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# Effect of Different Spacing of Eucalypts (*Eucalyptus tereticornis*) based Agroforestry System on Performance of *Rabi* Field Crops

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***Abstract***: The shrinkage of land is a big problem in the present time and to harvest the full opportunity of the land under different agroforestry system seems to be one the solution to the spatial and temporal arrangement of the different crops. The field experiment based on agroforestry system was conducted to find out the suitable crop combinations for *rabi* season and its economics at Farm Forestry, CCSHAU, Hisar, in which, eucalypts (P-23) planted in October 2018 was taken as forest tree with spacing: 6×3, 7×3, 8×3, 9×3m and *Rabi* crops *viz.,* wheat (HD 2967), barley (BH -393), raya (RH-30) as agricultural crops. The results revealed that three year old eucalypts planted at a spacing of 9×3 m exhibited significantly higher plant height (9.13 m) as compared to 8×3, 7×3 and 6×3 m spacing. The edaphic factors like pH (7.92-8.02), $EC_{1:2}$ (1.7-2.1dS/m), organic carbon (OC) ranged from 0.30-0.39 per cent of the field with different spacing were inclined to salinity, However, minimum grain yield reduction (11.34%) was observed in barley at eucalypts spacing 9×3m followed by 8×3m as compared to sole crop. In addition to this raya crop was found suitable under eucalypts based agroforestry system in 9×3m spacing. Maximum B: C ratio was obtained with eucalypts + mustard agroforestry system under two spacing 8×3m and 9×3 m *i.e.,* 1.66 and 1.67, respectively.

***Keywords***: Edaphic conditions, Eucalypts, Organic Carbon, *Rabi* crops and spacing

Haryana with geographical area of 4.42 million hectare is agrarian state carrying forward with intensive and mechanical agriculture, thusly, Forest cover limited to 1603 $km^2$ which makes 3.63 per cent of its geographical area (State of Forest Report 2021). Substantially, there is need to integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability (National Agroforestry Policy 2014). Agroforestry currently meets 50 per cent of the demand for fuel wood, 60 to 70 per cent of the demand for small timber, 70 to 80 per cent for plywood, 60 per cent of the raw material for paper pulp, and 9-11 per cent of the demand for green fodder, in addition to meeting the subsistence needs of households for grain, fruit, fibre, medicine, and so on (Arya et al 2018).

In India salt-affected soils occupy about 6.73 million hectares. Indo-Gangetic plains that lie between 21°55′-32° 39′N and 73°45′-88°25′E comprising of the states of Punjab, Haryana, Uttar Pradesh and part of Bihar (North), West Bengal (South) and Rajasthan (North) have about 2.7 million hectare salt-affected soils (Singh 2017).

## MATERIAL AND METHODS

The present study was conducted at the Research Farm, Department of Forestry, CCS HAU, Hisar, situated at $29^0$ 09' N latitude and $75^0$ 43' E longitudes at an elevation of 215.2 m above mean sea level situated in the arid region of North Western India. The climate is subtropical-monsoon with an average annual rainfall of 350-400 mm, 70-80 per cent of which occurs during July to September. The summer months are very hot with maximum temperature ranging from 40 to 45°C in May and June whereas, December and January are the coldest months (lowest January temperature may reach as low as 0°C). The mean monthly values of weather parameters *viz.,* temperature, relative humidity, evaporation and rainfall were recorded during the period of experimentation. The weather data during the study period 2019 to 2021 like maximum temperature ranged from 30.4 to 31.1°C, minimum temperature 16.6 to 17.4°C, morning relative humidity ranged from 83 to 85 per cent, evening relative humidity 48 to 49 per cent, average wind speed 4.6 to 4.7 km per hour, bright sun shine hours 5.9 to 6.7, pan evaporation 4.0 to 4.1 mm, total rain fall 474.8 to 795.0 mm and total rainy days 31-34 days (Table 1). There were four spacing of Eucalypts (P-23) spacing *i.e.*, (i) 6×3m, (ii) 7×3m, (iii) 8×3m, (iv) 9×3m. The plantation of eucalypts trees was done during October, 2018. In the *rabi* season, wheat, barley and raya were sown in different eucalypts based agro forestry system during 2020-21. The seeds of variety for wheat was HD 2967, BH 393 for barley and RH 30 for raya

were procured Department of Plant Breeding, CCSHAU, Hisar, Haryana. The respective varieties of the crops were included in the research for their peculiar characteristics which fit in the Agro forestry system as the experimental site falls under the semi-arid zone. There were three replications in the experiment with randomized block design. Among different spacing, soil pH ranged from 7.92 to 8.02, EC 1.7 to 2.1 dS/m, soil organic carbon 0.30 to 0.39 per cent, available N 102.4 to 112.8 kg $ha^{-1}$, available P 9.8 to 12.4 kg $ha^{-1}$ and $K_2O$ 212.4 to 228.2 kg $ha^{-1}$ under different tree spacing and control (Table 5).

**Soil data:** Organic carbon was determined by Walkley and Black (1934) method, soil pH and electrical conductivity by Antil et al. (2002), available nitrogen by Asija and Subbiah (1956) method, available phosphorus by Olsen et al (1954) and available potassium by Jackson (1973) method.

**Plant height:** Eucalypts plant height was measured in meters with Clinometer from the base up to the tip of the tree. Measurements were done at sowing time and after harvesting of wheat, barley and raya crops.

**Girth at breast height (GBH):** Circumference (C) of ten randomly selected trees were measured from 1.37 m height from the ground level and converted into dbh by using the formula:

$dbh = C/\pi$

It was measured in cm with the help of measuring tape. The measurements were taken at sowing time and after harvest of wheat, barley and raya.

**Crop parameters:** The various yield attributes and yield of wheat, barley and raya were measured with the standard techniques of each crop. *B: C ratio:* Benefit cost ratio was worked for each crop with the given formula:

$$B:C = \frac{Gross\ returns(Rs.)}{Total\ cost(Rs.)}$$

## RESULTS AND DISCUSSION

**Growth studies:** Three year old eucalypts planted at a spacing of 9×3 m exhibited significantly higher plant height (9.13 m) than other spacing's *i.e.,* 8×3, 7×3 and 6×3 m spacing plantation however, gbh was statistically at par with 8 x 3 m spacing (Table 2).

**Yield attributes and yield:** The yield attributes in wheat like grains/ spike, number of tillers /$m^2$ and grain yield/ ha were found less under 9×3 m (41.93, 409.98 and 41.65 q/ha) and 8×3 m (41.00, 367.66 and 41.15 q/ha) as compared to control *i.e.*, sole cropping system (44.62, 410.00 and 52.08 q $ha^{-1}$), respectively (Table 3 and Table 4). The yield attributes in barley like grains/spike, number of tillers/$m^2$ and grain yield /ha were found lower under spacing's 9×3m (40.65, 353.54 and 37.46 q $ha^{-1}$) and 8 × 3 m (39.50, 349.10 and 37.39 q $ha^{-1}$) as compared to control *i.e.,* sole cropping system (42.80, 357.50 and 42.25 q $ha^{-1}$), respectively. The yield attributes in mustard like plant height, number of primary and secondary branches, siliqua/ plant, number of seeds/ siliqua and grain yield/ ha were found less under tree spacing 9×3 m (167.60, 5.00, 9.00, 240.00, 12.16 and 18.15 q $ha^{-1}$) and 8×3m (167.30, 5.00, 8.30, 230.60, 11.90 and 18.03 q $ha^{-1}$) with control *i.e.*, sole cropping system (168.70, 5.25, 9.00, 263.00, 13.10 and 20.58 q $ha^{-1}$), respectively. The yield attributes and yield of wheat, barley and raya were found maximum under spacing 9×3 and 8×3 m spacing might be due to the reason that under broader spacing less light competition, more availability of nutrients and less competition for moisture among the field crops and eucalypts. Deep-rooted plants consume more deep soil moisture than conventional cropland due to their well-developed and deeper root systems and higher evapotranspiration rates (Zhang et al 2018, Arora et al 2021).

**Soil studies:** Among different spacing, organic carbon was found maximum under 6×3m (0.39%) and 7×3m (0.38) spacing. Soil pH (7.92 – 8.02) and electrical conductivity (1.7-2.1 dS/m) were also being lowered under different spacing as compared to sole crop (pH 8.01, EC 2.1 dS/m). However, the

**Table 2.** Growth performance of eucalypts tree under different spacing

| Tree spacing (m) | Plant height (m) | GBH (cm) |
|---|---|---|
| 6 × 3 | $5.68^{C}$ | $24.3^{C}$ |
| 7 × 3 | $7.12^{B}$ | $33.15^{B}$ |
| 8 × 3 | $7.97^{B}$ | $34.45^{AB}$ |
| 9 × 3 | $9.13^{A}$ | $40.3^{A}$ |
| CD (0.05) | 1.11 | 6.46 |

**Table 1.** Weather data during the study

| Year | Temperature (°C ) | | Relative humidity (%) | | Average wind speed (km/h) | Bright sun shine hours (h) | PAN evaporation (mm) | Rainfall (mm) | Rainy days |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum | Minimum | M | E | | | | | |
| 2019 | 30.4 | 17.0 | 83 | 48 | 4.6 | 5.9 | 4.0 | 474.8 | 31 |
| 2020 | 30.6 | 16.6 | 85 | 48 | 4.7 | 6.7 | 4.1 | 501.1 | 34 |
| 2021 | 31.1 | 17.4 | 84 | 49 | 4.6 | 6.3 | 4.0 | 795.0 | 34 |

magnitude of decrease was more in closer spacing. The available soil N, P and K increased significantly under different spacing of tree-based agroforestry system in comparison to control (sole crop). In the present study, the status of soil under study was EC >0.8 dS/m are saline soils; OC < 0.4% as low; N < 250 kg ha$^{-1}$ as low; 10-20 kg ha$^{-1}$ P as medium; $K_2O$ 125-300 kg ha$^{-1}$ as medium. The highest available soil N, P and K were recorded under 6×3m spacing (112.8, 12.4 and 228.20 q ha$^{-1}$, respectively). Soil pH and EC properties and did not differ significantly in different spacing and sole crop under study (Table 5).

Increase in soil OC under 6×3 and 7×3m tree spacing under eucalypts agroforestry system may be due to considerable addition of organic matter by more number of trees, which on decomposition release weak acids. Similar findings were observed by Bhupender (2021), Sirohi and Bhangrwa (2017) .

**Benefit cost ratio:** Maximum benefit cost ratio was estimated in raya under 9×3m tree spacing (1.67) and 8×3m (1.66) as compared to wheat (1.32), barley (1.13) under 9×3m tree spacing (Table 6). The tree spacing system 9×3m and 8×3m were found more economical as compared to other tree spacing system. This might be due to the reason of higher prices of grain of raya as compared to wheat and barley resulting in higher benefit cost ratio.

**Table 4.** Effect of different spacing of eucalypts based cropping system on yield of wheat, barley and raya

| Tree spacing (m) | Grain yield (q ha$^{-1}$) | | |
|---|---|---|---|
| | Wheat | Barley | Raya |
| 6 × 3 | 34.42$^{C}$ | 32.69$^{C}$ | 14.36$^{C}$ |
| 7 × 3 | 37.24$^{C}$ | 34.36$^{C}$ | 16.12$^{C}$ |
| 8 × 3 | 41.15$^{B}$ | 37.39$^{B}$ | 18.03$^{B}$ |
| 9 × 3 | 41.65$^{B}$ | 37.46$^{B}$ | 18.15$^{B}$ |
| Control (Sole) | 52.08$^{A}$ | 42.25$^{A}$ | 20.58$^{A}$ |
| CD (0.05) | 5.33 | 3.04 | 2.35 |

**Table 6.** Effect of different spacing of eucalypts based cropping system on benefit cost ratio in wheat, barley and raya

| Tree spacing (m) | Wheat | Barley | Raya |
|---|---|---|---|
| 6×3 | 1.09 | 0.98 | 1.32 |
| 7×3 | 1.18 | 1.03 | 1.49 |
| 8×3 | 1.30 | 1.12 | 1.66 |
| 9×3 | 1.32 | 1.13 | 1.67 |
| Control (Sole) | 1.64 | 1.27 | 1.90 |

Excluding economics of eucalypts plantation

**Table 3.** Yield attributes of *Rabi* field crops under eucalypts based agroforestry system

| Tree spacing (m) | Wheat | | Barley | | Raya | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of grains/spike | Number of tillers m$^{-2}$ | Number of grains /spike | No. of tillersm$^{-2}$ | No. of primary branches | No. of secondary branches | Siliqua/ plant | No. of seeds/ siliqua |
| 6×3 | 36.58$^{D}$ | 325.54$^{C}$ | 35.30$^{D}$ | 325.23$^{C}$ | 4.00$^{C}$ | 8.00$^{C}$ | 209.95$^{C}$ | 9.93$^{D}$ |
| 7×3 | 39.51$^{C}$ | 352.87$^{B}$ | 38.33$^{C}$ | 338.83$^{B}$ | 5.00$^{B}$ | 8.11$^{BC}$ | 214.72$^{C}$ | 11.18$^{C}$ |
| 8×3 | 41.00$^{B}$ | 367.66$^{B}$ | 39.50$^{BC}$ | 349.10$^{A}$ | 5.00$^{B}$ | 8.30$^{B}$ | 230.60$^{B}$ | 11.90$^{B}$ |
| 9×3 | 41.93$^{B}$ | 409.98$^{A}$ | 40.65$^{B}$ | 353.54$^{A}$ | 5.00$^{B}$ | 9.00$^{A}$ | 240.00$^{B}$ | 12.16$^{B}$ |
| Control | 44.62$^{A}$ | 410.00$^{A}$ | 42.80$^{A}$ | 357.50$^{A}$ | 5.25$^{A}$ | 9.00$^{A}$ | 263.00$^{A}$ | 13.10$^{A}$ |
| CD (0.05) | 1.86 | 24.99 | 1.86 | 12.19 | 0.14 | 0.23 | 12.5 | 0.6 |

**Table 5.** Soil chemical property of field under different spacing of eucalypts

| Tree spacing (m) | pH | $EC_{1:2}$ (dSm$^{-1}$) | OC (%) | Available nutrients (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | | | | N | P | $K_2O$ |
| 6×3 | 7.94 | 1.7 | 0.39 | 112.8 | 12.4 | 228.2 |
| 7×3 | 7.92 | 1.9 | 0.38 | 111.4 | 12.3 | 219.5 |
| 8×3 | 8.01 | 2.1 | 0.32 | 105.7 | 10.2 | 216.6 |
| 9×3 | 8.02 | 2.0 | 0.30 | 104.8 | 10.1 | 212.4 |
| Control (Sole) | 8.01 | 2.1 | 0.30 | 102.4 | 9.8 | 215.1 |
| Mean | 7.98 | 1.96 | 0.34 | 107.4 | 10.9 | 218.4 |
| CD (0.05) | NS | NS | 0.05 | 5.3 | 1.4 | NS |

## CONCULSION

Minimum grain yield reduction was observed in barley at eucalypts spacing 9×3m followed by 8×3m. However, mustard also found to be suitable under eucalypts based agroforestry system in 9×3m spacing. Maximum B:C ratio was obtained with eucalypts + mustard agroforestry system under two spacing 9 × 3 m followed by 8×3 m and 7×3 m.

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