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Evaluation of varietal growth and productivity performance of wheat under Jatropha based agroforestry system

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Abstract
The field experiment was conducted during the Rubi season 2020-21 at Forestry Research farm, Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh to evaluate the effect of different agroforestry systems on productivity of wheat with respect to insect pest. Result revealed that the performance of wheat varieties under different agroforestry system such as Jatropha+wheat, Guava+wheat, *Acacia nilotica*+wheat was compared to that of wheat grown in open condition (sole wheat crop). The highest number of plant population per m row length (41.08), Height of plant (97.64 cm), number of tillers per m row length (65.26) and highest length of spike (10.41 cm), Grain yield (3795 kg ha^{-1}), Straw yield (4759 kg ha^{-1}) and Biological yield (8554 kg ha^{-1}) was recorded under open condition (sole wheat) and significantly higher than that under Jatropha+wheat, Guava+wheat, and *Acacia nilotica*+wheat. However among the agroforestry system maximum plant population per m row length (38.20), Height of plant (96.44 cm), number of tillers per m row length (63.99) and highest length of spike (9.04 cm), Grain yield (3579 kg ha^{-1}), Straw yield (4546 kg ha^{-1}) and Biological yield (8125 kg ha^{-1}) recorded under Jatropha+wheat based system followed by Guava+wheat and *Acacia nilotica*+wheat based agroforestry system. In which wheat variety JW-3382 response maximum plant population per m row length (38.91), Height of plant (92.93 cm), number of tillers per m row length 64.02. and length of spike (9.50 cm), Grain yield (3451 kg ha^{-1}), Straw yield (4428 kg ha^{-1}) and Biological yield (7879 kg ha^{-1}) under Jatropha based agroforestry system followed by JW-3288, JW-3211 and GW-322 wheat variety.

Keywords: Agroforestry systems, growth parameter, plant population, yield attribute, biological yield etc.

1. Introduction
Agroforestry systems are characterized by land use management in which trees are grown in combination with agricultural crops or pastures, and/or animals at the same time (Quinkenstein *et al*. 2009, Cardinael *et al*. 2017) [25, 5] to improve temporal resource capture among species (Artru *et al.* 2017) [2], and thus, increase the efficiency of resource utilization (such as nutrients, light and water) (Nair *et al*. 2008 [19]). Agroforestry is a tool to modify the microclimate under field conditions. The micro-environment under tree canopy enhances biological activity and accelerates the crop performance through yield attributes and yield (Chauhan *et al.* 2012) [2]. Tree crop interaction is a complex phenomenon numerous reports documents favorable and harmful effect of trees on agricultural crops grown under their shade. The changes are more pronounced with increase in tree size and stand density (Harsh and Tewari, 1993) [10].

Wheat (*Triticum aestivum* L.) is one of the major cereal crops of the world. It is grown extensively under agro-forestry system in central and northern India. In India, wheat is second most important food crop, next to rice, with an area of 31.62 million hectares and production of 109.52 million tons (Anonymous, 2021) [1]. Growth and yield of wheat are affected by environmental conditions and can be regulated by sowing time and seeding rate (Ozturk *et al*., 2006) [21]. Highest wheat production is the understanding of an early crop establishment. Beside other agronomic factors seed rate and sowing method are major factors which determines the crop vigour and ultimate yield (Korres and Froud, 2000) [14].

Jatropha curcas L. is a non-food bioenergy plant belongs to the *Euphorbiaceae* family. Jatropha is a multipurpose plant that originated in Central America but can now be found throughout the tropics, including Africa and Asia (Openshaw 2000) [20]. Jatropha is a tropical plant and can be grown in low to high rainfall and diverse soil types. Integration of Jatropha

cultivation into a properly designed agroforestry system can reduce social, economic and environmental risks and conflicts of Jatropha biodiesel production. Jatropha has specific characteristics which make it suitable for more multifunctional agroforestry options such as Jatropha can be used for contour hedges as well. Jatropha is currently cultivated in tropical and subtropical areas of the world. It can reach a height of up to 6m, and it is a semi-evergreen, poisonous shrub, or small tree. It was recommended for cultivation in deserts because it is resistant to arid conditions. From the seeds of Jatropha, high-quality biodiesel fuel is produced for use in standard diesel engines. Seeds contain 27–40% oil. It is known for the production of biofuel. Jatropha can be considered a second-generation biofuel plant that may provide a portion of the fuel supply. Roots and leaves can be used to make antibiotics and products for the treatment of skin diseases (Henning, 2002) [11]. Being rich in nitrogen (N), the seed cake can be an excellent plant nutrient source if detoxified (Makkar *et al*. 1998) [17]. The detoxified cake by-product from oil extraction can be used for fish and animal feed, biogas, or as an organic fertilizer.

2. Method and Material

2.1 Experimental location, topography and climate

The present investigation was carried out at Forestry Research farm, Department of Forestry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, MP. during Rabi season of 2020-21 under well established plantation of Jatropha. Study area lies at 23°12'50" North latitude & 79°57'56" East longitude. Study area belongs to Kymore Plateau and Satpura Hills Agro-climatic Zone with a subtropical climate with hot, dry summers and cold, dry winters as per classification of National Agricultural Research Project and is broadly known as rice-wheat crop zone of Madhya Pradesh In May and June, the temperature reaches 46 °C, while in December and January, it drops to 2 °C. The average annual rainfall in the area is 1350 mm, with most of it falling between June and September. The soil is reasonably deep black, and the region is simple to softly sloppy (0-1 percent).

2.2 Experimental details

The experiment was laid out under well stablished plantation of jatropha with 5 m × 5 m meter spacing where plot size kept 5 m × 4 m and replicated four times with a field border of 1m and crop are showed in row which maintained row to row spacing of 20 cm and plant to plant spacing of 10 cm. the experiment was carried out in split plot design with four main plot treatement *viz*. Jatropha+wheat, Guava+wheat, *Acacia nilotica*+wheat and open condition (sole wheat crop) and four sub plot treatment. In which varieties of wheat JW-322, JW-3211, JW-3288, JW-3382.were showed in each treatment.

2.3 Growth and yield attributes of wheat under Jatropha based agroforestry

2.3.1 Plant population (one meter row length)

One meter row length area was selected randomly from all the plots of each treatment and each replication. Later on the number of plants are counted from each row and the average was taken for calculation at 20 days after sowing.

2.3.2 Height of plant (cm)

At the harvesting stage, the plant height was measured in centimeters from the ground level up to the base of the last fully open leaf. Five random plants were selected from each treatment plot for height measurement and obtained mean height

2.3.3 Number of tillers (one m row length)

Total number of tillers per meter row length at harvest stage were recorded by counting from five marked row in each plot and the mean values were calculated.

2.3.4 Length of spike (cm)

Total length of spikes was measured on five plants, from their base to tip of the spikes (excluding awns) which were taken from sample plant from all the plot of each treatment and each replication. Average length of spike was worked out by dividing the total length of spike by five.

2.3.5 Grain yield (kg ha^{-1})

After determine the biological yield the produce was sun dried, thrashed, cleaned and then weighed to record grain yield per plot and expressed in kg ha^{-1}.

2.3.6 Straw yield (kg ha^{-1})

Grain yield of the produce was subtracted from the total biological yield obtained for each net plot to get straw yield of each treatment and expressed in kg ha^{-1}.

2.3.7 Biological yield (kg ha^{-1})

The biological yield including grain and straw from each net plot was sun dried after harvesting and weighed. Biological yield was expressed in kg ha^{-1}.

3. Result

Among the main plot treatments, all the growth contributing characters *viz.* Plant population per meter row length, Height of plant (cm), Number of tillers per meter row length and Yield parameter *viz.* Length of spikes (cm), Grain yield (kg ha^{-1}), Straw yield (q ha^{-1}) and Biological yield (kg ha^{-1}) increased with an increase in light intensity and photosynthesis rate in open environment. The highest number of Plant population per m row length (41.08), Height of plant (97.64 cm), number of tillers per m row length (65.26) and highest length of spike (10.41 cm), Grain yield (3795 kg ha^{-1}), Straw yield (4759 kg ha^{-1}) and Biological yield (8554 kg ha^{-1}) was recorded under open condition (sole wheat) and significantly higher than that under Jatropha+wheat, Guava+wheat, *Acacia nilotica*+wheat based agroforestry system. Table 1.

Table 1: Performance of growth and yield attributes of wheat under different agroforestry and open farming system.

Treatment	Plant population (per m row length)	Height (cm) at harvest	Number of tillers (per m row length)	Length of spikes (cm)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})
Babool+ wheat	34.74	80.02	61.24	8.57	28.64	38.54	67.11
Guava+ wheat	37.30	95.13	62.15	8.88	33.26	43.58	76.84
Jatropha+ wheat	38.20	96.44	63.99	9.04	35.79	45.46	81.25
Open (sole wheat)	41.08	97.64	65.26	10.41	37.95	47.59	85.54
Sem	0.42	0.45	0.61	0.33	0.34	0.35	0.64
CD at 5%	1.34	1.45	1.95	1.07	1.10	1.12	2.06
Wheat varieties							
GW-322	36.42	91.61	62.46	9.09	33.37	42.88	76.16
JW-3211	37.78	92.01	62.80	9.16	33.62	43.90	77.52
JW-3288	38.20	92.69	63.36	9.15	34.15	44.13	78.28
JW-3382	38.91	92.93	64.02	9.50	34.51	44.28	78.79
Sem	0.52	0.43	0.42	0.35	0.35	0.44	0.65
CD at 5%	1.72	1.42	1.39	1.17	1.16	1.47	1.85

However among the different agroforestry system maximum plant population per m row length (38.20), Height of plant (96.44 cm), number of tillers per m row length (63.99) and highest length of spike (9.04 cm), Grain yield (3579 kg ha^{-1}), Straw yield (4546 kg ha^{-1}) and Biological yield (8125 kg ha^{-1}) recorded under Jatropha based agroforestry system followed by Guava+wheat and *Acacia nilotica*+wheat based agroforestry system. In which wheat variety JW-3382 response maximum Plant population per m row length (38.91), Height of plant (92.93 cm), number of tillers per m row length (64.02) and length of spike (9.50 cm), Grain yield (3451 kg ha^{-1}), Straw yield (4428 kg ha^{-1}) and Biological yield (7879 kg ha^{-1}) under Jatropha based agroforestry system followed by JW-3288, JW-3211 and GW-322 wheat variety.

Discussion

This study aimed to see how different agroforestry tree component affect to wheat growth and yield contributing charachtristics under Jatropha+wheat, Guava+wheat and *Acacia nilotica*+wheat based agroforestry system. Compared to an agroforestry system growth and yield contributing factors were higher in open circumstance i.e., without tree. The most likely reason for this that in an open environment, more light is accessible to the crop resulting in a batter rate of photosynthesis, cell multiplication and eventually a larger yield. Puri *et al.* (2001) [24]. Observed that when a wheat crop was grown beneath *ceiba pentandra*, the growth and yield contributing features were altered by tree as compared to solitary cropping. Goyal *et al*. (2001) [8], Pandey *et al*. (2001) [23], Dhillon *et al.* (2007) [7], Palai *et al.* (2021) [22], Sahoo *et al.* (2020) [26] have all found similar findings. Corroborative findings have also been reported by Bargali *et al.* (2004) [3] also reported similar findings of chickpea crop under *Acacia nilotica* based agroforestry system. The plant population per meter row length of chickpea increased as the distance from the tree line increased similar findings were recorded by Kaushik and Singh (2001) [12], Singh *et al.* (2012) [28] and Sarvade *et al.* (2014) [27]. Tripathi *et al*. (2006) [30] reported that plant height was more under open farming system than agroforestry system. Kumar *et al.* (2013) [15] found that less height of wheat under Eucalyptus plantation due to reduced light intensity as compared to sole cropping. Sirohi *et al.* (2016) [29] who reported that the growth attributes like total number of tillers and effective tillers of various wheat varieties (WH1105, WH-542, HD-2967, HD-943 and DPW-621-50) were also affected significantly under 5 × 4 m spacing poplar based agroforestry system. Gill *et al.* (2009) [9] reported that spike length decreased under trees due to lower production of photosynthates under low light conditions as the light intensity decreased under trees. Malik and Sharma (1990) [18] reported that the grain yield of wheat grown in continuous shade was lower than under periodical shade. Kumar *et al* (2006) [16] also observed lower straw productivity under narrow tree spacing as compared to broader spacing. Kar *et al.* (2022) [13]. Reported that all the yield contributing characters, grain yield and straw yield increase with an increase in light intensity on crop under agroforestry system. Bisht *et al*. (2017) [14]. They found that the more reduction in biological yield of wheat under eucalyptus based agroforestry system as compared to sole crop.

Conclusion

The above field trial revealed that the light intensity and canopy density play an essential role to enhancing crop output in an agroforestry system. In this study Jatropha+wheat based agroforestry system perform batter in all growth and yield contributing characteristics. It recorded maximum number of plant population per m row length, Height of plant(cm), Number of tillers per m row length, length of spike(cm), Grain yield (kg ha^{-1}), Straw yield (kg ha^{-1}) and Biological yield (kg ha^{-1}) followed by Guava+wheat and *Acacia nilotica*+wheat. In which among the wheat variety JW-3382 recorded maximum growth and yield under Jatropha+wheat followed by Guava+wheat and *Acacia nilotica*+wheat based agroforestry system.

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