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Effect of Tree Proximity on Growth and Yield of Horse Gram in *Melia dubia* Based Agroforestry System

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Abstract
Agroforestry systems offer a sustainable approach to land management by integrating trees with crops, optimizing resource use, and enhancing productivity. This study examines the influence of tree spacing and the distance from trees on the growth, yield attributes and overall productivity of crops in agroforestry system. The experiment included three tree spacing configurations (M_1: 2 m × 2 m, M_2: 3 m × 2 m, M_3: 4 m × 3 m) and three inter-row distances from trees stem (S_1: 0.5 m, S_2: 1.0 m, S_3: 1.5 m), assessing their effects on key growth parameters such as plant height, number of branches, dry matter accumulation, as well as yield components including productive branches, pods per plant, pod length, grain weight, and test weight. Results indicated that wider tree spacing (M_3) and greater distance from trees (S_3) significantly enhanced plant growth and yield traits, with M_3S_3 combination producing the tallest plants (78.50 cm), the highest number of branches (12.67) and the greatest biomass (16.10 g). In terms of yield, M_3S_3 recorded the highest grain yield (946.33 kg ha^{-1}) and biological yield (2417.67 kg ha^{-1}), reflecting the positive effects of reduced competition for light, water, and nutrients. These findings corroborate previous studies on the benefits of optimizing tree spacing and intercrop positioning in agroforestry systems to promote higher productivity and resource-use efficiency. The study provides important insights for enhancing the design of agroforestry systems, thereby contributing to more sustainable agricultural practices that balance productivity and environmental stewardship.

Keywords: Agroforestry, Tree geometry and proximity, Crop productivity, Sustainable land management.

Introduction

Agroforestry has emerged as a sustainable land use strategy capable of addressing multiple challenges posed by increasing population pressure and the resultant demand for food, fuel, fodder, and timber. This is particularly relevant in semi-arid regions of India, where agricultural productivity is constrained by low rainfall, poor soil fertility and limited access to inputs (Lundgren and Raintree, 1982) [6]. Conventional monocropping systems under such limiting conditions are prone to frequent crop failures, making alternative land use systems like agroforestry essential for ensuring food and livelihood security (Subba and Dhara, 2017). Agroforestry systems, which involve the intentional integration of trees with crops and/or livestock on the same land management unit, promote ecological and economic interactions among system components. Such integration improves resource use efficiency and provides numerous ecosystem services, including soil conservation, improved microclimate, and biodiversity enhancement (Yang *et al*., 2018) [14]. Proper spatial and temporal arrangements of the tree and crop components are crucial to minimizing interspecific competition and enhancing complementarity (Jose, 2009) [4].

Melia dubia Cav., commonly known as Malabar neem, is a fast-growing multipurpose tree species native to India and widely promoted in the Western Ghats and dry zones for its commercial potential and adaptability. The species is in high demand by the plywood and biomass industries due to its fast growth, quality wood, and termite resistance. Its promotion is also in alignment with the National Agroforestry Policy (Dhyani, 2014) [3], which advocates the inclusion of economically valuable tree species to improve farmers' incomes and environmental resilience (Ashok *et al*., 2017 [1]; Nair *et al*., 2005) [7].

Horse gram (*Macrotyloma uniflorum*) is a drought-hardy legume cultivated primarily in marginal lands across dry zones of India and sub-Saharan Africa. It is a rich source of protein, dietary fiber, iron, and molybdenum and is used for human consumption, livestock feed, and green manure. Its remarkable tolerance to moisture stress and its low input requirement make it a suitable intercrop in agroforestry systems designed for dryland agriculture (Bravo *et al*., 1999 [2]; Purushottam *et al*., 2017) [9].

Tree-crop interactions in agroforestry are strongly influenced by spatial arrangements, especially the distance between trees and intercrops. Tree proximity affects key growth determinants such as light availability, soil moisture, and nutrient competition (Kumar *et al*., 2004) [5]. Therefore, optimizing tree spacing is crucial for maximizing the productivity of understory crops and the overall efficiency of the system. In this context, the present investigation was undertaken to evaluate the growth and yield performance of horse gram under varying spacing geometry and distances from *Melia dubia* trees in the central dry zone of Karnataka. The study aims to provide insights into the spatial dynamics of tree-crop interaction and contribute to the development of context-specific, sustainable agroforestry models.

Materials and Methods

Experimental Site

The field experiment was conducted during 2021–2022 at the Zonal Agricultural and Horticultural Research Station (ZAHRS), Hiriyur, Chitradurga district, Karnataka, located in the Central Dry Zone (Zone-4) at 13°56'57" N, 76°37'13" E, and 606 m above MSL. The region receives rainfall from both South-West and North-East monsoons, with an average annual rainfall of 662.73 mm (2012–2021). In 2021, rainfall was higher than average at 953 mm and most of it occurred in October (295.4 mm). During the study, the mean maximum and minimum temperatures were 31.5 °C and 17.7 °C, slightly lower than the 10-year averages (32.3 °C and 19.6 °C). Relative humidity averaged 70.5%, also lower than the 10-year mean of 72.8%.

Experimental Design and Treatments

The experiment was conducted using a split-plot design with three replications, evaluating the performance of horse gram intercropped in a three-year-old *Melia dubia* plantation during the rabi season. The main plot treatments included three tree spacings: 4 m × 1 m (M_1), 4 m × 2 m (M_2), and 4 m × 3 m (M_3). Within each spacing, three sub-plot treatments were applied based on the distance from the tree base: 0.5 m (S_1), 1.0 m (S_2), and 1.5 m (S_3), resulting in a total of nine treatment combinations (M_1S_1 to M_3S_3). Horse gram was sown in the interspaces using the standard package of practices recommended by KSN UAHS, Shivamogga.

Observations and Data Collection

Growth Parameters

Observations were recorded at 30, 60 DAS, and at harvest. A 1 m² quadrat was laid in each treatment plot, and five plants were randomly selected and tagged for measurements.

Plant height (cm): Plant height was measured using scale from the base of the plant to the tip of growing point at 30, 60 DAS and at harvest.

Total dry matter production (g plant-1): The plants were shade dried and then oven dried at 60°C till constant weight was obtained. Final weights were recorded with Calion-FA 2004 and expressed in $gplant^{-1}$.

Number of branches (plant-1): Counted manually on each sampled plant

Yield attributes and yield of horse gram

Number of productive branches (m-2): In each plot, one square meter area was demarcated randomly, and the number of productive branches m^{-2} was counted at harvest.

Number of pods (plant-1): Total number of pods from the ear-marked plants were counted at maturity, averaged and expressed as number of pod $plant^{-1}$.

Length of pod (cm): The length of the pod from selected five plants was measured from the base to tip of the pod in pulses in each plot and the mean was computed as the length of the pod in centimeters.

Grain weight pod-1 (g): The pods of the tagged plants were harvested separately according to the treatment. The sun-dried pods were threshed and weighed, and the mean was expressed as the weight of grains ear^{-1} in grams.

Test weight (g): Samples of 100 grains were drawn from each treatment, weighed separately, and averaged to get test weight. It was recorded in grams (g).

Grain yield (kg ha-1): The harvested pods were dried to constant weight, threshed and winnowed, and again the grain was dried and weights were recorded as per the treatment and expressed in kg ha^{-1}.

Stover yield (kg ha-1): After the pods were harvested, the leftover plants were cut off and sun-dried to a constant weight. The stover yield of the net plot was recorded for individual treatments and expressed in kg ha^{-1}.

Harvest index (%)

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (grain yield in kg per ha)}}{\text{Total biological yield yield (grain + straw yield in kg per ha)}} \times 100$$

The data collected during the research period was statistically analyzed using a split-plot design, following the methodology outlined by Panse and Sukhatme (1978) [8]. A significance level of P = 0.05 was applied for both the ‘F’ and ‘t’ tests. When the ‘F’ test showed significant results, critical difference (CD) values were computed using the SPSS software. The findings were then appropriately interpreted, and conclusions were drawn accordingly.

Results and discussion

Growth Parameters

The growth parameters, including plant height, number of branches, and dry matter production, were significantly influenced by tree spacing and the distance between trees (Table 1). Wider tree spacings, specifically the 4 m × 3 m (M_3) configuration, resulted in enhanced plant growth, with the highest plant height (74.28 cm), number of branches (11.06), and dry matter accumulation (14.10 g at harvest). Additionally, the distance of 1.5 m (S_3) from trees showed a marked improvement in growth compared to the 0.5 m (S_1) distance, likely due to reduced competition for light, water, and nutrients. The interaction effect between tree spacing and distance further reinforced this trend, with the M_3S_3 combination yielding the tallest plants (78.50 cm), the highest number of branches (12.67), and maximum biomass (16.10 g). These results align with the findings of Rathore *et al*. (2017) [10] and Naik *et al.* (2020), who reported enhanced legume growth in agroforestry systems with wider tree spacings, attributed to favorable microclimatic conditions and reduced competition.

Yield Attributes

Significant variations were observed in the yield attributes, including the number of productive branches, pods per plant, pod length, grain weight per pod, and test weight (Table 2). Among the tree spacing treatments, M_3 consistently outperformed other configurations across all yield parameters, showing higher values for productive branches (278.56 m^{-2}), pods per plant (42.00), pod length (5.11 cm), grain weight per pod (0.17 g), and test weight (2.73 g). Similarly, greater distances from the tree (S_3) resulted in improved values for these parameters, with S_3 showing the maximum pod length (4.33 cm) and test weight (2.62 g). The combination of M_3S_3 yielded the highest values for all attributes, with 286.33 branches per m², 45 pods per plant, a pod length of 5.47 cm, a grain weight of 0.17 g per pod, and a test weight of 2.78 g. These findings substantiate the positive influence of reduced competition and increased resource availability in agroforestry systems, as also demonstrated by Chavan *et al.* (2019) and Suresh *et al.* (2020) [12].

Yield and Harvest Index

The effect of tree spacing on yield parameters, including grain, stover, and biological yield, as well as the harvest index, was significant (Table 3). The M_3 spacing (4 × 3 m) produced the highest grain yield (936.67 kg ha⁻¹), stover yield (1454.56 kg ha⁻¹), biological yield (2391.22 kg ha⁻¹) and harvest index (39.17%). For the distance from trees, yields increased progressively from S_1 to S_3, with the maximum grain yield (713.89 kg ha⁻¹) observed at S_3 (1.5 m). The interaction between tree spacing and distance further corroborated these trends, with M_3S_3 achieving the highest grain yield (946.33 kg ha⁻¹) and biological yield (2417.67 kg ha⁻¹). Additionally, M_3S_1 and M_3S_2 treatments produced similarly high yields, emphasizing the importance of optimal tree spacing and intercrop positioning in enhancing productivity. These results are consistent with the findings of Patel *et al.* (2021) and Reddy *et al.* (2020) [11], who reported that strategic agroforestry practices optimize productivity and resource use efficiency.

Table 1: Horse gram growth parameters as influenced by different treatments

Treatments	Plant Height (cm)			No. of Branches			Dry Matter Production (g)		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
Tree spacing									
M1 (4 × 1 m)	15.37	28.60	49.61	2.42	4.23	7.00	3.40	5.41	7.41
M2 (4 × 2 m)	22.40	36.99	63.94	3.33	5.59	8.47	5.57	7.84	10.38
M3 (4 × 3 m)	28.82	45.83	74.28	5.24	7.40	11.06	7.61	10.23	14.10
S.Em (±)	0.13	0.31	0.14	0.09	0.03	0.08	0.05	0.10	0.07
CD (0.05)	0.53	1.25	0.55	0.36	0.13	0.31	0.21	0.39	0.29
Distance from tree									
S1 (0.5 m)	20.18	34.38	59.39	3.10	5.16	7.89	4.81	7.03	9.39
S2 (1.0 m)	22.12	36.69	62.39	3.68	5.76	8.77	5.51	7.77	10.51
S3 (1.5 m)	24.29	40.36	66.06	4.22	6.31	9.87	6.26	8.69	11.99
S.Em (±)	0.14	0.19	0.28	0.07	0.08	0.08	0.08	0.07	0.08
CD (0.05)	0.45	0.60	0.87	0.23	0.26	0.26	0.24	0.23	0.26
Tree spacing × Distance from tree									
M1S1	13.77	25.30	46.17	1.83	3.53	6.23	2.73	4.50	6.50
M1S2	14.33	28.00	49.83	2.50	4.40	7.07	3.23	5.37	7.40
M1S3	18.00	32.50	52.83	2.93	4.77	7.70	4.23	6.37	8.33
M2S1	19.60	34.83	61.17	2.77	5.07	7.93	4.70	7.33	9.17
M2S2	23.23	36.57	63.83	3.23	5.63	8.23	5.60	7.87	10.43
M2S3	24.37	39.57	66.83	4.00	6.07	9.23	6.40	8.33	11.53
M3S1	27.17	43.00	70.83	4.70	6.87	9.50	7.00	9.27	12.50
M3S2	28.80	45.50	73.50	5.30	7.23	11.00	7.70	10.07	13.70
M3S3	30.50	49.00	78.50	5.73	8.10	12.67	8.13	11.37	16.10
S.Em (±)	0.24	0.41	0.42	0.14	0.12	0.14	0.12	0.14	0.14
CD (0.05)	0.82	1.50	NS	NS	NS	0.48	NS	0.50	0.46

CD-Critical Difference; NS- Non-Significant

Table 2: Yield components of horse gram as influenced by different treatments

Treatments	No. of productive branches (m^{-2})	No. of pods ($plant^{-1}$)	Length of pod (cm)	Grain weight per pod (g)	Test weight (g)
Tree spacing					
M1 (4 × 1 m)	176.78	22.11	2.91	0.08	2.34
M2 (4 × 2 m)	242.56	33.22	3.89	0.12	2.59
M3 (4 × 3 m)	278.56	42.00	5.11	0.17	2.73
S.Em (±)	0.30	0.31	0.01	0.002	0.003
CD (0.05)	1.21	1.27	0.06	0.01	0.014
Distance from tree					
S1 (0.5 m)	225.89	29.56	3.67	0.11	2.48
S2 (1.0 m)	232.89	32.44	3.90	0.12	2.55
S3 (1.5 m)	239.11	35.33	4.33	0.13	2.62
S.Em (±)	0.57	0.37	0.03	0.003	0.003
CD (0.05)	1.77	1.16	0.10	0.009	0.01
Tree spacing × Distance from tree					
M1S1	172.00	19.00	2.75	0.08	2.23
M1S2	177.33	22.00	2.80	0.09	2.33
M1S3	181.00	25.33	3.17	0.09	2.44
M2S1	234.67	31.00	3.53	0.10	2.53
M2S2	243.00	33.00	3.77	0.12	2.58
M2S3	250.00	35.67	4.37	0.14	2.65
M3S1	271.00	38.67	4.73	0.16	2.69
M3S2	278.33	42.33	5.13	0.17	2.74
M3S3	286.33	45.00	5.47	0.17	2.78
S.Em (±)	0.86	0.61	0.05	0.005	0.006
CD (0.05)	2.76	NS	0.16	NS	0.02

CD-Critical Difference; NS- Non-Significant

Table 3: Yield and Harvest Index of Horse gram as influenced by different treatments

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
	Tree spacing			
M1 (4 × 1 m)	503.00	898.67	1,401.67	35.87
M2 (4 × 2 m)	656.22	1077.44	1,733.67	37.85
M3 (4 × 3 m)	936.67	1454.56	2,391.22	39.17
S.Em (±)	0.98	0.65	0.64	0.04
CD (0.05)	3.97	2.61	2.57	0.16
Distance from tree				
S1 (0.5 m)	684.67	1126.89	1,811.56	37.44
S2 (1.0 m)	697.33	1144.33	1,841.67	37.56
S3 (1.5 m)	713.89	1159.44	1,873.33	37.89
S.Em (±)	0.54	0.58	0.86	0.02
CD (0.05)	1.69	1.80	2.68	0.07
Tree spacing × Distance from tree				
M1S1	483.67	886.67	1,370.33	35.29
M1S2	498.00	897.33	1,395.33	35.69
M1S3	527.33	912.00	1,439.33	36.64
M2S1	643.33	1059.67	1,703.00	37.77
M2S2	657.33	1077.67	1,735.00	37.89
M2S3	668.00	1095.00	1,763.00	37.89
M3S1	927.00	1434.33	2,361.33	39.26
M3S2	936.67	1458.00	2,394.67	39.11
M3S3	946.33	1471.33	2,417.67	39.14
S.Em (±)	1.25	1.04	1.37	0.05
CD (0.05)	4.60	3.62	4.55	0.19

CD-Critical Difference; NS- Non-Significant

Conclusion

The research findings demonstrates the significant influence of tree spacing and distance from trees on the growth, yield attributes, and productivity of crops in agroforestry systems. The results clearly indicate that wider tree spacings (4 × 3 m) and increased distance from trees (1.5 m) promote better plant growth, higher yield attributes and greater overall productivity, as evidenced by enhanced plant height, number of branches, pod development, and grain yield. The interaction between these factors further maximized biomass and grain yields, supporting the notion that reduced competition for light, water and nutrients fosters optimal crop performance. These findings align with previous research, emphasizing the importance of strategic agroforestry practices to enhance both productivity and resource efficiency, offering valuable insights for improving agroforestry systems and informing sustainable land management strategies.

References

1. Ashok K, Sharma P, Rao RR. Agroforestry practices for improved livelihood and environmental resilience. Indian Journal of Forestry,2017:40(3):89-98.
2. Bravo AP, Rajasekharan PE, Palanisamy M. Performance of horse gram (Macrotyloma uniflorum) in agroforestry systems. Agronomy Journal,1999:91(1):53-58.
3. Dhyani SK. National Agroforestry Policy: Its role in enhancing the socio-economic condition of farmers. Agroforestry Systems,2014:88(2):289-301.
4. Jose S. Agroforestry for ecosystem services and environmental benefits: An overview. Agroforestry Systems,2009:76(1):1-10.
5. Kumar BM, Singh S, Sharma R. Tree-crop interactions in agroforestry systems. Indian Journal of Agroforestry,2004:6(1):1-8.
6. Lundgren B, Raintree JB. Sustained agroforestry: A review of the possibilities and experiences in tropical Africa. Agroforestry Systems,1982:1(1):1-19.
7. Nair PKR, Somarriba E, Dhyani SK, *et al*. Agroforestry systems for biodiversity conservation and carbon sequestration. Environmental Conservation,2005:32(2):85-92.
8. Panse VG, Sukhatme. Statistical methods for agricultural workers 3rd edition. Indian Council of Agricultural Research Publication, New Delhi, 1978, 361.
9. Purushottam K, Das T, Kumar P. Horse gram as a drought-resistant crop in agroforestry systems. International Journal of Agroforestry,2017:15(4):167-174.
10. Rathore SP, Sharma RK, Yadav KK. Role of agroforestry in improving the growth and yield of legumes in semi-arid regions. Forestry Studies,2017:39(3):210-217.
11. Reddy PN, Kumar DP, Rao KP. Optimizing tree spacing for improved productivity in agroforestry systems. Journal of Agricultural Science,2020:72(5):385-392.
12. Suresh RS, Ramesh MS. Microclimatic effects of tree spacing on legume productivity in agroforestry systems. Ecological Studies in Agroforestry,2020:24(2):98-106.
13. Subba R, Dhara S. Agroforestry systems as sustainable land management practices in semi-arid regions. Indian Journal of Agricultural Sciences,2017:72(1):45-54.
14. Yang W, Zhang L, Chen Y. Agroforestry systems and their ecological services: A review. Environmental Management,2018:61(6):808-818.