifteen years is 515.8 mm. Study was conducted in the campus, Dr. PDKV, Akola. Results obtained from investigations are discussed below.

Photosynthetically active radiation
Weekly averages of PAR recorded during 9:00 am, 2:00 pm, 4:00 pm (Appendix I) and percentage availability of PAR values were given in Table 1. From recorded data it was observed that among all the four direction, West and South direction has recorded same PAR value (144 µmol m$^{-2}$ s$^{-1}$) and East direction has lowest PAR (133 µmol m$^{-2}$ s$^{-1}$) followed by North direction (134 µmol m$^{-2}$ s$^{-1}$). Average PAR in all the direction under canopy was highest in 8th week (190 µmol m$^{-2}$ s$^{-1}$) followed by 2nd week (157µmol m$^{-2}$ s$^{-1}$) and lowest in 11th week (112 µmol m$^{-2}$ s$^{-1}$) followed by 12th week (115 µmol m$^{-2}$ s$^{-1}$). PAR outside the canopy was highest in 1st week (428 µmol m$^{-2}$ s$^{-1}$) followed by 2nd week (369 µmol m$^{-2}$ s$^{-1}$) and lowest in 4th week (155 µmol m$^{-2}$ s$^{-1}$).

Table 1: Average PAR (µmol m$^{-2}$ s$^{-1}$) recorded in a day/week under and outside the canopy of Acacia nilotica (Linn.) during October to December

| Month | PAR under the tree canopy (µmol m$^{-2}$ s$^{-1}$) | PAR outside the canopy | Percent availability of PAR under canopy |
|-------|---------------------------------------------|------------------------|-----------------------------------------|
|       | East  | West  | North | South | Mean | Outside |                     |
| Oct   |       |       |       |       |      |         |                     |
| Week 1 | 125   | 153   | 153   | 155   | 147  | 428     | 32.50                |
| Week 2 | 155   | 166   | 170   | 164   | 157  | 369     | 42.67                |
| Week 3 | 138   | 127   | 122   | 136   | 130  | 287     | 45.37                |
| Week 4 | 129   | 139   | 145   | 148   | 140  | 155     | 90.72                |
| Nov   |       |       |       |       |      |         |                     |
| Week 5 | 146   | 158   | 139   | 153   | 149  | 326     | 45.85                |
| Week 6 | 145   | 141   | 125   | 148   | 140  | 356     | 39.28                |
| Week 7 | 140   | 148   | 121   | 140   | 138  | 169     | 81.63                |
| Week 8 | 169   | 194   | 189   | 207   | 190  | 222     | 85.65                |
| Dec   |       |       |       |       |      |         |                     |
| Week 9 | 126   | 167   | 124   | 136   | 138  | 277     | 46.58                |
| Week 10 | 119   | 116   | 112   | 122   | 120  | 258     | 46.58                |
| Week 11 | 113   | 112   | 111   | 112   | 112  | 222     | 50.64                |
| Week 12 | 115   | 118   | 112   | 117   | 115  | 263     | 43.96                |
| Week 13 | 111   | 127   | 120   | 127   | 122  | 198     | 61.44                |
| Mean   | 133   | 144   | 134   | 144   | 138  | 239     | 54.80                |
| SD     | 17.5  | 24.0  | 24.2  | 24.6  | 20.6  | 53.0    | 18.90                |
| Min    | 111   | 112   | 111   | 112   | 112  | 155     | 32.50                |
| Max    | 169   | 194   | 189   | 207   | 190  | 428     | 90.70                |

The percentage availability of PAR under canopy in comparison to outside canopy was highest in 4th week (90.7%) and lowest in 1st week (32.5%) with average percent availability of 54.8%. The data in Table 1 were represented graphically in Fig.1.
Overall behavior of photosynthetically active radiation under and outside *Acacia nilotica* (Linn.)

Average PAR recorded during October to December months were showed in table 2. Average monthly PAR under tree canopy ranged from 121 µmol m\(^{-2}\) s\(^{-1}\) to 154 µmol m\(^{-2}\) s\(^{-1}\) with a mean PAR value (140.1 µmol m\(^{-2}\) s\(^{-1}\)). South direction had recorded highest average PAR (162 µmol m\(^{-2}\) s\(^{-1}\)) in November and lowest PAR value (116 µmol m\(^{-2}\) s\(^{-1}\)) was recorded in North direction in December.

Table 2: Overall behavior of PAR under and outside the canopy of *Acacia nilotica* (Linn.) trees recorded during October to December

| Months | Photosynthetically active radiation (PAR) under tree canopy (µmol m\(^{-2}\) s\(^{-1}\)) | PAR outside tree canopy (µmol m\(^{-2}\) s\(^{-1}\)) |
|--------|-----------------------------------------------------------------------------------|--------------------------------------------------|
| Oct    | East: 137  West: 146.6  North: 148.1  South: 151.3  Average: 143.9 | PAR outside tree canopy (µmol m\(^{-2}\) s\(^{-1}\)) |
| Nov    | East: 150  West: 160.8  North: 144.0  South: 162.7  Average: 154.6 | 316.2 |
| Dec    | East: 117.4  West: 128.5  North: 116.5  South: 123.3  Average: 121.9 | 248.2 |
| mean   | East: 135.0  West: 145.3  North: 136.2  South: 145.8  Average: 140.1 | 277.6 |
| SD     | East: 16.6  West: 16.1  North: 17.1  South: 20.2  Average: 16.6 | 34.70 |
| min    | East: 117.4  West: 128.5  North: 116.5  South: 123.3  Average: 121.9 | 248.2 |
| Max    | East: 150.5  West: 160.8  North: 148.1  South: 162.7  Average: 154.6 | 316 |

In comparison, monthly PAR value (316 µmol m\(^{-2}\) s\(^{-1}\)) outside the tree canopy control was higher in the month of October whereas under canopy PAR value (154 µmol m\(^{-2}\) s\(^{-1}\)) was higher in November. Average PAR value (140.1 µmol m\(^{-2}\) s\(^{-1}\)) under tree canopy recorded during all three months was less than that of outside canopy PAR (277 µmol m\(^{-2}\) s\(^{-1}\)). It may be due to the canopy spread of tress which restricts the entry of photosynthetically active radiation to pass below the crown. Alados et al., (1996) observed that the highest value is for summer months, while in winter value were lower and more variable. The effect of sky conditions has been studied using different ratios of broadband solar radiation the more influencing factor is the presence of cloud that could be evaluated using ratios of solar broadband radiation.

Appendix-I

Table 3: Average PAR recorded under and outside canopies of *Acacia nilotica* (Linn.) at different intervals during October to November

| Week no. | E  | W  | N  | S  | Mean | E  | W  | N  | S  | Mean | E  | W  | N  | S  | Mean |
|----------|----|----|----|----|------|----|----|----|----|------|----|----|----|----|------|
| W 1      | 110| 128| 134| 150|131   | 230| 135| 167| 148|148   | 292| 131| 164| 177|167   |
| W 2      | 174| 189| 187| 156|156   | 390| 156| 164| 177|187   | 212| 136| 145| 146|149   |
| W 3      | 140| 121| 105| 131|124   | 152| 144| 131| 129|145   | 353| 129| 127| 132|133   |
| W 4      | 122| 139| 138| 154|138   | 143| 160| 149| 163|143   | 154| 104| 129| 136|148   |
| W 5      | 140| 128| 109| 132|127   | 130| 179| 197| 174|187   | 370| 119| 147| 135|141   |
| W 6      | 140| 110| 104| 113|113   | 176| 177| 181| 174|199   | 665| 117| 132| 101|142   |
| W 7      | 123| 124| 104| 123|121   | 220| 179| 189| 145|176   | 153| 118| 132| 113|122   |
| W 8      | 124| 147| 136| 152|139   | 105| 270| 308| 308|338   | 346| 114| 128| 125|132   |
| W 9      | 112| 129| 106| 145|123   | 247| 158| 157| 149|141   | 296| 110| 216| 118|122   |
| W 10     | 113| 108| 114| 108|108   | 236| 127| 128| 127|135   | 312| 118| 112| 113|116   |
| W 11     | 105| 107| 99 | 99 |103   | 213| 123| 114| 126|120   | 263| 112| 115| 109|118   |
| W 12     | 107| 109| 107| 108|107   | 236| 120| 127| 119|122   | 302| 116| 117| 113|123   |
| W 13     | 111| 125| 119| 133|122   | 213| 114| 129| 134|125   | 168| 110| 129| 108|124   |
| Mean     | 120.0|122.9|111.8|126.7|120.5 | 191.9| 161.2| 168.4|162.3|169   | 165| 303| 118.5|138|125.2 |

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Conclusion

The study showed that the influence and effect of microclimatic factors changes seasonally so that according to this changes understory crop can be introduced. On the basis of total amount of PAR under the canopy of babul, farmers can check the suitability of this tree for raising the agriculture crops and pasture grasses in agroforestry system. The suitable agricultural crops and pasture grasses which will withstands with the recorded microclimatic conditions under Babul can be select by the farmers. This study will help the farmers to overcome the failures of agroforestry system and increase the overall production of the farmers also the off seasons crops can be grown as the microclimate under the tree is varied from microclimate outside the trees canopy.

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