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Performance of three pulse crops under *Gmelina arborea* based landuse systems in Madhya Pradesh, India

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Abstract
An investigation was carried out in 2022-23 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. Treatments consisted of 7-year old *Gmelina arborea* tree (8 m x 2.5 m spacing) as woody crop and arhar, cowpea and greengram as intercrops in kharif season. The experiment was carried out in Randomized Block Design. Various growth parameters like crop height, number of branches, number of pods per plant and grain yield of the crops were studied. Arhar sole reflected significantly higher height growth (198 cm) at harvest whereas Greengram as sole as well as with *Gmelina arborea* recorded significantly lower value (56 cm, 50 cm, respectively). Significant variation was also observed in number of branches which ranged from 5.2-21.2durig harvest. Arhar sole recorded significantly higher value and Greengram as sole as well as with *Gmelina arborea* recorded significantly lower value. The number of pods varied from 16.4-97.2. Arhar sole had significantly higher number of pods whereas Cowpea as sole as well as with *Gmelina arborea* recorded significantly lower number of pods. Grain yield of different intercrops ranged from 7.42-9.26 q/ha. Arhar sole reflected significantly higher yield (9.26 q/ha). Greengram with *Gmelina arborea* recorded significantly lower yield.

Keywords: Agroforestry systems, *Gmelina arborea*, arhar, cowpea, greengram

Introduction
Agroforestry is an important landuse system in the present scenario of climate change and sustainable food production. Both ecologically and economically it is one of the most beneficial landuse system. Multifunctional properties of agroforestry are the part of the solution to address the issues, whether those be environmental, economic or social. *Gmelina arborea* based agrisilvicultural practices has the potential to provide higher income as well as protect soil health (Swamy *et al*., 2003) [12]. The species has the potential to store carbon and is also remunerative due to its multiple uses (Sahoo and Wani, 2019) [9]. It is contributing to 0.47% of total volume of trees under agroforestry systems of the country (ISFR, 2013) [5]. In addition to timber, wood of the tree is used for fuel wood, paper and pulp making, and is used in other forest based industries (Verma *et al*., 2017) [13].Various plant parts like root, fruit, leaf, flower, bark etc. can be used pharmaceutically and is an essential component among Dashamuala, Rasayana (rejuvenation), Medhya (Memory enhancer) and Vrishya (Aphrodisiac) (Pathala *et al*., 2015) [8]. The crops like cowpea, arhar and greengram are considered compatible to grow under *Gmelina arborea* based agroforestry practices. These crops are leguminous crops having good nitrogen fixing ability and help in maintaining the nitrogen content in the soil. In the present study, the performance of three pulse crops was studied under *G. arborea* based agroforestry system.

Materials and Methods
The investigation was carried out in 2022-23 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. The mean annual rainfall of the locality is 1350 mm which is mostly received during mid June to end of September. The mean maximum temperature varies from 40-42 °C during May - June and mean minimum temperature varies from 5.3-6.1 °C during December- January. Treatments consisted of 7-year old *Gmelina arborea* (8m x 2.5m spacing) as woody crop and arhar (var. TJT 501), cowpea (var. CP-4) and greengram (var. TJM 3) as intercrops in kharif season. The experiment was carried out in Randomized Block Design with five replications. Various growth and yield parameters were studied to assess the performance of different crops and their combinations.

Results and Discussion

Height of crop plant

The plant height of different intercrops varied significantly under different treatments (Table 1). At 30 days after sowing (DAS) cowpea sole recorded maximum value (49 cm) which was at par with T_2 and T_7. The minimum height was recorded under *G. arborea* + Arhar (T_1). At 60 DAS plant height ranged from 50-88cm. Arhar sole attained maximum height which showed parity with T_1, T_2 and T_6.Greengram with *Gmelin aarborea* (T_3) positioned last. At harvest significant variation was also observed in plant height which ranged from 50-198cm. Arhar sole (T_5) reflected significantly higher value over others. Greengram (T_7) as sole as well as with *Gmelina arborea* (T_3) recorded significantly lower value. The height of crops progressively increased from 30 DAS to harvest stage. Arhar initially put slow growth but after 60 DAS it crossed over others in open condition as well as with tree. The height of all crops in open condition was higher than the respective crops under trees.

Table 1: Crop plant height (cm) in different landuse systems in Madhya Pradesh

Name of the system	30 DAS (D_1)	60 DAS (D_2)	At harvest (D_3)
G. arborea + Arhar (T_1)	36^{b}	83^{a}	172^{b}
G. arborea + Cowpea (T_2)	45^{ab}	78^{a}	84^{c}
G. arborea + Greengram (T_3)	40^{b}	50^{b}	50^{d}
G. arborea Sole (T_4)	-	-	-
Arhar Sole (T_5)	38^{b}	88^{a}	198^{a}
Cowpea Sole (T_6)	49^{a}	82^{a}	91^{c}
Greengram Sole (T_7)	43^{ab}	56^{b}	56^{d}
$SE_{(m)}$	2.8	3.4	6.5
$CD_{(0.05)}$	8.3	10.0	19.4

The plant height of three pulse crop varied significantly under different landuse system in three different periods. This may be because of difference in genetic makeup of three crops, growing condition and period of growth. The height of plants increased with time till their harvest due to cumulative growth. At harvest, arhar exhibited maximum height both in open as well as along trees which may be ascribed to its long duration of about five months which is quite high in comparison to cowpea and greengram. Further, the height of crops in open condition was comparatively higher than the plants with tree which may be due to more light availability in open conditions. The findings are in line with (Artu *et al*., 2017; Dhyani *et al*., 2009 and Sharma *et al*., 2023) [2, 4, 11].

Number of branches of crop plant

The number of branches in different intercrops varied significantly under different treatments (Table 2). At 30 DAS greengram as sole (T_7) as well as with *Gmelina arborea* (T_3) recorded significantly higher values such as 5.4 and 5.2, respectively over other treatments. At 60 DAS the number of branches ranged from 5.2 to 9.4. Arhar sole had maximum number of branches which is significantly higher over other treatments. Greengram with *Gmelina arborea* (T_3) positioned last. At harvest significant variation was also observed in number of branches which ranged from 5.2 to 21.2. Arhar sole (T_5) reflected significantly higher value over others. Greengram as sole (T_7) as well as with *Gmelina arborea* (T_3) recorded significantly lower values. The number of branches progressively increased from 30 DAS to harvest stage. Arhar initially put slow growth but after 60 DAS it crossed over others in open condition as well as with tree. Number of branches of all crops in open condition was higher than the respective crops under trees.

Table 2: Number of branches/crop plant in different land use systems in Madhya Pradesh

Name of the system	30 DAS (D_1)	60 DAS (D_2)	At harvest (D_3)
G. arborea + Arhar (T_1)	0.0^{d}	8.8^{b}	21.2^{b}
G. arborea + Cowpea (T_2)	4.0^{c}	6.0^{c}	6.0^{c}
G. arborea + Greengram (T_3)	5.2^{a}	5.2^{d}	5.2^{c}
G. arborea Sole (T_4)	-	-	-
Arhar Sole (T_5)	0.0^{d}	9.4^{a}	22.8^{a}
Cowpea Sole (T_6)	4.4^{b}	6.2^{c}	6.2^{c}
Greengram Sole (T_7)	5.4^{a}	5.4^{d}	5.4^{c}
$SE_{(m)}$	0.11	0.16	0.34
$CD_{(0.05)}$	0.33	0.48	1.02

The number of branches in different crops varied remarkably under different treatments which may be due to varied genetical character of different crops and variation in light availability. It increased progressively with age because of enhancement of height. Arhar demonstrated significantly higher number of branches both in open condition as well as in agroforestry system over other crops due to its higher height and longer duration in comparison to other crops. Greengram recorded lower value at the time of harvest both in open and in agroforestry system because of its lower height and shorter duration than others. In all crops number of branches was comparatively higher in sole condition than their corresponding value with tree may be due to their higher height growth in open condition.

Number of pods of crop plant

The data in Table 3 shows that number of pods per plant in different intercrops varied significantly under different treatments. At 30 DAS no pod was developed in all the treatments. At 60 DAS the number of pods per plant ranged from 0.0-25.2 and greengram sole had maximum number of pods (25.2) which was significantly higher over other treatments followed by greengram with *Gmelina arborea* (22.2). At harvest significant variation was also observed in number of pods which ranged from 16.4 to 97.2 and arhar sole (T_5) reflected significantly higher value over others. Number of pods of all crops in open condition was higher than the respective crops under trees.

Table 3: Number of pods per plant in different landuse systems in Madhya Pradesh

Name of the system	30 DAS (D_1)	60 DAS (D_2)	At harvest (D_3)
G. arborea + Arhar (T_1)	0.0	0.0^{d}	82.8^{b}
G. arborea + Cowpea (T_2)	0.0	13.6^{c}	14.1^{d}
G. arborea + Greengram (T_3)	0.0	22.2^{b}	22.2^{cd}
G. arborea Sole (T_4)	-	-	-
Arhar Sole (T_5)	0.0	0.0^{d}	97.2^{a}
Cowpea Sole (T_6)	0.0	14.2^{c}	16.4^{d}
Greengram Sole (T_7)	0.0	25.2^{a}	25.2^{c}
$SE_{(m)}$	-	0.67	2.53
$CD_{(0.05)}$	N.S.	1.99	7.52

The number of pods under different treatments varied remarkably at 60 DAS and at harvest. At 30 DAS no pod was formed because all plants were in vegetative phase. Even

arhar witnessed no pod at 60 DAS because it was still under vegetative stage. At harvest the variation of pod number under different treatments may be attributed to difference in the genetic character of crops and light condition. Arhar witnessed maximum number in open followed by agroforestry system because of its higher height and number of branches. All crops recorded more number of pods in open condition than agroforestry system because of more height and branches.

Grain yield of crops

At harvest significant variation was also observed in grain yield of different intercrops which ranged from 7.42-9.26q/ha. Arhar sole (T_5) reflected significantly higher yield which was at par with T_6.Greengram with *Gmelina arborea* (T_3) recorded significantly lower yield than other treatments and showed parity with T_2.

Table 4: Yield of crops (q/ha) in different landuse systems in Madhya Pradesh

Name of the system	Grain yield at harvest (Kg/ha)
G. arborea + Arhar (T_1)	7.88^{bc}
G. arborea + Cowpea (T_2)	7.42^{c}
G. arborea + Greengram (T_3)	6.94^{c}
G. arborea Sole (T_4)	-
Arhar Sole (T_5)	9.26^{a}
Cowpea Sole (T_6)	8.62^{ab}
Greengram Sole (T_7)	7.82^{bc}
$SE_{(m)}$	0.31
$CD_{(0.05)}$	0.93

The grain yield of three pulse crops was different because of their varied genetical character, size of the plant and duration of the crop. Arhar yield was higher over others because of higher values plant height and crop duration period. In open condition yield of these crops was more in comparison to agroforestry systems because of no shade effect. Greengram with *Gmelina arborea* accounted lowest yield due to maximum growth of trees casting highest shade.

The results are in line with the report of (Ahlawat *et al*., 2019; Bisht *et al.*, 2018; Kanwal *et al*., 2022; Karwar *et al*., 2006; Saroj *et al*., 2003 and Werner *et al*., 2017) [1, 3, 6, 7, 10, 14].

Conclusion

The growth and yield performance of three pulse crop such as arhar, cowpea and greengram was remarkably different under different landuse systems. The crops performed better in open condition than under *Gmelina arborea*. Among the three crops arhar witnessed higher vegetative growth as well as grain yield both as sole and intercrop.

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