Effect of Fertilizer and Organic Manures on Growth and Yield Attributes of Wheat and Paddy Variety under Casuarina (Casuarina equisetifolia) Based Agrisilviculture System

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ABSTRACT

Casuarina equisetifolia is the most widely planted species in India having multiple utility and suitability in agrarian ecosystem. Present study was carried out fifteen –year –old Casuarina equisetifolia (Jhau) trees, planted at10 x 3m distance with wheat variety NW-1067 and paddy variety Sarjoo-52 was taken in RBD experimental design with four replications in five treatments along with using cultivated in Agri-silviculture system and open area. Findings revealed that maximum growth of C. equisetifolia (tree height 14.75m and dbh 28.10 cm etc at end of experiment) was measured in T₂ (NPK 120:60:40 kg ha⁻¹). The significantly higher grain yield(27.6 q ha⁻¹ and 29.20 q ha⁻¹) of wheat variety NW-1067 has been achieved due to T₂ (NPK 160:60:40 kg ha⁻¹) treatment in agri-silviculture system and open area respectively, whereas significantly higher grain yield (38.40 q ha⁻¹ and 40.70 q ha⁻¹) of paddy variety Sarjoo-52 has been achieved due to T₂ (NPK 160:60:40 kg ha⁻¹) treatment in agri-silviculture system and open area respectively. It may be concluded that additional income of the farmers can be generated by successful utilization of vacant land under C. equisetifolia based agri-silviculture system as inter crops of wheat computed with enhancing fertility status of soil.

Key words: Casuarina equisetifolia, Agri-silviculture, Grain yield, Fertility and Sarjoo-52

INTRODUCTION

Agroforestry is a system of land use, where woody perennials are deliberately used on the same land management unit as annual agricultural crops and/or animals either sequentially or simultaneously with the aim of obtaining greater output on a sustained basis. India has developed self-sufficiency in food grain production but the production of fodder for live-stock and fuel wood is far less than required level in the present time. Agri-silviculture system of agroforestry is one of the dominant agroforestry systems in Eastern UP, in which woody plants such as tree species are deliberately planted in association with annual crops on the same piece of land.

However, no comprehensive scientific information is available on the effect of crops and woody trees on each other when grown in association. Farmers of our country integrate fast growing trees on their farm land in association with agricultural crops. The role of trees in soil erosion control and productivity maintenance on a sustained basis has been proved. The increasing deforestation for human habitation, developmental activities and intensive agriculture resulted in ecological imbalance. Therefore, need has been realized for conservation of natural resources and protection of the deteriorating environment so that the required growth in agriculture is maintained with sustainability. It requires optimization and sustained management of available resources in a given area rather than their over exploitation. It is increasingly seen as a promising approach for improving food security, largely because the trees are associated with enhancing and sustaining soil health and crop yield. Realizing the importance of agroforestry Government of India has pronounced a National Agroforestry Policy (2014) and its implementation, is in progress.

*Casuarina equisetifolia* is a very good source of fuel wood in the Phillipines. The merit of planting *Casuarina* for fuel wood lies in its high tolerance to salinity and nutrient poor sodic land conditions. Apart from a fuel wood species, it is an efficient N fixer and also allows tremendous nutrient return to soil through litter input. Relying on its tolerance to unusually high pH range (8.5-9.5), it has been introduced in agroforestry systems on problem sodic soil. Casurina is also used on pulp and rayon production. It is fast growing, multipurpose and actinorhizal tree species.

The main advantage of planting casuarinas is the fixation of atmospheric nitrogen due to its association with Frankia, in the root nodules, thus enriching the soil with nitrogen. Marcolin et al. have shown that Casuarinas are very efficient at carbon sequestration due to their fast growth rate and adaptability. Agri-silviculture system which is gaining ground in most developing countries, which ensures an intensive utilization of the land. It provides employment means of subsistence to people. This system provides the basic requirement of fodder, fuel, pulp and green manure for agricultural crops. Farmers of our country integrate fast growing trees on their farm land in association with agricultural crops. The higher income from agroforestry unlike monocropping of agricultural crops is a major reason for farmer to plant more trees in association with agricultural crops. The role of trees in soil erosion control and productivity maintenance on a sustained basis has been proved.

*Casuarina equisetifolia* is the most widely planted species in India. It is regarded as the farmer’s favourite tree in southern states of the country because of its multiple utility and suitability in agrarian ecosystems. Apart from the traditional uses as fuel wood poles and small timber, casuarinas wood is also used for making paper. This nitrogen fixing species has proved to be an excellent soil condition and finds its inevitable role in salt affected soils. Component interaction refers to the influence of one component of a system on the performance of the other components as well as the system as a whole. In an ideal relationship, production of trees as well as crops in combination could be comparable to their sole performance. Agroforestry could be even more advantageous, if the production of associated components is increased due to influence of tree. This is possible because trees are capable of improving productivity of soil in many ways. “Multipurpose trees are of great significance in agroforestry systems, as they not only yield numerous products such as timber, fuel wood, fruits, fodder, but also provides medicines, fibres, rubber, tanning agents, N fixation protective soil amelioration functions. The soil quality and its production capacity can be restored and improved by adopting a kind of agroforestry system called agri-silvi-horti system, which provides a way to sustain agricultural productions. Therefore the present study was undertaken to study the effect of fertilizer and organic manures on...
growth and yield potential of Wheat and Paddy Variety under Casuarina (*Casuarina equisetifolia*) based agrisilviculture system.

**METHOD AND MATERIALS**

The present study was conducted during 2012-2013 in already established 15 years old casuarina plantation spaced at 10 m x 3 m at N. D. University of Agriculture and Technology, Kumarganj, Faizabad (26°27' N latitude and 82°12' E longitude at an elevation 113 m above mean sea level). The experimental site is located under sub-tropical climatic conditions, which possess three climatic seasons, *i.e.* summer (March to mid-June), rainy (mid-June to September) and winter (October to February). The annual rainfall during 2012-2013 was 1148 mm. The mean monthly maximum temperature ranged from 18.4°C (January) to 33.1°C (May) and mean monthly minimum temperature varied from 7.6°C (December) to 25.1°C (June) during the study period. The soil of experimental site is partially improved salt affected soil (pH=8.5). It was medium in available nutrient (NPK) and organic matter. The paddy variety-Sarjoo-52 and wheat variety NW-1067 were taken in RBD experimental design with four replications in 5 treatments: T<sub>1</sub>,Control (Open area) T<sub>2</sub>, NPK (120:60:40 kg ha<sup>-1</sup>) T<sub>3</sub>, FYM (24 t ha<sup>-1</sup>) T<sub>4</sub>, Paddy straw (24 t ha<sup>-1</sup>) T<sub>5</sub>, Pressmud (10 t ha<sup>-1</sup>). The trees at random on in 10 x 3 m spacing was measured for their top height and girth at breast height (GBH). The total height was measured from ground to top of the trees. The girth at breast height (1.37 m above the ground level) was taken. For soil sampling, surface (0-20 cm depth) soil was sampled from four random spots. Paddy variety (Sarjoo-52) seedlings which were raised in well prepared nursery beds during 30<sup>th</sup> May to 29<sup>th</sup> June, 2012, were transplanted on 30<sup>th</sup> June at the distance of 20 cm from row to row and 10cm from hill to hill. Before transplanting of seedlings, half dose of nitrogen (60kg) and full dose of phosphorus (60 kg) and potash (40 kg) were applied (at the rate of 120 + 60 + 40+ kg, N + P + K/ha). Remaining 60 kg nitrogen was used twice *i.e.* after 30 and 60 days of transplanting. Other treatment such as FYM (24 t ha<sup>-1</sup>), Pressmud (10 t ha<sup>-1</sup>), Paddy straw (24 t ha<sup>-1</sup>) were applied whole amount at the time of field preparation and Control (Open area), where no any manures and fertilizer were applied under agrisilviculture system. Wheat variety (NW-1067) was sown during the 15<sup>th</sup> November, 2013. Keeping a row to row distance of 22.5 cm with a seed rate of 100 kg ha<sup>-1</sup>. One half of the nitrogen and whole of the phosphorus was applied at the time of sowing and remaining N was applied to wheat crop under 10 m x 3 m spacing of casuarina plantation and open area after the first irrigation. Other treatment such as FYM, Pressmud, and Paddy straw were applied whole amount at the time of field preparation. Paddy and wheat crops were estimated in terms of growth and yield parameters (plant height, No. of panicles/ hill, effective tillers, grains/ear and 1000 grain weight and grain and straw yield (q/ha) by quadrat method at time of harvest. Five quadrates of 1 m<sup>2</sup> were selected per replication between rows of casuarina. The yield of produce (grain) was extrapolated to be expressed in q ha<sup>-1</sup>. All cultural practices were adopted as per recommended for cultivation of paddy and wheat. All cultural practices were adopted as per recommended for cultivation of paddy and wheat crops. The experiment was laid out in a Randomized Block Design with three replications. Data were analysed statistically as per method given by Panse and Sukhatme<sup>18</sup> and results were expressed at 5% levels of significance. The critical difference (CD) was calculated using following formula:

\[
C.D. = \sqrt{\frac{2 \times MSE}{r}} \times t \text{ value of error degree of freedom at } 5\% \text{ of significance.}
\]
RESULTS AND DISCUSSION

Tree performance: The results showed in (Table 1) clearly indicated that the height, dbh and canopy width of casuarina after 15 years of plantation found significant difference among the different treatment (T1-control, T2-FYM (24 t ha⁻¹), T3-paddy straw (24 t ha⁻¹) and T4-pressmud (10 t ha⁻¹)). The casuarina showed maximum height (14.75 m), dbh (28.10 cm) and canopy width (4.8 m) in T2 – treatment in final year as compared to initial year. This might be attributed to addition of fertilizer in surface soil layer. Similar results were also obtained by Dur and Ram Niwaj (2007) With Albizia procera tree grown in agrisilviculture system.

Productivity of crops: The plant height of wheat differs significantly under casurina and in open (sole wheat). In agri-silviculture system plant height and No. of tillers/m² of wheat was found lesser as compared to control. This might be due to advanced germination under casurina. Maximum plant height (67.4 cm) was recorded in open area (Table 2). Less height of crops under casurina may be primarily due to reduced light intensity under casurina. The growth of wheat and paddy crops under Casuarina equisetifilia based agrisilvicultural system was lower than open area cultivation. The results are in conformity with Rana et al. (2011) who have also found similar results for different species based agrisilvicultural systems. Thus, when a crop is grown in association with trees, there is a competition for light, moisture, nutrients etc., and a positive or negative interaction might be expected to develop between them

Data presented in Table 2 clearly shows that the growth characters of wheat variety NW -1067 and paddy variety Sarjoo-52 was significantly affected by perennial tree Casuarina equisetifilia. In wheat variety, the maximum plant height (71.70 cm) was found in T2 treatment NPK (120:60:40 kg ha⁻¹) which was significantly higher than other treatments under Casuarina equisetifilia based agri-silviculture system. The plant height of 71.70 cm and 92.5 cm for wheat and paddy was maximum under T2 treatment and was closely followed by T3, T4 and T5 in both the agricultural crops. However, also number of tillers m⁻² was observed greater in T2 treatment in wheat (248.5) and paddy (355.0) as compared to other treatment. This might be due to the fact that in agri-silviculture system, crops got the benefits of fertilizer applied to intercrops that resulted in higher crop growth. Sharma et al. (2023) reported that single and combined application of nitrogen and phosphorus led to substantial increase in crop growth, relative growth rate and photosynthetic efficiency at various stages of crop growth in greengram crop. Mishra (2014), Bhilare and Patil (2011) and Sharma and Jat (2023) in cowpea and Khalid et al. (2011) and Angadi et al. (2011) in sorghum have reported similar findings.

Yield attributing characters

The data related to No. of ears m⁻². Grains ear⁻¹ and Test weight (g) of wheat was (5.6, 39.8 and 38.8) in T2 treatment are presented in fig 1. In wheat, the No. of ears m⁻² (5.6), Grains ear⁻¹(39.8) and Test weight (38.8 g) were found significantly maximum under T2 treatment as compared to other treatments. On the other hand the paddy crop was also significantly higher No. of panicles/ hill, No. of grains panicle⁻¹ and Test weight (g) (8.1, 175 and 24.2) in T2 treatment and it was closely followed by T3, T4 and T5 in treatments (fig 2). Thereafter, Yield attributing characters increased with added fertilizer dose in wheat and paddy crop. Increase in growth and yield attributes of green gram with the application of N and P has also been reported by Kumar (2012) and Singh et al. (2027). Among all the different treatments, in open area showed significantly higher Yield attributing characters in wheat and paddy crops as compared to casurina based agroforestry system. Nandal and Singh (2015) have also reported reduced branching in lentil and munbean under all spacings of shisham as compared to control.

Yield

The data on grain yield (q/ha), straw yield (q/ha) are presented in table 3. In general, the grain yield and straw yield of wheat and paddy increased with increase in fertility levels. Grain yield was more in T2 treatment in wheat
and paddy crops. The observation recorded with respect to grain and straw yield of wheat and paddy were significantly influenced by different treatment of casurina has been shown in Table-3 in control, the maximum grain yield (29.2 and 40.7 q/ha) and straw yield (43.6 and 59.6q/ ha) were recorded in wheat and paddy crops in T2 treatment. The grain and straw yield which are reflection of all the growth and yield attributes characters increased significantly with increase in fertilizer level up to recommended dose of fertilizer in both the crops (wheat and paddy) (Table 3). Favorable response of wheat and paddy to nitrogen and phosphorus application might be attributed to the fact that nitrogen application helps to meet the nitrogen requirement of plant until the time it fixes its own nitrogen and beneficial effect of phosphorus on nodulation26. The combined application of these nutrients resulted in better vigour and superior yield attributes which ultimately produced more yields of green gram. Sharma et al.14 observed increase in test weight, biological yield and harvest yield of green with the application of fertilizer upto 20 kg N + 60 kg P2O5 ha−1.

The grain and straw yields of both the crops under casurina decreased significantly as compared to open field (crops without casurina) and 56.8 % grain yield reduction was observed in wheat (Table 3). The decrease in the straw yield of paddy and wheat was of the order of 35.3 % and 56.8 %, respectively. Yield reduction in wheat and paddy indicated that higher tree density had more suppressing effect on crops, reduced solar radiation on crop canopy and lower availability of moisture and nutrients. Light intensity in wheat and paddy under casurina reduced as compared to sole crop. Reduced yield of groundnut under teak due to reduced PAR availability has also been recorded by Venkatarao et al.. Reduction in yield of wheat and paddy crop under system may be because of fact that shade negatively affects grain yield. Yield reduction depends on the light intensity. Similar findings were also reported by Bisaria et al.4 in wheat crops. The findings are in conformity to Puri et al.18, Nadal and Hooda16. The yield of wheat crop under Casuarinaequisetifilia based agri-silvicultural system was lower than paddy crop. Results revealed (fig 3) that the average grain yield reduction under shade of tree canopy was noticed 53.0 % for wheat and 38.2 % paddy crop. The results are in conformity with Rana et al.20 who have also found similar results for different species based agri-silvicultural systems. In fact the paddy crop is more tolerant to the sodic soils Rana et al.19.

### Table 1: Performance of casurina trees growth under agri-silviculture system

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Tree growth initial year</th>
<th>Tree growth final year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tree height (m)</td>
<td>Dbh (cm)</td>
</tr>
<tr>
<td>T1 Control (Open area)</td>
<td>11.8</td>
<td>21.6</td>
</tr>
<tr>
<td>T2 NPK (120:60:40)</td>
<td>12.9</td>
<td>26.5</td>
</tr>
<tr>
<td>T3 FYM (24 t ha−1)</td>
<td>12.5</td>
<td>24.2</td>
</tr>
<tr>
<td>T4 Paddy straw (24 t ha−1)</td>
<td>12.1</td>
<td>22.2</td>
</tr>
<tr>
<td>T5 Pressmud (10 t ha−1)</td>
<td>12.4</td>
<td>23.9</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>0.63</td>
<td>1.79</td>
</tr>
</tbody>
</table>
Table 2: Effect of INM on growth of wheat and paddy crop under *Casuarina equisetifolia* based agri-silviculture system and open area

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Wheat growth parameters</th>
<th>Paddy growth parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plant height (cm)</td>
<td>No. of tillers/m²</td>
</tr>
<tr>
<td></td>
<td>Agrisilviculture system</td>
<td>Open area</td>
</tr>
<tr>
<td>T₁, Control (Open area)</td>
<td>60.8</td>
<td>58.2</td>
</tr>
<tr>
<td>T₂, NPK (120:60:40)</td>
<td>71.7</td>
<td>73.2</td>
</tr>
<tr>
<td>T₃, FYM (24 t ha⁻¹)</td>
<td>67.5</td>
<td>70.4</td>
</tr>
<tr>
<td>T₄, Paddy straw (24 t ha⁻¹)</td>
<td>65.4</td>
<td>66.7</td>
</tr>
<tr>
<td>T₅, Pressmud (10t ha⁻¹)</td>
<td>66.3</td>
<td>68.5</td>
</tr>
<tr>
<td>Mean</td>
<td>66.3</td>
<td>67.4</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>4.506</td>
<td>5.16</td>
</tr>
</tbody>
</table>

Table 3: Effect of INM on yield of wheat and paddy crop under *Casuarina equisetifolia* based agri-silviculture system and open area

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Wheat yield characters</th>
<th>Paddy yield characters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agrisilviculture system</td>
<td>Open area</td>
</tr>
<tr>
<td>T₁ Control (Open area)</td>
<td>21.5</td>
<td>22.7</td>
</tr>
<tr>
<td>T₂, NPK (120:60:40)</td>
<td>27.6</td>
<td>29.2</td>
</tr>
<tr>
<td>T₃, FYM (24 t ha⁻¹)</td>
<td>25.7</td>
<td>26.9</td>
</tr>
<tr>
<td>T₄, Paddy straw (24 t ha⁻¹)</td>
<td>24.9</td>
<td>25.4</td>
</tr>
<tr>
<td>T₅, Pressmud (10t ha⁻¹)</td>
<td>25.2</td>
<td>27.6</td>
</tr>
<tr>
<td>Mean</td>
<td>25.0</td>
<td>26.4</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>1.677</td>
<td>1.74</td>
</tr>
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</table>

Fig. 1: Effect of INM on yield attributing of wheat crop under *Casuarina equisetifolia* based agri-silviculture system and open area
Fig. 2: Effect of INM on yield attributing of paddy crop under *Casuarina equisetifolia* based agri-silvicultural system and open area

![Graph showing the effect of INM on yield attributing of paddy crop](image)

Fig. 3: Grain yield reduction of wheat and paddy under *Casurina equisetifolia* based agri-silvicultural systems in different treatments

![Graph showing grain yield reduction](image)
CONCLUSION

Growth and yield parameters of wheat and paddy were higher in T2 treatment as compared to T3, T4 and T5 treatments in both the systems. Therefore, Growth and yield of wheat and paddy were lower in crop grown under casurina compared to open field. The yield of wheat and paddy were recorded 2.7 and 5.7 times higher in open field as compared to casurina based agroforestry system. Paddy crop was found more suitable for cultivation under casurina.

REFERENCES


