Performance of cowpea (Vigna unguiculata) under mandarin based agroforestry systems in Vidarbha region of Maharashtra

Aarti P. Deshmukh1, Lalji Singh1 and V.M. Ilorkar2

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ABSTRACT: Traditional agroforestry is very common in Vidarbha region of Maharashtra with tree species. Now fruit tree crops are also introduced in farm land to increase the farmer’s income. Hence, the experiment was conducted at AICRP on Agroforestry research farm at College of Agriculture, Nagpur, Maharashtra under citrus (mandarin) based agroforestry systems. The citrus fruit trees were planted at a distance of 6 m and tree species including Tectona grandis, Eucalyptus tereticornis and Ailanthus excelsa were planted during 2015-16 at equilateral distance of 3 m in each treatment between two mandarin trees, where, cowpea crop (Vigna unguiculata var. Gomati) was cultivated as intercrop under the traditional agri-horti-silviculture system during 2020-21. The growth performance and yield of cowpea under different set of treatments viz., T1 (sole cowpea), T2 (sole Mandarin + cowpea), T3 (mandarin + T. grandis + cowpea), T4 (mandarin + E. tereticornis + cowpea) and T5 (mandarin + A. excelsa + cowpea) were recorded. The growth parameter and yield of cowpea crop was found maximum in open field (sole cowpea) than the treatments under citrus based agroforestry systems and it was 25.57, 56.35, 44.00 and 63.12% higher as compared to T3, T5, T4 and T1, respectively. The grain and straw yield of cowpea was 0.57 and 1.13 t ha⁻¹ in crop of open field (sole cowpea). As regard the soil fertility, the most important parameter i.e. the organic carbon was significantly increased in sole cropping (0.37), sole mandarin (0.53) and mandarin + A. excelsa (0.49), Whereas, it was decreased under mandarin + T. grandis (0.48), and mandarin + E. tereticornis (0.44) after the harvesting of kharif cowpea crop.

1. INTRODUCTION

Agroforestry is a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible, and socially acceptable to the farmers (Nair, 1993). Agroforestry systems can be advantageous over conventional agricultural and forest production methods through increased productivity, economic benefits, social outcomes and the ecological goods and services provided.

Lesser availability of land, low returns from traditional crops and the ever-increasing demand for fuel, fodder, timber, etc. are the reasons that compel farmers to integrate multipurpose tree species on their farmland. Also intercropping provides certain environmental benefits and enriches the soil through nutrient pumping from deep profile, return of litter and reduces soil erosion. It is well recognized that agroforestry is one among the few options that can successfully address food security, poverty reduction and environmental protection. It is a key path to prosperity of the farmers and a mean to address the changing climate issue. Current et al. (1995) reviewed 56 agroforestry practices in eight countries and found that a majority was profitable and in 40% of cases, financial returns were at least 25% higher than alternative farming systems (Chauhan et al., 2012). Keeping this in view, an investigation was carried out to study the performance of cowpea (Vigna unguiculata) under citrus based agroforestry systems in Vidarbha region of Maharashtra.

2. MATERIALS AND METHODS

The study was conducted on AICRP on Agroforestry farm having loam soil of Nagpur district of Maharashtra. The selected level field of 0.29 ha in which horti-silviculture-system including Mandarin, Tectona grandis, Eucalyptus tereticornis and Ailanthus excelsa planted during 2015 was selected. The experiment was laid out in Randomized Block Design (RBD) with four replications. The size of unit plot was 6 m × 6 m. The mandarin was planted at a distance of 6 m, whereas the tree species were planted at a distance of 3 m between two mandarin plantations.

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ARTICLE INFO

Received: 04.09.2021
Accepted: 05.12.2021

Keywords:
Agroforestry system
Citrus
Cowpea
Mandarin

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Cowpea (V. unguiculata) variety (Gomati) was cultivated as per recommended package and practices in kharif season. The treatment includes sole mandarin + cowpea (T1), mandarin + Tectona grandis + cowpea (T2), mandarin + Eucalyptus tereticornis + cowpea (T3), mandarin + Ailanthus excels + cowpea (T4), while sole cowpea (T5) without trees were laid down to assess the growth and yield performances of cowpea under different agroforestry systems as affected by microclimatic condition available to cowpea at different growth stages. The observations were made for plant population (m²), height of plant (cm), number of branches plant⁻¹, number of siliqua plant⁻¹, seed siliqua⁻¹, length of siliqua (cm), grain yield (t ha⁻¹), straw yield (t ha⁻¹), harvest index (%), test weight (g) 1000 seed⁻¹, fresh weight (kg m⁻²), dry weight (kg m⁻²), fresh root weight plant⁻¹ (g) and root length (cm). The dry weight of sample was estimated after drying of sample at 75°C for 24 hours. The microclimate observation i.e. solar radiation, atmospheric temperature, humidity was recorded at different growth period by wind LICOR -photo meter, digital thermometer and hygrometer at 9.00 to 10.00, 12.00 to 13.00 and 15.00 to 16.00 hours in each replication of the treatments during crop period.

The soil of the experimental area was collected at a depth of 20 cm and analyzed for organic carbon, pH, electrical conductivity (EC), available nitrogen (N), available phosphorus (P) and available potassium (K) before and after harvesting of cowpea crop as per standard methods of Jackson (1957), Piper (1967), Olsen et al. (1954) and AOAC (2002).

3. RESULTS AND DISCUSSION

Plant population

The maximum average plant population of cowpea (27 m²) was recorded under sole cropping, followed by sole mandarin (26.25 m²) based agroforestry system (Table 1). Whereas, the minimum plant population (24.75 m²) was recorded under mandarin + A. excelsa based agroforestry system. No significant differences in plant population were found amongst different agroforestry system. Rahangdale et al. (2014) recorded highest reduction in plant population in soybean (21.61%) and the lowest in paddy (12.35%). They also noticed that the moong and sesame showed the almost similar trend of yield reduction (16.06 and 17.63%, respectively) under bamboo based agri-silviculture system over the control that is sole crop.

Height

No significant difference was observed as regards to plant height of cowpea at 30, 60 and 90 DAS (Table 1). However, maximum plant height i.e. 35.66, 95.78 and 147.50 cm at 30, 60 and 90 DAS of cowpea was recorded in sole cropping as compared to different agroforestry systems. Amongst different citrus based agroforestry systems, maximum plant height was recorded in sole mandarin. The lowest height of cowpea was recorded under mandarin + A. excelsa agroforestry systems i.e. 29.40, 86.17 and 119.50 cm at 30, 60 and 90 days after sowing (DAS) of cowpea. Rahangdale et al. (2014) also recorded reduction in plant height of paddy (3.90%) and sesame (2.84%) as compared to soybean (8.83 %) and moong (7.57%) under bamboo based agri-silviculture system over control (sole crop) which may be due to the fact that bamboo canopy could have even affected the proper penetration of light on the understory annual crop.

Number of branches

Significant differences in number of branches plant⁻¹ of cowpea were observed under different agroforestry systems (Table 1). Significantly higher number of branches of cowpea was recorded at 30 DAS (6.48), 60 DAS (15.50) and 90 DAS (22.33) under sole cowpea cropping, followed by sole mandarin. Whereas, lowest number of branches plant⁻¹ was recorded under mandarin + A. excelsa agroforestry system in 30, 60 and 90 DAS of cowpea. Rahangdale et al. (2014) noticed that among kharif crop, highest reduction in soybean (33.66%) for number of branches and the lowest was in paddy (23.75%) for number of effective tillers plant⁻¹. They also observed that moong and sesame showed the almost similar trend of reduction (31.32 and 30.41%, respectively) for number of branches plant⁻¹ under bamboo based agri-silviculture system over control (sole crop).

Number of leaves

Significant differences were observed in number of leaves plant⁻¹ of cowpea at 30 DAS (Table 1). The highest number of leaves was observed when cowpea was sown as sole crop (19.83). Whereas lowest was recorded in mandarin + A. excelsa (16.33). No significant differences were observed as regards to number of leaves plant⁻¹ of cowpea under different agroforestry systems. Kumar and Nandal (2004) found that the entire test crop sown in the interspaces of E. tereticornis showed reduced plant vigour in terms of plant height, stem diameter, number of branches, number of leaves and yield attributes as compared to sole cropping.

Number of siliqua plant⁻¹

Results revealed that there were no significant differences as regards to number of siliqua plant⁻¹ amongst different treatments (Table 1). However, maximum number of siliqua plant⁻¹ was recorded under sole cropping in cowpea (37.28). The lowest siliqua plant⁻¹ was recorded under mandarin + A. excelsa agroforestry system (27.80). The number of siliqua plant⁻¹ was highest under sole cropping as
compared to sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa agroforestry systems, which may be due to competition of light among the annuals and perennials. Kumar et al. (2013) studied the performance of wheat and mustard under E. tereticornis based agri-silviculture systems and found that parameters such as plant running meter row lay (161.7), spike length (7.7 cm), grains spike\(^{-1}\) (37.7) and test weight (26.7 g) was significantly less under E. tereticornis than sole cropping. In mustard, seeds siliqua\(^{-1}\) was less under E. tereticornis than sole cropping. Yield parameter such as secondary siliqua plant\(^{-1}\) and test weight was also significantly higher in sole cropping.

**Seed siliqua\(^{-1}\)**

As regards to number of seed siliqua\(^{-1}\), maximum seed siliqua\(^{-1}\) (Table 1) was recorded under sole cropping (19.25). Whereas, lowest seeds siliqua\(^{-1}\) was recorded under mandarin + A. excelsa agroforestry system (13.39). The per cent reduction in seed siliqua\(^{-1}\) was 10.34, 25.25, 14.75 and 30.44 in cowpea under sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa, respectively as compared to sole cropping of cowpea. The yield attributing parameter i.e. seed siliqua\(^{-1}\) of cowpea was highest under sole cropping as compared to other citrus based agroforestry systems, may be due to competition for light among the annuals and perennials. These results are in conformity with the findings of Rana et al. (2007) and Verma and Rana (2014) who witnessed a yield reduction in paddy and wheat (14.9 and 29.7%, respectively) under agroforestry system as compared to sole cropping. Dev et al. (2017) noticed that during 5th year of plantation, 12.6, 11.6, 6.48 and 0.3% reduction in number of capsules plant\(^{-1}\) were observed at a distance of 1.0, 2.0, 3.0 and 4.0 m, respectively from the clump in both the spacing of bamboo (M1: 10 m × 10 m and M2: 10 m × 12 m) as compared to pure crop. The number of seeds capsule\(^{-1}\) was 7.41 and 3.6% less in intercropped sesame between bamboo spacing M1: 10 m × 10 m and M2: 10 m × 12 m, respectively as compared to sole crop.

**Grain and straw yield (t ha\(^{-1}\))**

It was observed that due to the competition for moisture, light and nutrients among the annual crops, trees and fruit plants, the observed values for different yield parameters under different citrus based agroforestry systems were lesser than the sole cropping. From the results (Table 2) it was observed that maximum grain and straw yield of cowpea was recorded under sole cropping (0.57 and 1.13 t ha\(^{-1}\)). Whereas, lowest was recorded under mandarin + A. excelsa i.e. 0.21 and 0.46 t ha\(^{-1}\). Grain yield under sole cowpea cropping was 25.57, 56.35, 44.00 and 63.12% higher as compared to sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa, respectively. This may be due to competition for light among the annuals and perennials. Highest harvest index of cowpea intercrop was under sole cropping. Whereas, lowest harvest index was recorded under mandarin + A. excelsa agroforestry systems (31.65).

In cowpea the harvest index under sole cropping was 4.02, 1.64, 0.98 and 5.60% higher as compared to sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa, respectively. Rahangdale et al. (2014) recorded that soybean (67.88%) and moong (61.30%) showed relatively higher reduction in grain and straw yield as compared to sesame (49.25%) and paddy (34.00%) under old bamboo based agri-silviculture system over the sole crops and this reduction in grain yield may be due to less PAR (Photosynthesis active radiation) interception and available energy below the canopy of bamboo species in comparison to sole crop (open condition). These results are also in conformity with the findings of Kaushik et al. (2002), Kiran et al. (2002), Swamy et al. (2003), Yadav et al. (2005) and Bijalwan et al. (2009).

**Test weight (g) 1000 seed\(^{-1}\)**

Test weight of cowpea was significantly higher (84.75 g) as compared to other citrus based agroforestry systems (Table 2). Whereas, the different citrus based agroforestry systems were at par with each other. It was observed that the test weight of cowpea in sole cropping was 2.65, 5.04, 3.35 and 5.60% higher than sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa. Johar et al. (2017) studied the effect of E. tereticornis based agri-silvicultural system on growth and yield of wheat and reported that the test weight of wheat was...
Table 1. Effect of tree crops on plant population, height of plant, number of branches, number of leaves, number of siliqua, seed siliqua and length of siliqua of cowpea under different citrus based agroforestry systems.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant population (m⁻²)</th>
<th>Height of plant (cm)</th>
<th>Number of branches plant⁻¹</th>
<th>Number of leaves plant⁻¹</th>
<th>No. of siliqua plant⁻¹</th>
<th>Seed siliqua (g)</th>
<th>Length of siliqua (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>60 DAS</td>
<td>90 DAS</td>
<td>30 DAS</td>
<td>60 DAS</td>
<td>90 DAS</td>
<td>30 DAS</td>
</tr>
<tr>
<td>Sole cropping</td>
<td>27.00</td>
<td>35.66</td>
<td>95.78</td>
<td>147.50</td>
<td>6.48</td>
<td>15.50</td>
<td>22.33</td>
</tr>
<tr>
<td>Sole mandarin</td>
<td>26.25</td>
<td>34.18</td>
<td>93.00</td>
<td>142.00</td>
<td>6.31</td>
<td>14.66</td>
<td>21.65</td>
</tr>
<tr>
<td>Mandarin + T. grandis</td>
<td>25.00</td>
<td>29.99</td>
<td>88.91</td>
<td>129.00</td>
<td>5.90</td>
<td>13.33</td>
<td>19.58</td>
</tr>
<tr>
<td>Mandarin + E. tereticornis</td>
<td>25.50</td>
<td>33.16</td>
<td>92.02</td>
<td>136.00</td>
<td>6.23</td>
<td>14.16</td>
<td>20.67</td>
</tr>
<tr>
<td>Mandarin + A. excelsa</td>
<td>24.75</td>
<td>29.40</td>
<td>86.17</td>
<td>119.50</td>
<td>5.84</td>
<td>12.33</td>
<td>18.67</td>
</tr>
<tr>
<td>S. Em. (±)</td>
<td>1.32</td>
<td>5.14</td>
<td>4.07</td>
<td>12.72</td>
<td>0.43</td>
<td>0.60</td>
<td>1.03</td>
</tr>
<tr>
<td>LSD₀.₀₅</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>1.34</td>
<td>1.86</td>
<td>3.19</td>
</tr>
</tbody>
</table>

Table 2. Effect of tree crops on grain yield, straw yield, harvest index, test weight (g) 1000 seed⁻¹, fresh weight, dry weight, fresh root weight plant⁻¹ and root length cowpea under citrus based different agroforestry systems.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Straw yield (t ha⁻¹)</th>
<th>Harvest index (%)</th>
<th>Test weight (g) 1000 seed⁻¹</th>
<th>Fresh weight (kg m⁻²)</th>
<th>Dry weight (kg m⁻²)</th>
<th>Fresh root weight plant⁻¹ (g)</th>
<th>Root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sole cropping</td>
<td>0.57</td>
<td>1.13</td>
<td>33.56</td>
<td>84.75</td>
<td>1.36</td>
<td>0.62</td>
<td>17.73</td>
<td>21.36</td>
</tr>
<tr>
<td>Sole mandarin</td>
<td>0.42</td>
<td>0.86</td>
<td>33.20</td>
<td>82.50</td>
<td>1.07</td>
<td>0.32</td>
<td>15.25</td>
<td>16.58</td>
</tr>
<tr>
<td>Mandarin + T. grandis</td>
<td>0.25</td>
<td>0.52</td>
<td>32.18</td>
<td>80.50</td>
<td>0.93</td>
<td>0.26</td>
<td>12.65</td>
<td>12.66</td>
</tr>
<tr>
<td>Mandarin + E. tereticornis</td>
<td>0.32</td>
<td>0.65</td>
<td>32.99</td>
<td>81.75</td>
<td>1.07</td>
<td>0.29</td>
<td>14.03</td>
<td>15.71</td>
</tr>
<tr>
<td>Mandarin + A. excelsa</td>
<td>0.21</td>
<td>0.46</td>
<td>31.65</td>
<td>80.00</td>
<td>0.80</td>
<td>0.23</td>
<td>10.84</td>
<td>11.21</td>
</tr>
<tr>
<td>S. Em. (±)</td>
<td>0.08</td>
<td>0.15</td>
<td>0.82</td>
<td>1.15</td>
<td>0.46</td>
<td>0.32</td>
<td>1.25</td>
<td>2.07</td>
</tr>
<tr>
<td>LSD₀.₀₅</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>3.54</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>6.40</td>
</tr>
</tbody>
</table>
significantly reduced under kinnon + wheat (46.1 g) and kinnon + Euclayptus + wheat (42.3 g) agroforestry model as compared to sole cropping (47.2 g).

**Fresh weight, dry weight, fresh root weight and root length of cowpea**

From the result (Table 2) it revealed that the fresh and dry weight of cowpea was not significantly affected by different agroforestry systems. The highest fresh and dry weight of cowpea was recorded under sole cropping i.e. 1.36 and 0.62 kg m⁻², respectively. It was also observed that the fresh and dry weight of cowpea was 20.99, 31.86, 21.54 and 41.06 and 48.38, 58.06, 53.22 and 62.90% higher under sole cropping as compared to sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa, respectively. As regards fresh root weight plant⁻¹, there is no significant difference amongst the different agroforestry systems in cowpea. However, highest fresh root weight plant⁻¹ in cowpea were recorded under sole cropping i.e. 17.73 g, whereas, lowest was recorded under mandarin + A. excelsa agroforestry systems (10.84 g plant⁻¹) in cowpea. The agroforestry systems significantly affected the root length of cowpea. Significantly highest root length (21.36 cm) was recorded under sole cropping, and lowest was recorded under mandarin + A. excelsa (11.21 cm). The root length was at par with each other under all agroforestry systems, except sole cropping. Sharma et al. (2012) studied the dry matter accumulation pattern of wheat grown as intercropped with 3 and 4 years old poplar boundary plantation under irrigated conditions. They observed that the dry matter accumulation declined considerably due to presence of poplar tree line during all the stages of crop growth as compared to sole crop.

**Fertility status of soil**

From the results (Table 3) it can be inferred that organic carbon, available N, P and K ranged between 0.44-0.53%, 173.05–231.10 (kg ha⁻¹), 16.03- 17.88 (kg ha⁻¹) and 268.80–314.50 (kg ha⁻¹), respectively. The highest soil available N, P and K were recorded under sole cropping. Whereas, lowest values of soil available N (173.05 kg ha⁻¹) and P (16.03 kg ha⁻¹) were recorded under mandarin + E. tereticornis agroforestry system. Lowest value of available K (268.80 kg ha⁻¹) was recorded under mandarin + A. excelsa. As regards fertility status of soil after harvest of cowpea crop it inference that the organic carbon was significantly increased in sole cropping (0.57), sole mandarin (0.53) and mandarin + A. excelsa (0.48). Whereas, it was decreased under mandarin + T. grandis (0.48) and mandarin + E. tereticornis (0.44) after harvest of kharif crop. The initial available N status under sole cropping, sole mandarin, mandarin + A. excelsa was 231.10, 225.15 and 199.95 kg ha⁻¹ and it increased to 239.00, 230.23 and 207.90 kg ha⁻¹, respectively after harvest of cowpea. Whereas, under mandarin + T. grandis and mandarin + E. tereticornis, the N status before sowing of cowpea was 195.73 and 173.05 kg ha⁻¹ and it significantly reduced to 187.08 and 166.63 kg ha⁻¹. Similar results were also observed for available K which was initially observed as 314.50, 27, 275.85, 282.80, 280.00 and 268.80 kg ha⁻¹ under sole cropping, sole mandarin, mandarin + T. grandis, mandarin + E. tereticornis and mandarin + A. excelsa, respectively and it significantly reduced to 311.75, 273.50, 274.58, 273.10 and 263.75 kg ha⁻¹ after harvest of cowpea. This may be due to over utilization of the nutrients by the different components in the agroforestry system as returned to soil in the form of litter fall and its decomposition. The increase in N status in some agroforestry system may be due leguminous nature of cowpea as a result of which, there was slight increase in soil available N status due to atmospheric N fixation. While, there was no significant difference in the available status of P in soil before sowing and after harvest of kharif cowpea.

Nutrients are made available to plants in agroforestry mainly by atmospheric N fixation and mineralization of nutrients from organic forms (Muthuri et al. 2005; Fang et al., 2008; Jose, 2009). The intercropping of trees with crops that are above to biologically fix N is common in tropical agroforestry systems. Non N-fixing trees can also affect soil physical, chemical and biological properties by adding some amount of organic matter and releasing and recycling of nutrients in agroforestry system (Paoli et al., 2008; Yadav et al., 2008; Antonio and Gama-Rodrigues, 2011).

**CONCLUSION**

We can conclude that the growth parameters, grain and straw yield of cowpea crop was found maximum in open field (sole cowpea) than the treatments under citrus (mandarin) based agroforestry systems. As regard to the soil fertility, the most important parameter i.e. the organic carbon significantly increased in sole cropping, sole mandarin and mandarin + A. excelsa. Whereas, it decreased under mandarin + T. grandis and mandarin + E. tereticornis after the harvest of kharif cowpea.

**ACKNOWLEDGEMENTS**

We thank the authorities of IGKV, Raipur and PDKV, Akola. We also thank the Project Director of AICRP on Agroforestry for the support and guidance.
### Table 3. Initial and final soil fertility status under different agroforestry systems.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Before sowing of kharif cowpea crop</th>
<th>After harvest of kharif cowpea crop</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH</td>
<td>EC</td>
</tr>
<tr>
<td>Sole cropping</td>
<td>7.14</td>
<td>0.38</td>
</tr>
<tr>
<td>Sole mandarin</td>
<td>7.16</td>
<td>0.32</td>
</tr>
<tr>
<td>Mandarin + T. grandis</td>
<td>7.21</td>
<td>0.25</td>
</tr>
<tr>
<td>Mandarin + E. tereticornis</td>
<td>7.25</td>
<td>0.30</td>
</tr>
<tr>
<td>S. Em. (+)</td>
<td>7.15</td>
<td>0.29</td>
</tr>
</tbody>
</table>

**EC (dS/m):** 0.06, NS 0.26

**LSD (0.05):** 15

**REFERENCES**


Chauhan, S.K., Sharma, R. and Dhillon, W.S. 2012. Status of intercropping in *Poplar* based agroforestry in India. Department of Forestry and Natural Resources, Department of Fruit Sciences, Punjab Agricultural University, Ludhiana, Punjab, India.


Johar, V., Dhilion, R.S., Bangarwa, K.S. and Bhardwaj, K.K. 2017. Effect of *Eucalyptus* based agri-silvicultural system on growth and yield of wheat in North-Western region of Haryana, India. Department of Forestry, CCS Haryana Agricultural University, Hisar, Haryana, India.


Rahangdale, C.P., Pathak, N.N. and Koshta, L.D. 2014. Impact of bamboo species on growth and yield attributes of kharif crops under agroforestry system in wasteland condition of the central India. *Department of Forestry, Jawaharlal Nehru Agriculture University, Jabalpur, Madhya Pradesh, India.*


Sharma, M.K. 2012. Final project report on development, evaluation and dissemination of technologies for improving productivity and production of bamboo and bamboo based cropping system. Assam Agriculture University.


