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Performance of intercrop in *Melia dubia* based agroforestry in central dry zone of Karnataka

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Abstract
An experiment was conducted at Zonal Agricultural and Horticultural Research Station, Babbur Farm, Hiriyur during the year 2021-2022. Agroforestry is becoming more significant in light of the increased need for wood and the accessibility of farmland. The main area for agroforestry consideration is the creation of a suitable tree crop spacing combination and productivity evaluation. The present field experiment was conducted to assess growth and yield performance of horse gram under three spacing *i.e.*, 4 m × 1 m, 4 m × 2 m, and 4 m × 3 m of *Melia dubia* and with sole crops as horsegram. The experiment consists of four treatments with five replications in RCBD design treatments T_1- horse gram in 4 m × 1 m, T_2- horse gram in 4 m × 2 m, T_3- horse gram in 4 m × 3 m and T_4- sole horse gram. Horse gram growth parameters were recorded at 30 DAS, 60 DAS and at harvest and yield parameters were estimated. Results revealed that there was a significant difference between horse gram growth parameters *i.e*., plant height, number of branches and dry matter production at 30 DAS, 60 DAS and at harvest. The horse gram yield parameters were ranked as $T_4 > T_3 > T_2 > T_1$ with significant difference among T_1, T_2, T_3 and T_4. The highest yield of horse gram was obtained in T_4 (1220.02 Kg/ha) followed by T_3 (931.4 Kg/ha), T_2 (667 Kg/ha) and T_1 (529 Kg/ha). The horse gram growth and yield increases with increasing spacing of *Melia dubia* and relatively higher in sole horse gram plot. The shade impact that trees have on crops may be the reason of the decline in yield with decreasing spacing. However, the long term benefit of trees wood accumulation fetched more economic returns in the future.

Keywords: *Melia dubia*, horsegram, dryland and agroforestry

1. Introduction

Agroforestry is becoming more significant in light of the increased need for wood and the accessibility of farmland. The main area for agroforestry consideration is the creation of a suitable tree crop spacing combination and productivity evaluation. Malabar neem (*Melia dubia* Cav.), commonly called as Hebbuvu or Dreak or Gora Neem, is a dry deciduous multipurpose tree belongs to the family *Meliaceae*. It is indigenous to Western Ghats and Himalayas and grown extensively in upper Assam, West Bengal, Khasi hills of Orissa, Western Ghats and moist deciduous forests of Kerala up to an altitude of 1500-1800 m above mean sea level (Ashok *et al*., 2017) [2]. Due to the fast growth, it is being promoted among the farmers to improve the economic sustainability of farmers as well to meet the raw materials requirement of wood based industries.

Horse gram (*Macrotyloma uniflorum* Lam.) is an important crop of south India. It is known as a poor man's pulse crop used for human consumption in Africa and India. It's grain is used for human consumption as 'dal' as well as in preparation of so called 'rasam' and also as a concentrated feed for cattle. It is also be used as green manure. In India, horse gram is cultivated as a pulse crop contributing about 0.33 per cent of the total food grain production. Horse gram is an excellent source of protein (up to 25%), carbohydrates (60%), essential amino acids, energy and low content of lipid (0.58%), iron and molybdenum (Bravo *et al*., 1999) [4]. It is an excellent source of dietary fibre. Horse gram is a hardy and a potential crop of future for dry land areas as well as a fodder crop of economic importance. Farmers in dry zone of Karnataka are suffering from economic fragile due to low yield and productivity and prevailing unfavorable environmental conditions. In order to uplift farmers income and livelihood specially in dry zone of Karnataka by increasing their additional income through tree components and to mitigate climate change by increasing tree cover, the present study was carried out to assess the growth and yield performance of horse gram under different spacing of *Melia dubia*.

2. Materials and Methods

2.1 Site description

The field experiment was carried out at, Zonal Agricultural and Horticultural Research Station (ZAHRS), Hiriyur, Chitradurga district during 2021-2022, Karnataka. The experimental sites are situated in central dry zone (Zone-4) of Karnataka and lies in13°56'57" N and 76°37'13" E with an elevation at 606 m above Mean Sea Level (MSL). The study area (Hiriyur) receives rainfall from both South- West and North- East monsoon. The average annual rainfall for last 10 years (2012 to 2021) at the study area was 662.73 mm and the significant portion of the rainfall received in October (295.4 mm). During the experimental period, the rainfall received in 2021 (953 mm) was higher than the 10 years average (662.73 mm) annual rainfall. The mean maximum and minimum temperature during the study period was 31.5 °C and 17.7 °C as compared to 10 years mean (32.3 and 19.6 °C, respectively). The annual mean relative humidity recorded during the study period was 70.5 per cent which was lower than 10 years average of 72.80 per cent.

2.2 Details of the experiment

Horse gram was cultivated as intercrop in three years old *Melia dubia* at 0.5m from the tree base under three spacing of *Melia dubia* and as a sole crop without mixing with tree component. There are four treatments with 5 replications in RCBD design.

Treatment details:

T_1 – 4 m × 1 m spacing with horse gram

T_2 – 4 m × 2 m spacing with horse gram

T_3 – 4 m × 3 m spacing with horse gram

T_4 - Sole horse gram crop

2.3 Observations

For recording of horse gram growth parameter observations 1 m^2 plot was laid out in all the treatments and five plants were selected randomly and tagged in each plot for recording non-destructive sampling parameters *viz*., plant height, number of branches and dry matter production. Similarly, at 30, 60 DAS and at harvest five plants for destructive sampling were uprooted from two rows on either side between border and net plots earmarked for the purpose. Yield parameters like number of productive branches (m^{-2}), number of pods (plant^{-1}), length of pod (cm), grain weight (g pod^{-1}), test weight (g), grain yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) are measured at harvest. The data recorded during the research period was analyzed statistically with RCBD design by the method given by Panse and Sukhatme (1978) [12]. The level of significance used for 'F' and 't' test was P = 0.05. Critical difference values were calculated whenever 'F' test was found significant (SPSS package). The results were interpreted suitably and conclusion was drawn.

3. Results and Discussion

3.1 Horse gram growth parameters

The data on horse gram growth parameters *viz*., plant height (cm), number of branches plant^{-1} and dry matter production plant^{-1} (g) at various stages of crop growth are presented in Table 1. Plant height of horse gram has increased linearly from 30 DAS up to harvest in all treatment combinations. The plant height of horse gram under different treatments differed significantly at various growth stages (Table.1). Sole horse gram recorded significantly higher plant height at 30 DAS (29.26 cm), 60 DAS (57.26 cm) and at harvest (79.61 cm) which was significantly superior over all the treatment combinations. Plant height of horse gram as intercrop in association with different spacing of *Melia dubia* was significantly higher under T_3 (4 m × 3 m) at 30 DAS (26.5 cm), 60 DAS (49.66 cm) and at harvest (74.07 cm) which was on par with sole crop followed by T_2 (4 m × 2 m) and T_1 (4 m × 1 m). Plant height of horse gram was significantly lower in T_1 (4 m × 1 m) at 30 DAS (16.14 cm), 60 DAS (31.16 cm) and at harvest (46.5 cm). Number of branches plant^{-1} of horse gram has increased linearly from 30 DAS up to harvest in all the treatment combinations. Significantly higher number of branches was recorded in sole horse gram treatment at 30 DAS (4.56), 60 DAS (9.00) and at harvest (12.08 cm) which was significantly superior over all other treatment combinations (Table.1). Number of branches plant^{-1} of horse gram as intercrop in association with different spacing of *Melia dubia* was significantly higher under T_3 (4 m × 3 m) at 30 DAS (4.16), 60 DAS (7.84) and at harvest (11.16) which was on par with sole crop followed by T_2 (4 m x 2 m) and T_1 (4 m x 1 m). Whereas, the lower number of branches were recorded in T_1 (4 m × 1 m) at 30 DAS (2.44), 60 DAS (4.64) and at harvest (7.68). Dry matter production plant^{-1} of horse gram has increased linearly from 30 DAS up to harvest in all treatment combinations. The dry matter production plant^{-1} of horse gram under different treatments differed significantly at various growth stages (Table 1). Sole horse gram recorded the significantly higher dry matter production of 7.61, 11.96 and 16.33 g at 30, 60 DAS and at harvest, respectively which was significantly superior over all other treatment combinations. Dry matter production plant^{-1} of horse gram as intercrop in association with different spacing of *Melia dubia* was significantly higher under T_3 (4 m × 3 m) at 30 DAS (6.74 g), 60 DAS (10.72 g) and at harvest (15.05 g) which was on par with sole crop followed by T_2 (4 m × 2 m) and T_1 (4 m × 1 m). The lowest dry matter production plant^{-1} of horse gram in T_1 (4 m x 1 m) at 30 DAS (2.90 g), 60 DAS (5.92 g) and at harvest (8.98 g).

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

Treatments	Plant height (cm)			Number of Branches			Dry matter production (g)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1 (4 m × 1 m)	16.14	31.16	46.50	2.44 (1.56)	4.64 *(2.15)	7.68 (2.77)	2.90	5.93	8.98
T_2 (4 m × 2 m)	18.98	39.04	58.08	3.24 (1.80)	6.12 (2.47)	9.28 (3.05)	4.87	8.94	12.93
T_3 (4 m × 3 m)	26.50	49.66	74.07	4.16 (2.04)	7.84 (2.80)	11.16 (3.34)	6.74	10.72	15.08
T_4 (Sole horse gram)	29.26	57.26	79.61	4.56 (2.14)	9.00 (3.00)	12.08 (3.48)	7.61	11.96	16.33
S.Em±	0.12	0.22	0.41	0.01	0.02	0.01	0.04	0.05	0.10
C.D. (0.05)	0.36	0.68	1.27	0.04	0.05	0.04	0.11	0.16	0.31

* Parenthetical values are square root transformed values

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)
T_1 (4 m × 1 m)	180.40 (13.43)	27.44 *(5.24)	3.304	0.087	2.488
T_2 (4 m × 2 m)	246.60 (15.70)	32.24 (5.68)	4.248	0.124	2.628
T_3 (4 m × 3 m)	282.40 (16.80)	38.60 (6.21)	5.036	0.146	2.722
T_4 (Sole horse gram)	305.20 (17.47)	42.04 (6.48)	5.712	0.163	2.800
S.Em ±	0.08	0.02	0.031	0.002	0.010
C.D. (0.05)	0.24	0.07	0.096	0.006	0.030

* Parenthetical values are square root transformed values

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 (%)
T_1 (4 m × 1 m)	529.00	915.60	1444.60	36.62
T_2 (4 m × 2 m)	667.00	1112.60	1779.60	37.48
T_3 (4 m × 3 m)	931.40	1489.20	2420.60	38.48
T_4 (Sole horse gram)	1220.20	1886.00	3106.20	39.28
S.Em ±	20.47	32.08	52.48	0.07
C.D. (0.05)	63.06	98.85	161.71	0.20

3.2 Horse gram yield parameters

The results of yield components of horse gram like number of productive branches (m^{-2}), number of pods ($plant^{-1}$), length of pod (cm), grain weight (g pod^{-1}), test weight (g), grain yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) are presented in Table 2 and Table 3. Sole crop of horse gram recorded significantly higher number of productive branches m^{-2} (305.20), which was superior over all the treatment combinations (Table 2). Number of productive branches were significantly higher under T_3 (4 m × 3 m) treatment (282.40 m^{-2}) followed by T_2 (4 m × 2 m) (282.40 m^{-2}), whereas significantly lower number of productive branches were recorded in T_1 (4 m × 1 m) with 180.40 m^{-2}. Sole crop of horse gram recorded significantly higher number of pod $plant^{-1}$ (42.04), which was superior over all the treatment combinations (Table 2). Number of pods per plant was significantly higher in T_3 (4 m × 3 m) treatment (38.60) followed by T_2 (4 m × 2 m) (32.24), whereas significantly lower number of pods per plant were recorded in T_1 (4 m × 1 m) with 27.44 pods. Sole crop of horse gram recorded significantly higher pod length (5.71 cm), which was superior over all the treatment combinations (Table 2). Length of pod was significantly higher under T_3 (4 m × 3 m) treatment (5.04 cm) followed by T_2 (4 m × 2 m) (4.25 cm), whereas significantly lower pod length was recorded in T_1 (4 m × 1 m) with 3.30 cm. Sole crop of horse gram recorded significantly higher grain weight pod^{-1} (0.16 g), which was superior over all the treatment combinations (Table 2). Grain weight pod^{-1} was significantly higher under T_3 (4 m × 3 m) treatment (0.15 g) followed by T_2 (4 m × 2 m) (0.12 g), whereas significantly lower grain weight pod^{-1} was recorded in T_1 (4 m × 1m) with 0.09 g. Sole crop of horse gram recorded significantly higher test weight (2.80 g), which was superior over all the treatment combinations (Table 2). Horse gram as an intercrop with different *Melia dubia* spacing treatments differed significantly with respect to test weight. Test weight was significantly higher under T_3 (4 m × 3 m) treatment (2.72 g) followed by T_2 (4 m × 2 m) (2.63 g), whereas significantly lower test weight was recorded in T_1 (4 m × 1 m) with 2.49 g.

Sole crop of horse gram recorded significantly higher grain yield (1220.20 kg ha^{-1}), which was superior compared with other treatment combinations (Table 3). Grain yield was significantly higher under T_3 (4 m × 3 m) treatment (931.40 kg ha^{-1}) followed by T_2 (4 m × 2 m) (667.00 kg ha^{-1}), whereas significantly lower grain yield was recorded in T_1 (4 m × 1 m) with 529.00 kg ha^{-1}. Sole crop of horse gram recorded significantly higher stover yield (1886.0 kg ha^{-1}), which was superior compared with other treatment combinations (Table 3). Stover yield was significantly higher under T_3 (4 m × 3 m) treatment (1489.20 kg ha^{-1}) followed by T_2 (4 m × 2 m) (1112.60 kg ha^{-1}), whereas significantly lower grain yield was recorded in T_1 (4 m × 1 m) with 915.60 kg ha^{-1}. Sole crop of horse gram recorded significantly higher biological yield (3106.20 kg ha^{-1}), which was superior compared with other treatment combinations (Table 3). Biological yield was significantly higher under T_3 (4 m × 3 m) treatment (2420.60 kg ha^{-1}) followed by T_2 (4 m × 2 m) (1779.60 kg ha^{-1}), whereas significantly lower biological yield was recorded in T_1 (4 m × 1 m) with 1444.60 kg ha^{-1}.Similar trend was observed by Mutanal *et al*. (2001) [8] in sorghum, Bayala *et al* (2002) [3] in pearl millet, Dai *et al*. (2008) [6] in maize, Mutanal *et al*. (2009) [7] in sorghum, groundnut, chilly, finger millet, Sharma and Dhadwal (2011) [15], Osman *et al.* (2011) [10] in cowpea and pearl millet and Pandey *et al.* (2011) [11] in chickpea and Ram and Krishna (2013) [14] in maize and finger millet.

Better performance of growth and yield parameters in sole horse gram crop was due to better light interception and better availability of various resources as compared to horse gram in association with different spacing of *Melia dubia*. The lower growth performance of crop under lesser spacing of *M. dubia* tree treatments proximity of demonstrated the competition for soil fertility level between trees and crop under dry and rain fed condition. Among different planting spacing of *Melia dubia* tree treatments reduction in grain yield of horse gram was 23.67, 45.34, and 56.65 per cent, and stover yield was 21.04, 41.01 and 51.45 per cent under *M. dubia* T_3 (4 m ×3 m), *M. dubia* T_2 (4 m × 2 m) and *M. dubia* T_1 (4 m × 1 m), respectively. Reduction in yield horse gram in association with different treatments was attributed to competition for low light transmission and soil fertility. The competition for above ground and below ground resources suppressed the growth of horse gram under trees. Similar results were found by Patil *et al.* (2012) [13] in *M. azedarach* as intercropped with soybean, Mutanal *et al.* (2001) [8] while studying the effect of teak on sorghum. Horse gram yield as intercrop under *M. dubia* (4 m × 3 m) treatment was higher as compared to other treatments combinations. This was mainly due to influence of higher planting spacing on growth and yield parameters.

The harvest index shows how well an organism is able to translocate photosynthates into organs that have a high economic yield. An effective way to assess crop yield potential is through the harvest index (Abdalla *et al*., 2015) [6]. In the current study, after intercropping of horse gram the value of HI ranged from 36.62% to 39.28% (Fig. 5.2). Sole crop of horse gram recorded significantly higher harvest index (39.28%), which was superior compared with other treatment combinations (Table 3). Harvest index was significantly higher under T_3 (4 m × 3 m) treatment (38.48%) followed by T_2 (4 m × 2 m) (37.48%), whereas significantly lower harvest index was recorded in T_1 (4 m × 1 m) with 36.62%. Relatively low HI may be a result of high levels of total dry matter accumulation but relatively low grain yield of horse gram. Muthuri *et al.* (2005) [9] found similar trend of higher harvest index under sole maize compared to *Grevillea, Alnus* and *Paulownia*-based agroforestry practices in semi-arid region of Kenya.

4. Conclusion

The horse gram growth and yield parameters were ranked as $T_4 > T_3 > T_2 > T_1$ with significant difference among T_1, T_2, T_3 and T_4. Horse gram growth and yield increases with increasing spacing of *M. dubia* and relatively higher in sole horse gram. The shade impact that trees have on crops may be the reason for decline in yield with decreasing spacing. However, the long-term benefit of trees wood accumulation fetched more economic returns in the future.

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