Biological Forum – An International Journal **14(3): 1030-1035(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Performance of Field Crops and Growth of Eucalyptus Clones under Eucalyptus based Agri-silvicultural System in Semi-arid Regions of Western Haryana

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(Received 24 June 2022, Accepted 05 August, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The experiment was carried out to study performance of two different crops such as barley and cowpea with eucalyptus different clones. It was carried out at 29°09'N latitude and 75° 43'E longitude at an elevation of 215.2 m above the mean sea level situated in the semi-arid region of western Haryana, India. Experiment was laid out in Randomized Block Design. The observations revealed that growth and yield attributes of both of the crops had higher value or performance in sole cropping as compare to agroforestry system with eucalyptus. Whereas, among the eucalyptus clones it was found that C-413 perform better in tree growth parameters *viz.* tree height, basal diameter and diameter at breast height, while the growth parameters and green and dry fodder yield were found higher under the interspaces of C-83 clone. The reduction in yield may be due to less PAR (Photosynthesis active radiation) interception and available energy below the canopy of eucalyptus species in comparison to sole crop (open condition).

Keywords: Eucalyptus, Growth, Agroforestry, Clones, Parameters.

INTRODUCTION

The population of the country is rising at an increasing pace, this has raised the demand for timber and non-timber wood products and ultimately also threatens the natural forest cover because of agricultural expansion and construction and industrialization. Besides this, managing the productivity of the soil is challenging the sustainability of the present mono-cropping system. These problems call for a holistic solution like agroforestry, which provides a dynamic land-use system that integrates both traditional knowledge and modern techniques where trees are managed with farm crops and livestock to enhance productivity, profitability, diversity and ecosystem sustainability. Along with this, agroforestry also helps in diversified and sustained food production and escalates ecosystem services through carbon storage, prevention of deforestation, biodiversity conservation, and soil and water conservation and ultimately, decreases the vulnerability of small-scale farmers to climate change in the long run (Murthy *et al.*, 2013). Agroforestry is a means of halting the vicious circle of deforestation, soil erosion and other environmental problems facing the country (Sobola *et al.*, 2015). In 2014, India became the first country in the world to adopt a national agroforestry policy. One of the major objectives of NFP 2014 is to encourage and expand tree plantation in a complementarity and integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of farmers (Cooperation, 2015). In India, major Agroforestry systems are estimated to cover 25.32 million ha (Kumar *et al.*, 2017). Agroforestry systems in the country are highly diverse in their function, structure, composition and on the basis of the climatic condition of the country and there are a number of multi-purpose trees species e.g., poplar, eucalyptus, teak, sal, acacias etc. that are found suitable for agroforestry systems depending upon the agro-climatic regions of the country.

Eucalyptus is one of the multi-purpose exotic trees that are most widely preferred for planting in cooperation with field crops because of its fast-growing habits, no negative effect on the production of field crops, straight bole, short rotation, higher density wood, higher timber production and returns (Luna, 2009). Eucalyptus is the second most widely planted species after teak, to be planted along the edges, or bunds, of agricultural fields, and appears to be well incorporated and accepted in agroforestry in India. In states like Haryana and Punjab, nearly 90% of the timber produced annually is generated outside the forests through sustainably managed plantations (Lal, 2010).

Eucalyptus is a genus of the Myrtaceae family endemic to Australia, Tasmania, and nearby islands. Eucalyptus plantations occupy more than 20 million hectares

worldwide, especially in tropical regions (Iglesias *et al.*, 2009; Laclau *et al*., 2010; Ribeiro *et al*., 2015). Productivity and profitability of eucalypt plantations have been revolutionized with the deployment of genetically improved clonal planting stock of Eucalypts since 1992. The average productivity of commercial eucalyptus clones is around 20 to 25 m^3 ha^{-1} yr^{-1} and many farmers have achieved record growth rates of 50 m^3 ha^{-1} yr^{-1} even under rain-fed conditions making clonal Eucalyptus plantations an economically attractive land-use option both for reforestation projects and agroforestry plantations (Lal, 2003, 2011)[8, 9]. Agroforestry and farm forestry promoted by the private sector with clonal eucalyptus plantations benefited thousands of farmers who planted 8 million ha from 1992 to 2007 (Piare Lal, 2015).

MATERIAL AND METHODS

Experimental site. Geographically, the experimental site is situated at 29° 09' N latitude and 75° 43' E longitude at an elevation of 215.2 m above the mean sea level situated in the semi-arid region of north-western India. The climate is subtropical-monsoon with an average annual rainfall of 350-400 mm, 70-80 percent of which occurs during July to September. The summer months are very hot with mean maximum temperature ranging from 40 to 45 °C in May and June whereas; December and January are the coldest months (lowest temperature may reach as low as 0°C). The soil of the experimental area classified as coarse loamy Typic Ustochrept according to Soil Survey Staff (1992), is alkaline but non saline and has loamy sand to sandy loam texture, low lime content and inadequate organic C and phosphorus. Nitrogen was also at a low level while potassium was medium in upper as well as in the deeper layers.

Experimental details. The fodder crop was intercropped under a one year old, pre-established plantation of four different eucalyptus clones *viz.,* C-7, C-413, C-83 and C-288 planted at spacing of 7×3 m during the kharif season of 2016-17. The randomized block design was used for assessing the variability of the clones and it was replicated three times. The standard package and practices as recommended by university were followed for raising of fodder cowpea crop. The fertilizer and irrigation requirements of trees were fulfilled from the irrigation and fertilizers application to the fodder crop. Growth measures of eucalyptus clones *viz*., Diameter at breast height (DBH), basal diameter, tree height and crown width were measured at the beijing and the end of the cropping season. Growth attributes of cowpea *viz*., plant population was recorded 20 DAS. Plant height and number of green leaves per plant were recorded at 50 percent flowering of cowpea. Fresh leaves and stem weight per plant, green and dry fodder yield of cowpea were recorded from each plot by quadrant method (using a quadrant of 1 × 1 m). Green leaves of cowpea from each plot were harvested, oven dried, grinded to powder form and analyzed for crude protein percentage by using formula

Crude Protein (%) = N content (%) × 6.25 (Ezeagu *et al.* 2002)

Crude Protein Yield = Crude protein content (%) × Total green fodder yield from cowpea (t/ha)

RESULTS AND DISCUSSION

The growth parameters of eucalyptus clones differ significantly as shown in Fig. 1.

The C-413 clone was reported to exhibit maximum height at the beginning of the year as well as the end of the cropping season, while the minimum height was recorded under the C-83 clone. The maximum increment in height was shown by the C-413 clone closely followed by C-7, C-288 and C-83 clones respectively. Similar trend was recorded for basal diameter and diameter at breast height (DBH). The C-413 clone exhibits maximum basal diameter and DBH while these parameters are reported as minimum by the C-83 clone as shown in Fig. 1. However, the maximum crown width was reported by the C-288 clone that was closely followed by the C-413 clone.

A. Growth performance of cowpea

Plant population. The plant population (m^{-2}) of cowpea showed a significant variation under the eucalyptus based agri-silvicultural system as depicted in Fig. 2. The number of plants per meter sq. was found maximum under the sole cropping system (crop devoid of trees) and among different clones, C-83 exhibits the maximum plant population followed by C-288, C-7 and least plant population was reported under C-413 clone. The reduction of plant population range from 25 to 68 % over sole cropping (crop without trees). Kiran *et al.* (2002) also revealed that plant population of wheat crop reduced up to 34 to 54 percent, respectively under *Eucalyptus teretocornis* and *Dalbergia sissoo* based agroforestry system.

Plant height and number of leaves per plant. The plant height and number of leaves per plant were higher in sole cowpea in comparison with cowpea intercropped with eucalyptus. However the plant height and number of leaves per plant both were reported higher under C-83 clone, while least under C-413 amongst the eucalyptus based agri-silvicultural system. Kumar and Nandal (2004) also evaluated that the entire test crop sown in the interspaces of *Eucalyptus teretocornis* 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.

Fodder yield of cowpea. The green and dry fodder yields of cowpea differ significantly under eucalyptus based agroforestry system. Both green and dry fodder yield were reported highest in sole cropping while under the eucalyptus based agri-silvicultural system, maximum fodder yield was found under C-83 clone and it was followed by C-7, C288 and C-413 clones. 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 percent, respectively) under agroforestry system as compared to the sole cropping. Kaushal and Verma (2003) also reported the negative effect of tree were more on growth and yield of the crop which were grown in its close vicinity. Rahangdale *et al.* (2014) recorded that the soyabean (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 per cent) 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).

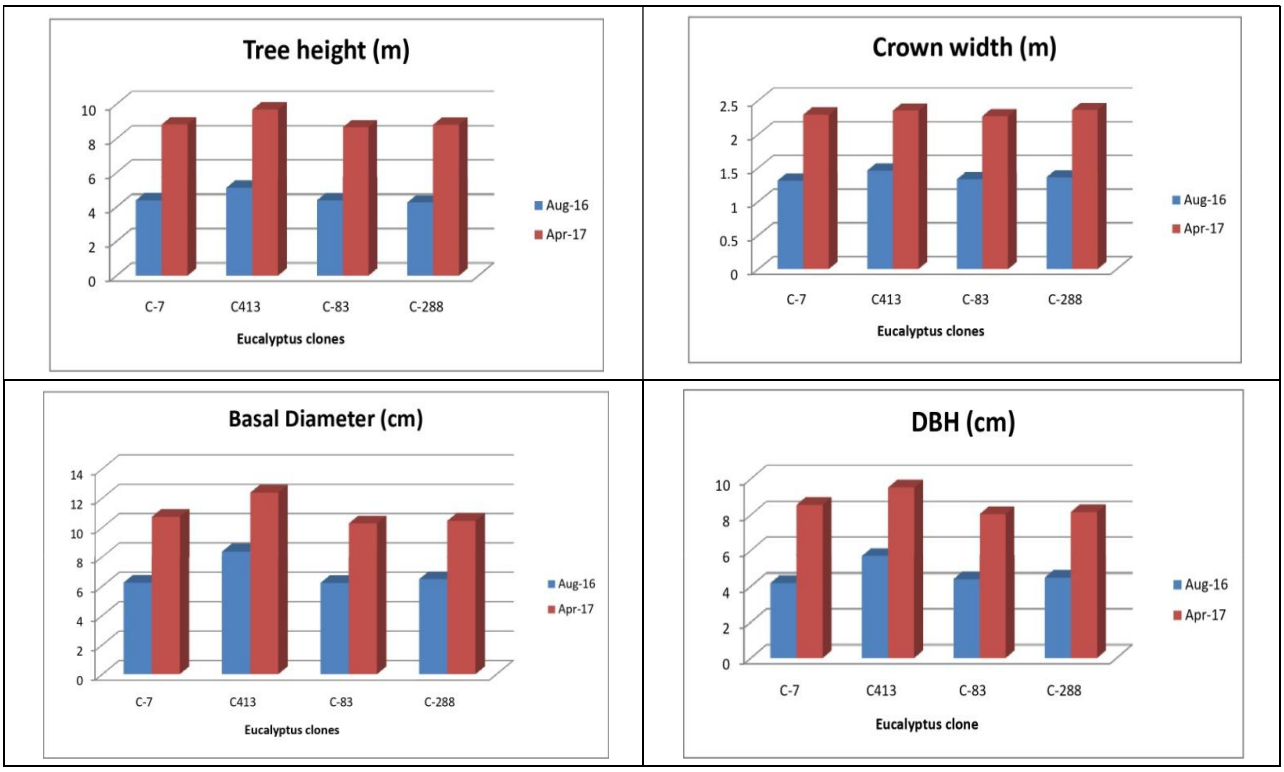

Fig. 1. Plant height, crown width, basal diameter and DBH of different eucalyptus clones under eucalyptus based agroforestry system.

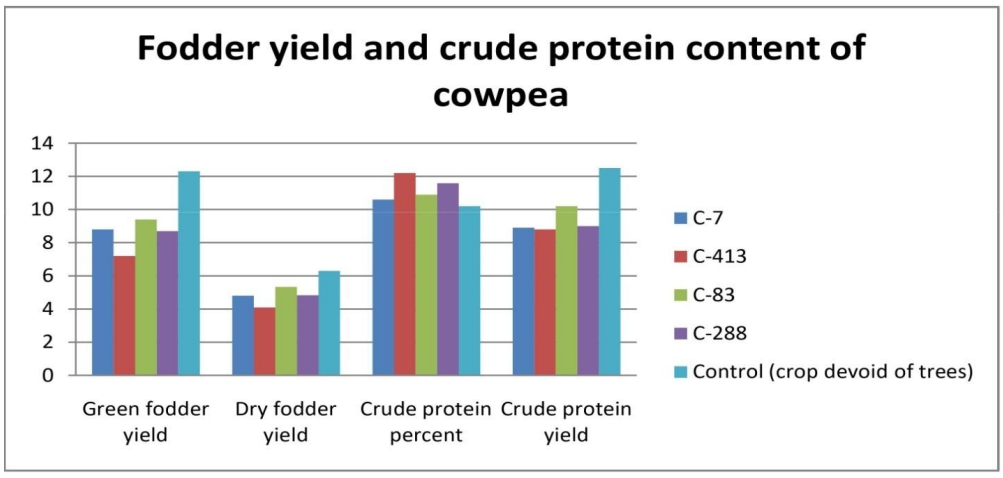

Fig. 2. Fodder yield and Crude Protein content of Cowpea.

Crude protein content and yield. The crude protein content and crude protein yield of cowpea showed a significant variation as shown in Fig. 2. The maximum crude protein content was found under C-413 clone followed by C-288, C-83 and C-7 clones. The minimum crude protein content was however minimum in sole

cropping. However, the crude protein yield was found maximum under sole cropping (crop devoid of trees) followed by C-83 clone and minimum under the interspaces of C-413 clone.

B. Growth performance of Barley

Plant population of barley. Plant population of barley varies significantly among different clones of eucalyptus. Amongst different eucalyptus clones, maximum number of plants was recorded under the interspaces of C- 83 clone and least under C-413 clone (Fig. 3). However, highest number of plant population was still under sole cropping (crop without trees).These results follow the pattern as same given by Khan *et al.* (2008) who found that aqueous extract of *Eucalyptus camaldulensis* inhibit the germination of wheat as compared to control treatment.

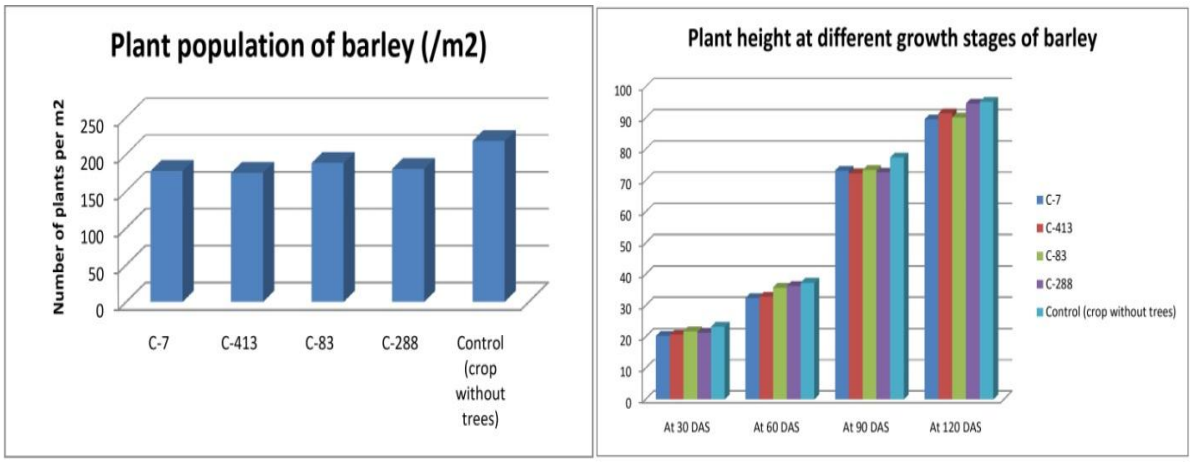

Fig. 3. Plant population and Height at different stages of Barley.

Plant height. Plant height of barley crop differed significantly under eucalyptus based agri-silvicultural system. Sole cropping (crop devoid of trees) exhibited maximum plant height at each observation followed by C-83 clone and least under C-413 clone (Fig. 3). Kumar *et al*. (2013) also found that less height of wheat under Eucalyptus plantation due to reduced light intensity under Eucalyptus.

Number of tillers and spikes. The number of tillers (/m^2) showed a significant variation under different eucalyptus clones at each observation (Fig. 4). The maximum number of tillers were recorded under C-83 clone and followed by C-288, C-7 and least under C-413. However, the maximum number of tillers was higher under sole cropping devoid of trees. The maximum number of spikes per plant was also highest under sole cropping and least under C-413 clone. Similarly Khan *et al*. (2008); Kumar *et al.* (2013) also observed lesser number of tillers under agroforestry system than sole cropping.

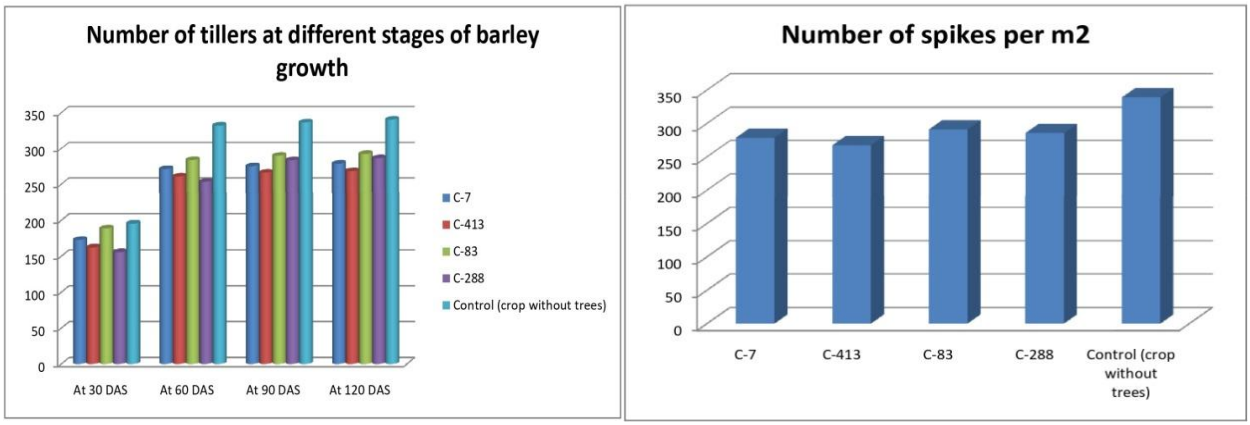

Fig. 4. Number of tillers and number of spikes of Barley.

Grains per spike and test weight. Grains per spike and test weight both show a significant variation of similar trend under the interspaces of eucalyptus clones. Both were recorded higher under sole cropping as compared to the interspaces of different eucalyptus clones (Fig. 5). Amongst the clones, C-83 exhibited maximum numbers of grains as well as test weight and least were recorded under C-413 clone. In the same pattern Daniel and Larkin (2017) also reported that grain per spike was more in control than agroforestry system.

Grain yield and straw yield of barley. The grains and straw yield of barley differed significantly under interspaces of eucalyptus clones. Both grain yield as well as straw yield was higher in sole cropping as compared to under eucalyptus clones (Fig. 5). C-83 clone showed maximum grain and straw yield closely followed by C-288 clone. The yield of barley was highly affected under the interspaces of C-413 and C-7 clones. As per the above finding Kumar *et al.* (2013) conducted a field experiment on wheat and mustard under *Eucalyptus teriticornis* and found that grain yield of both crops is decreased significantly as compared to sole cropping. The reduction (63.2%) was less in wheat. Sarvade *et al*. (2014) found that highest grain yield (36.0q ha) was under open farming system. The reduction in grain yield was 16-62% under agroforestry system as compared to sole crop.

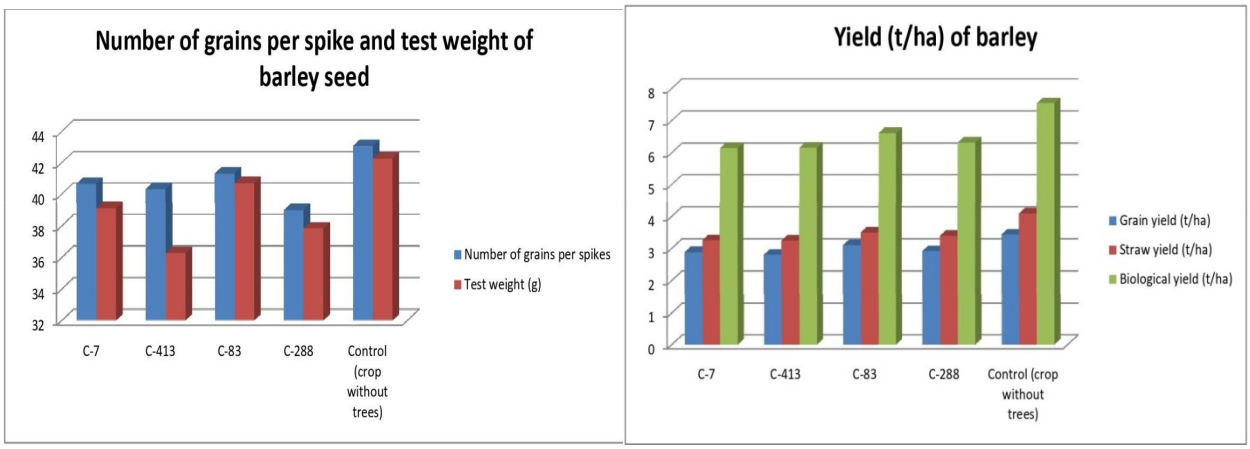

Fig. 5. Number of grains per spike, test weight and Yield of Barley.

CONCLUSION

Among the eucalyptus clones it was found that C-413 perform better in tree growth parameters *viz.* tree height, basal diameter and diameter at breast height, while the growth parameters and green and dry fodder yield were found higher under the interspaces of C-83 clone. The crude protein percent in cowpea was found higher under C-413 clone while the crude protein yield was higher under C-83 clone. Thus, the study concluded that clones C-413 and C-83 were found suitable for agroforestry on the basis of the objective of management of eucalyptus based agri-silvicultural system.

Acknowledgement. I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals. I would like to extend my sincere thanks to all of them. It has been great honour and priviledge to undergo research at Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana). I would like to express my gratitude towards my parents and members of Department of Forstry, CCSHAU, Hisar for their kind cooperation and encouragement which help me in completion of this research.

Conflict of interest. None.

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How to cite this article: Ashish Kumar, Manish Kumar, Pawan Kumar Poonia, R.S. Dhillon, Vijay Daneva and Harender Dagar (2022). Performance of Field Crops and Growth of Eucalyptus Clones under Eucalyptus based Agri-silvicultural System in Semi-arid Regions of Western Haryana. *Biological Forum – An International Journal*, *14*(3): 1030-1035.