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Performance of rice crop in association with Eucalyptus based bund agro forestry system in plains of Chhattisgarh

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Abstract
The experiment on bund plantation of *Eucalyptus teretricornis* and its effect on paddy were studied as bund Agroforestry system on growth of paddy and its yield at different distances from the base of the trees, the effect of crown shade on growth and productivity was also observed this experiment laid on farmer's field in the Village Khudmuda, Durg district (CG), during the year 2019-20 in Kharif season.
The Eucalyptus was planted on field bund in North - South direction of the field. The experiment was carried out in a Randomized Block Design (RBD) with one control plot. The trees were selected having different DBH and crown width range from 21.33–27.38 cm and 6-8 m, respectively. The results showed that the bund based Ago-forestry system reveled adverse affect on growth and yield of paddy which varies in different dbh and crown width of the tree with distance from the tree line. Due to increasing crown width and closeness from the tree, the growth of rice *ie.* Number of hills per quadrate and number of tillers per quadrate of Paddy reduced drastically. The maximum number of tillers at different distances from the line of the tree was reported at a control plot (99.12) from tree 3 and the minimum number of tillers found at the nearest distance, *ie* 1-3 m from the tree line. The minimum reduction in grain weight with inflorescence quadrate (5.67 gm) was observed at a control plot from tree 3 and the maximum decreased (1.22) was observed at a distance of 1 m from tree 1, in comparison with all other distances. The maximum reduction was observed at the different distances from the line of the tree at a distance of 1-5 m from the tree line, which decreased successively with the rise in distance from the tree line, which indicates that inflorescence / quadrate grain weight (g) was substantially increased due to decreased crown width and increased distances from the tree line. The number of tillers of paddy was influenced by various aspects at various distances from the tree line. The maximum plant height was found (113.88 cm) at a control plot from the base of the tree 3 and the minimum Plant height was found to be lower (81.00 cm) at a distance of 1 m from tree 1. The tillers were substantially reduced from the tree line to a control plot. The highest (98.53 percent) harvest index percent was found on the 1 m distance tree 1, followed by tree 2 (97.47 percent), at a distance of 1 m from the tree line and the lowest at a 1 m distance from the tree line at tree 2 (97.27). Due to higher bole dbh and crown width of the Eucalyptus tree and decreasing distance from the tree line, the adverse effect of the tree line on harvest index percent was recorded. Thus results of present study indicates that highest reduction in the yield was observed near the tree line *ie*1-5 m the decrease followed the order, tree3> tree 2>, and tree at all distances from the line of the tree. Thus it can be concluded that minimum crown width and increasing distance from the tree line of Eucalyptus had less effect on the growth and yield of rice as compared to the trees with maximum crown width and closeness with tree or tree line.

Keywords: Bund agroforestry, eucalyptus, paddy

Introduction
Eucalyptus is one of the most planted woody species in the world next to *Pinus. Eucalyptus* belongs to the family Myrtaceae, mostly found in tropical region is a native to Australia. Eucalyptus spp. grows under wide range climatic and edaphic conditions in their natural habitats. It is fast growing, easy to care, drought tolerate, and can be grown in poor or less fertile soil. It is a raw material for paper pulp industries, and a major source of bio-energy. It distributed to other parts of the world in late 19th century and beginning of 20th century when the demand for energy escalated in Europe, South America, Asia and Africa. FAO has reported the area of productive eucalypt plantations by country, species and age class (Raj *et al.* 2016) [4].
Foresters and wood industries support its expansion looking at its socio-economic benefits. Because of their demand in soft wood production, wood for industrial need, construction materials, easy to grow and care, fast growing ability, drought tolerate, and growing potential in poor or less fertile soil, these resources are planted under cropland agro-forestry along with various annual crops like paddy, wheat, cereals and other cash crops in farmers' lands either in

scattered or in bund plantation. Boundary plantation under agro forestry program includes trees planted along boundaries or on bunds in such way to holding the soil against erosion and stabilizing soil.

Agro forestry is a standard term for land-use systems and techniques in which woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used in some form of spatial arrangement or temporal sequence on the same land-management units as agricultural crops and/or animals. In agro forestry systems, interactions here between various components are both ecological and economical. Agro forestry also can be characterized as a complex, environmentally based resource management system that diversifies and sustains development for increasing social, environmental and economic benefits for land users at all levels through the incorporation of trees on farms and in the agricultural landscape. Agro forestry, in general, is important for smallholders and other urbanites since it can increase their food supply, income and safety. Agro forestry systems are multipurpose structures capable of delivering a wide range of commercial, sociocultural, and economic benefits (Steven *et al.* 2019) [5].

Eucalyptus based agro forestry system is most commonly accepted practice in India by the farmers for fulfilling the market demand of plywood, paper, pole and furniture industries. The boundary planting of Eucalyptus is preferred by farmers due to their less interference with agricultural operations. Boundary plantation under agro forestry helps in holding the soil against erosion and improving soil fertility by fixing nitrogen or bringing minerals from deep in the soil and depositing them by leaf fall. Such a suitable combination play a vital role in enhancement of better yield productivity, soil nutrient status and microbial population dynamics which plays a major role in nutrient cycling to maintain ecosystem. Due to shading effect and strong root system of Eucalyptus, which compete for moisture and nutrient with crops resulting grain yield near the tree lines was comparatively low.

Material and Method

Study area

The present study entitled **"**Performance of Rice Crop in Association with Eucalyptus based Bund Agroforestry System"was carried out in the experimental field of village Khudmda of Durg district (C.G.), during the year 2019-20 in kharif season (July- November). The mean monthly temperature varies between 27.4 °C (December) to 40.7 °c (May), and the annual temperature averages 33 C. The mean annual rainfall is 1264.9 mm, 95% of which occurs during the rainy season 8 months of the year are almost dry. Soils are tropical black with tremendous swell-shrink behavior, deep (> 50r_m) with high base saturation and dominated by smectite kind of clay minerals.

Methodology

In each quadrate the number of hills was counted along with the number of tillers. The mean tiller value was multiplied with the number of hills to find out the total number of tillers in the quadrate. At harvesting time 5 tillers were removed and kept in labeled polyethylene bags and brought to the laboratory at the harvesting stage of crop from each quadrate to estimate the biomass and yield. Tiller density and shoot biomass were measured when the crop was at its peak growth. The sample for grain yield was taken when crop was mature for harvesting. The correlation coefficient test and regression techniques were used to develop the relationship between crop parameters and tree line distance from the crop.

Statistical Analysis

All observations recorded from this experimental study were tabulated in a systemic manner. Values were given as means for their respective number of replications used. The data were statistically analyzed using ANOVA for randomized block design (RBD). The significant difference was tested through F- test at a 1% level of significance. The standard error of means (SEm ±) and CD were calculated where F-test was significant for comparing treatment means (Panse and Shukhatme. 1978).

Result

Growth characteristics of Eucalyptus

The Eucalyptus trees were planted on field bund in north-south direction of the field. The tree parameters like (DBH) diameter at breast height and crown width were measured with the help of field tape. The distance from tree to tree ranged between 1.25 to 1.50 m. Tree DBH, and crown width ranged respectively, between 22.61 and 28.66.cm, 7.62 m and 9.62 m.

Growth characteristics of rice crop

Observation on numbers of hills, numbers of tillers per hill and grain yield were measured while comparing crop parameters at different distance, distance 12 meter was treated as maximum (control) and it was assumed that beyond this distance effect of tree trunk will be negligible.

Number of hills per quadrate

The interaction studies showed that the lowest Number of hills (highest reduction) was observed in the immediate vicinity of the tree, i.e. 1-3 m. As the distance from the tree line increased, the Number of hills increased and the declining percentage decreased. Similarly, a significant reduction of up to 9 m was reported at tree 2. However, a statistically significant reduction of up to 7 m and the highest Number of hills recorded at the under control plot (11.67) distance from the tree base line were recorded at tree 3.

Plant height

The maximum plant height (113.88 cm) recorded in transplanted paddy at a control plot from the base of the tree line (tree 3) is due to the highest percentage of interception of solar radiation by rice crops (Kiran and Agnihotri. 2001). The data also showed that the number of tiller is most affected during the early vegetative phase. This result is confirmed as reported by Lso Akhtar *et al*. (2008). Similar observations were also recorded in this experiment as reported by above workers

Total Weight of Single plant of Paddy

The maximum Total Weight (8.07 g) reported for transplanted rice at a control plot from the base of the tree line (tree 3) is due to the highest percentage of interception of solar radiation (Fig. 4.8) by rice crops and the lowest Total Weight (6.21 g) reported for rice transplanted at a distance 1 m. (Kiran and Agnihotri. 2001). The data also shows that when filleting occurs, the Total Weight is most affected during the early vegetative phase. This result shows confirmation as reported by Newaj *et al*. (2013), Sarvade *et al*. (2014) and Awan *et al*. (2015).

Numbers of grains / hill of Paddy

Numbers of grains / hill showed that maximum number of grains / hill were recorded in control plot from the tree 3 (121.0) as compared to Tree 1 and 2, which were significantly higher than those recorded on the control plot from the tree 2 (110.0), tree l (101.0) and tree 3 (121.0) than 9 m distance (117.0). The maximum numbers of grains were weighted under the distance 1 m for all the trees found in bund of the field.

Harvest index (%)

Crown width and distance from the tree base in the harvest index (percentage) of rice. The harvest index (percent) was registered equal to each other at 7 m distance from tree 1 line (96.08 percent) and 3m distance from tree 1 lines (95.82 percent). However, the highest reduction percentage was found to be at 1 m away from tree 1 (96.08), followed by 3 m away from tree 1 (95.82) and 5 m away from tree 1 (95.38).

Plate 1: Paddy under Eucalyptus based bund plantation

Table 1: Growth characteristics of Eucalyptus

Tree	Girth (cm)	GBH (cm)	Crown Width (m)
T1	76	24.20	7
T2	86	27.38	8
T3	67	21.33	6

Table 2: Number of hills per quadrate (.25 m^2) under Eucalyptus bund agro forestry system

Distance from the tree line (m)	(Tree 1- 24.20cm)	(Tree 2- 27.38cm)	(Tree 3 – 21.33 cm)
1	7.44±0.23	8.00±0.27	8.34±0.38
3	7.83±0.29	8.37±0.35	8.73±0.46
5	8.33±0.36	8.67±0.49	9.67±0.57
7	8.48±0.47	9.33±0.53	10.00±0.68
9	9.00±0.62	9.70±0.82	11.00±0.91
Control>9	10.00±0.82	11.00±0.99	11.67±1.06
S.Em	0.48	0.42	0.52
CD(p=0.05)	1.41	1.22	1.53
Significance	S	S	S

Table 3: Plant height in (cm) under Eucalyptus bund agro forestry system

Distance from the tree line (m)	(Tree 1- 24.20cm)	(Tree 2- 27.38cm)	(Tree 3 – 21.33 cm)
1	81.00±1.22	89.2±0.56	100.1±0.76
3	83.00±1.59	91.12±0.98	102.02±0.85
5	85.00±1.98	94.3±1.11	105.2±1.63
7	89.00±2.33	98.23±1.87	109.13±1.87
9	90.33±2.87	100.52±2.10	111.42±2.15
Control>9	93.00±2.99	102.98±2.30	113.88±2.47
S.Em	1.09	1.64	1.38
CD(p=0.05)	3.19	5.24	4.28
Significance	S	S	S

Table 4: Total weight of paddy plant (g) under Eucalyptus bund agro forestry system

Distance from the tree line (M)	(Tree 1- 24.20cm)	(Tree 2- 27.38cm)	(Tree 3 – 21.33 cm)
1	3.04±0.56	4.18±0.78	6.21±0.98
3	3.19±0.98	4.33±1.13	6.36±1.33
5	3.53±1.12	4.67±1.36	6.70±1.48
7	3.92±1.45	5.06±1.68	7.09±1.82
9	4.30±1.98	5.44±2.13	7.47±2.45
Control>9	4.90±2.59	6.04±2.85	8.07±3.16
S.Em	0.23	0.52	1.03
CD(p=0.05)	0.68	1.56	3.06
Significance	S	S	S

Table 5: Numbers of grains / hill under Eucalyptus bund agro forestry system

Distance from the tree line (m)	(Tree 1- 24.20cm)	(Tree 2- 27.38cm)	(Tree 3 – 21.33 cm)
1	82.00±1.26	91.00±1.52	102.00±1.80
3	85.00±1.58	94.00±1.98	105.00±2.06
5	90.00±1.98	99.00±2.15	109.00±2.35
7	94.00±2.14	103.00±2.45	112.00±2.70
9	99.00±2.28	108.00±2.78	117.00±2.98
Control>9	101.00±3.12	110.00±3.65	121.00±3.95
S.Em	2.16	2.36	2.9
CD(p=0.05)	6.30	7.1	8.64
Significance	S	S	S

Table 6: Harvest index (%) under Eucalyptus bund agro forestry system

Distance from the tree line (m)	(Tree 1- 24.20cm)	(Tree 2- 27.38cm)	(Tree 3 – 21.33 cm)
1	96.08±4.15	95.01±4.65	70.74±4.77
3	95.82±4.77	94.81±5.13	93.27±5.46
5	95.38±4.91	94.47±5.59	93.00±5.87
7	95.24±5.18	94.37±5.80	92.92±6.23
9	95.18±5.89	94.36±6.26	92.97±6.80
Control>9	95.13±7.54	94.34±7.64	93.04±8.11
S.Em	0.23	0.39	0.41
CD(p=0.05)	0.68	1.15	1.25
Significance	S	S	S

Conclusion

The results showed that the boundary plantation of Eucalyptus had an adverse affect on growth and yield of rice. The effect on growth of paddy crop in farmer's field showed that Eucalyptus boundary plantation shade differs with the different dbh and crown width of the base of the tree gave variation in yield and growth of crop planted in the field. Thus, the adverse impact of the tree line on maximum growth and rice yield near the tree base. The yield and yield characteristics of rice increases as the distance from the line of the tree increases. The width of the crown has an important effect, as the trees significantly reduce the yield and yield attributes of rice to the maximum width of the crown, and has less impact on the minimum width of the crown. In the competition between trees and crops, light is the main factor. In various ways, the strength of light was decreased by the tree canopy to variable distances from the tree line. Thus it can be concluded that minimum crown width and increasing distance from the tree line of *Eucalyptus* has a lesser effect on the growth and yield of paddy as compared to the trees growing in a maximum crown width and near the tree line. As a guide for extrapolating complex planting arrangements using the same tree and crop, the data generated at the interface can be used. *Eucalyptus* tree gives extra income to the farmers after harvesting the tree crop. The rate of wood of *Eucalyptus* ranges around 6000-8000 rupees per tons. The wood of eucalyptus is utilized in pulp, paper, Plywood and in packaging industry.

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