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Performance of wheat crop under different tree crop combination of a land use system

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ABSTRACT

Agri-horti-silviculture system of agroforestry are very suitable to marginal or small farmers. The basic needs of food, fodder, fuel and timber for farmers in addition to its economic benefits can be easily fulfilled with this combination of cropping system. Among several combinations one of the suitable systems in hilly area with wheat, aonla and sissoo. A study was carried out to evaluate the performance of wheat as under storey crop with different proportion of tree combinations. Five treatments viz. 100% *Emblica officinalis*, 75% *Emblica officinalis* + 25% *Dalbergia sissoo*, 50% *Emblica officinalis* + 50% *Dalbergia sissoo*, 25% *Emblica officinalis* + *75% Dalbergia sissoo* and 100% *Dalbergia sissoo* were selected for the study. Wheat production trend was evaluated continuously for two years from 2017-18 to 2018-19. One-year old trees were planted with desired combinations in all the treatments. Wheat variety JW-3173 was grown in all two years. Significantly highest grain yield was recorded in agroforestry (AF) with 100% Aonla (1758.25 and 1519.5 kg/ha/yr during 2017-18 and 2018-19 respectively) than all other treatments. In case of straw yield and harvest index same trend was observed during both the years. The reduction of yield was observed due to increase of canopy of tree during subsequent years.

Key word: *Marginal farmer, Agri-horti-Silviculture, JW-3173, Equivalent yield etc.*

Introduction

For proper utilization of land and sustenance livelihood of small farmers, agroforestry practices of farming open new dimension in recent era of farming. Agroforestry is a sustainable land used system with tree, crop and livestock at the same time same unit of land. Word wide these systems are vastly adopted by the small farmers with or without modification of these components (Tree, crop and livestock) conferring to their climate and necessity of provenance or locality. The agroforestry systems and their wide adoptability through farmers were studied by several researchers across the world like park land agroforestry in the semi-arid and sub-humid zone of Africa (Boffa, 1999 and Kindya, 2004). These locally adopted systems are very important for livelihood security, income generation and environment protection. Agroforestry system is one of the options to conserve and regenerate natural resources in recent era. Till date India has been unable to achieve its target of 33% forest area cover, could be possible through agroforestry interventions. In Punjab, Haryana poplar and eucalyptus base agroforestry made both states self sufficient to meets industrial and timber requirements (Ahmed *et al.*, 2008). Similarly, Kerala has become wood surplus state due to adoption of agroforestry (Krishnankutty

et al., 2008). Upgraded agroforestry systems (agri–silvi–horti) for marginal and small farmers can fulfil basic needs, nutritional security and the timber requirement of industry (Kumar *et al.,* 2017a,b,c; Bijalwan 2017, 2019; Verma *et al.,* 2017). Improved or upgraded Agroforestry system has trapped the devotion of farmers across the world, especially in India where both forest and agricultural land are under severe stress due to population pressure and industrialization. The agroforestry creates micro-climate to beneath crop can enhance the productivity and yield of these crops. Productivity in agri–silvi–horticultural system is comparatively higher than the productivity of sole agriculture (Thakur et al. 2017). Soil quality and its production capacity can be restored and improved by adopting agroforestry system like agri–silvi–horti system, which provides a way to sustain agricultural productions (Thakur and Thakur, 2014; Thakur *et al.,* 2020; Rawat *et al.,* 2022) The integrating trees (forest and fruit) enhances overall productivities and incomes by ameliorating harsh environment of the area (Kaushik *et al.,* 2014; Thakur *et al.,* 2014, 2017, 2019; Bijalwan *et al.,* 2020; Kumar et al. 2021). Integration of horticulture components in agroforestry provide consistent & additional income with nutritional security in early stage of the system. The Silviculture component in system fulfil timber requirement and reduce burden on forest resource. Agri– silvi–horti system (*Dalbergia sissoo* + *Emblica offcinalis* + wheat) had very little effect on wheat yield as an agricultural crop; thus, this system may be recommended for adoption for marginal & small farmers in tropics to fulfil their basic requirements. These systems provide multiple benefits to farmers with conservation of natural resources. However, selection of best tree-crop combination is most important factor for viability and adoptability of a particular agroforestry system. Hence locality specific systems of farming have developed to fulfil basic needs with sustainability of natural resources.

Materials and Methods

Study area

The present investigations were carried out in Agroforestry unit of Krishi Vigyan Kendra (KVK), Indira Gandhi National Tribal University, Amarkantak M.P. India in the year 2017-2019. It lies between 22^0 15′ to 22^0 58′ North latitudes and 81^0 25′N to $82^0$5′ East longitudes. The mean daily maximum temperature ranges from 24^0 - 42^o C whereas its mean daily minimum temperature 2.4^{o}C in December-January months to maximum temperature of 42^0C in May–June months. Based on 20 years mean meteorological data, the average annual rainfall of the locality is 1350 mm, which mostly received between mid-June to end of September with an occasional winter shower during December and January months.

Experimental Details

The study was carried out in Randomized Complete Block Design (RCBD) with five treatments and four replications. One-year old Plants were planted with plant-to-plant distance of 4.5 meter and Row to Row distance of 5 meters. Sixteen plants were planted under each treatment in June 2016. Each plot was of 360 m^2. A bare strip of 2-meter-wide was maintained between each replication and treatment. Wheat crop variety JW-3173 was grown as under storey crop in all the treatments during Rabi 2018 and Rabi 2019. The variety JW-3173 has medium height, long bales and tolerant to diseases. The treatments comprised, T1: 100% *Dalbergia sissoo L.* (all 16 plants of *D. sissoo*), T2: 75% *Emblica officinalis Gaertn.* + 25% *Dalbergia sissoo L.* (12 plants of *E. officinalis* & 4 plants of *D. sissoo*), T3: 25% *Emblica officinalis Gaertn.* + 75% *Dalbergia sissoo L.* (4 plants of *E. officinalis* & 12 plants of *D. sissoo*), T4: 50% *Emblica officinalis Gaertn.* + 50% *Dalbergia sissoo L.* (8 plants of *E. officinalis* & 8 plants of *D. sissoo*), and T5: 100% *Emblica officinalis Gaertn.* (All 16 plants of *E. officinalis*). The crop was harvested after 128 days of sowing. Grain yield, straw yield and biomass yield were recorded by 1 m X 1 m crop cutting data. Five crop cutting data were recorded in each plot. The mean of these five data were considered for analysis. All data were analysed in RCBD design.

Results

Performance of Wheat grain, straw and Equivalent grain yield were analysed by preparing ANOVA for different years which is presented below.

Yield performance of Wheat crop 2017-18 & 2018-19

Grain yield

The statistically analyzed data presented in Table 1 and Fig.1 showed that Grain yield with significant

difference is recorded in treatments. Significantly highest yield is recorded in agroforestry (AF) with 100% Aonla (1758.25 & 1519.5 kg/ha/yr during 2017-18 and 2018-19 respectively) than 100% Sissoo, 25% Aonla + 75% Sissoo 50% Aonla + 50% Sissoo (T1: 1473/1426, T3: 1458.5/1453.75 and T4: 1593.5/1419 kg/ha/yr during 2017-18 and 2018-19 respectively). Grain yields are moderate and at par in 75% Aonla + 25% Sissoo (T2: 1661 and 1471 kg/ha/yr during 2017-18 and 2018-19 respectively). The statistically analysed pooled data showed that the soyabean crop produced Significantly highest yield is recorded in agroforestry (AF) with 100% Aonla (T5: 1638.88 Kg ha^{-1} yr^{-1}) than 100% Sissoo, 75% Aonla + 25% Sissoo, 25% Aonla + 75% Sissoo and 50% Aonla + 50% Sissoo (T1: 1449.5, T2: 1566 T3: 1436.13 and T4: 1506.25 Kg ha^{-1} yr^{-1}). Trend of reduction in g grain yield of under storey crop may be result of canopy development and expansion of rooting structure of trees.

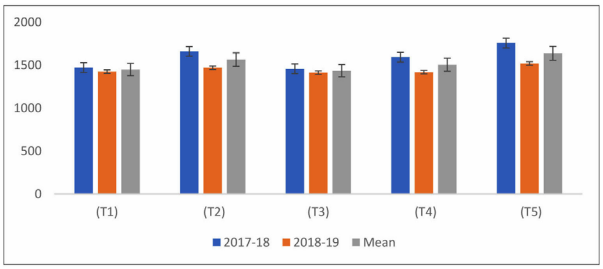

Fig. 1. Error bar graph of grain yield represent the significant difference of grain yield (kg ha-^{1} yr-^{1})

Straw yield

The statistically analysed data presented in Table 1 and Fig. 2 showed that the wheat crop gave higher straw yield production growing with 100% Aonla (2420 & 2063.75 kg/ha/yr during 2017-18 and 2018-19 respectively) however it is at par with all treatment. The statistically analysed pooled data showed that the wheat crop produced Significantly highest yield is recorded in agroforestry (AF) with 100% Aonla (T5: 2241.88 Kg ha^{-1} yr^{-1}) than 100% Sissoo, 75% Aonla + 25% Sissoo (T1: 2133.38 and T2: 2030 Kg ha^{-1} yr^{-1}). The straw yield of wheat crop during both the years shows same trend as grain yield of underlying crop during course of investigation

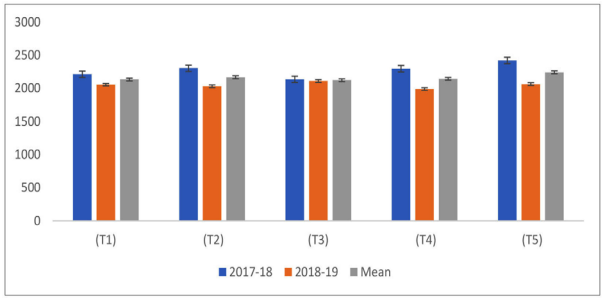

Fig. 2. Error bar graph of Straw yield represent the significant difference of straw yield (kg ha-^{1} yr-^{1})

Harvest index

The perusal of data presented in Table 1 and Fig.3 showed that the harvest index of wheat crop during 2017-18 was significantly higher in 100% Aonla (T5: 42.11%) than100% Sissoo (T1: 39.47%). However, it was significantly at par with 75% Aonla + 25% Sissoo, 25% Aonla + 75% Sissoo and 50% Aonla + 50% Sissoo (T2:41.89, T3: 40.61 and T4: 41.01%). Harvest index during 2017-18 was significantly at par with other treatments. During 2018-19 the trend of harvest index show that significantly higher harvest index observed with 100% Aonla (T5: 39.23%) than 25% Aonla + 75% Sissoo (T3:40.15%). All other

Table 1. Treatment wise grain, straw yield and harvest index of wheat crop in 2017-18 to 2018-19

Land use systems	Grain Yield (Kg ha^{-1} yr^{-1})			Straw Yield (Kg ha^{-1} yr^{-1})			Harvest Index (%)		
	2017-18	2018-19	Mean	2017-18	2018-19	Mean	2017-18	2018-19	Mean
100% D. sissoo (T1)	1473.00	1426.00	1449.50	2212.50	2054.25	2133.38	39.97	41.00	40.49
75% *E. officinalis* + 25% *D. sissoo* (T2)	1661.00	1471.00	1566.00	2303.25	2030.00	2166.63	41.89	42.03	41.96
25% *E. officinalis* + 75% *D. sissoo* (T3)	1458.50	1413.75	1436.13	2135.50	2110.25	2122.88	40.61	40.15	40.38
50% *E. officinalis* + 50% *D. sissoo* (T4)	1593.50	1419.00	1506.25	2296.50	1988.75	2142.63	41.01	41.67	41.34
100% *E. officinalis* (T5)	1758.25	1519.50	1638.88	2420.00	2063.75	2241.88	42.11	42.44	42.27
SEm±	63	22.2	22.8	105.6	62.5	34.3	0.7	0.72	0.14
CD at 5% (P= 0.05)	188	66.3	67	315	186.5	100.7	2.1	2.2	0.42

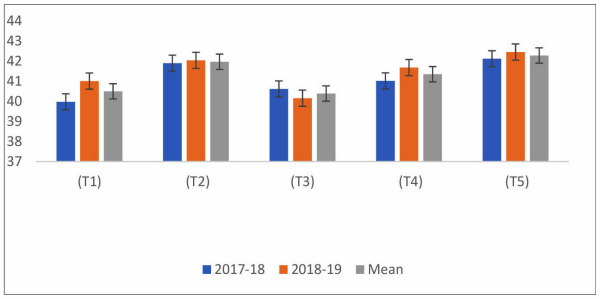

Fig. 3. Error bar graph of harvest index represent the significant difference of harvest index (%)

treatments were moderately at par with each other.

Discussion

The mean yield of grain, straw and harvest of the experiment are in declining trend from 2018 to 2019. As the age of tree increase, yield of crop may decline due to morphological development of adjacent tree components. Several researchers across the globe also conclude same findings (Hauggaard-Nielsen *et al.,* 2006; Bayala *et al.,* 2012; Kumar *et al.,* 2017a,b,c; Verma *et al.,* 2017; Bijalwan *et al.,* 2020). Li *et al.* (2008) reported that due to overhead shading, wheat yield inside the tree-based intercropping system was 51% lower than that outside the intercropping in a Paulownia/wheat intercropping system in China. The degree of competition will also play important role to decide tree-crop combination in agroforestry system. There are several tree-crop combinations in which tree-crop component promote yield of each other compared to the sole crop. The tree with monolayer canopy with deep root system promotes yield of crop. The tree canopy regulate light to understorey crop at same time deep root system extract or pulled out nutrient from deeper layer of soil and provide to adjacent crop. The present study revealed different type of tree-crop combination, in which tree having mono layer canopy and deep root system viz; *Emblica offcinalis* observed maximum yield followed by 75% (*E.offacinalis*)+ 25% (*D. Sissoo*). The present study also supported by other researchers worldwide (Toky OP *et al.,* 1992; Kaushik *et al.,* 2017; Thakur *et al.,* 2014; 2019; Mishra *et al.,* 2021). The age of tree become 3-year in *Rabi* 2018. Tree increases its biomass which affect the yield of wheat in few treatments however this effect is partial. In the *Rabi* 2019 the age of tree become 4-year. Its height, canopy and lateral roots expanded. In this year the impact of tree growth was more pronounced on under storey crop. There was significant variation in grain, straw, biomass and equivalent grain yields among the selected five treatments. The strong competition in agroforestry system for resources like light, space, moisture and nutrient affect the yield of crops in various manners. The yield of underneath crop with pure sissoo tree was significantly lower compare to pure *Emblica officinalis* component, which is significantly higher among the treatments. Dalbergia sissoo, have strong habit to produce more side roots (sucker) and closed crown canopy. The *Emblica officinalis* have phyllode type of leaf morphology; make easy availability of light & moisture to under storey crop. The leaves of *Emblica officinalis* decomposed easily compare to sissoo leaves. Higher rate of litter decomposition makes easy availability of nutrient to under storey crop. Morphological characters of tree contribute a reasonable impact to reduce tree-crop competition in agroforestry system (Sahoo *et al.,* 2021). The micro climate created by tree species play significant role to yield attributes of under storey crop. The microclimate creates by tree encourage easily availability of nutrient from soil which would be responsible for higher yield of underlying crops. The potential of agroforestry systems to enhance soil fertility, maintain OC and ameliorated soil ph has already been recognized (Yadav *et al.,* 2008; Githae *et al.,* 2011 and Seddaiu *et al.,* 2013). In overall view, adaptation of agroforestry system is very essential for conservation and sustainable use of natural resources.

Conclusion

During the present study different assortment of tree-crop combination were analysed. The current study revealed that an agroforestry system comprises all three components (Tree, fruit tree & crop) is best appropriate to marginal or small farmers in all aspects of life. As timber tree, reduce the additional burden on forest resources at the same time fruit tree may be source of income and provide nutritional security to their families. The agriculture crop grown with these systems provide food for their livelihood. However, it is also advisable to farmers to grow these components in appropriate assort like 75% fruit tree with 25% timber tree and agricultural crop, the species of tree component and crop may be replaced with other species and crops according to climatic condition and necessity of particular area.

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