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Influence of different fodder crops on the growth Parameters of pigeonpea under pigeonpea based fodder intercropping system under rainfed conditions of north Karnataka

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Abstract
Pigeonpea is the major crop of northern parts of Karnataka. Most of the farmers depend on the pigeopea for their livelihood. But now a days fodder shortage has become the major problem of pigeonpea growing area. There is a huge gap between the fodder demand and fodder supply. There is a need to grow fodder crops without affecting the yield of pgeonpea. Hence, improving cropping system can be a probable solution. Pigeonpea being a long duration crop offers ample opportunity for intercropping system. Hence, One should opt for good intercrop which doesn't affect the growth and yield of the main crop i.e., pigeonpea. The grain yield of pigeonpea depends on its growth parameters such as plant height, number of primary branches, number secondary branches per plant, leaf area and leaf area index. Which depict the yield potential of the crop. Hence, for finding out the most suitable fodder crop for intercropping with pigeonpea, A field experiment was conducted to study the effect of different fodder crops on growth parameters of pigeonpea under intercropping system. There were 13 treatments replicated thrice and Randomised Complete Block Design was followed for statistical analysis. Different fodder crops such as fodder sorghum, fodder maize, fodder bajra, fodder cowpea, fodder horsegram and fodder fieldbean were intercropped with pigeonpea at 1:2 row proportions. All the growth parameters of pigeonpea were significantly influenced by intercropping system with different fodder crops. Sole pigeonpea recorded highest values of plant height, number of primary branches per plant, number of secondary branches per plant, leaf area and leaf area index at 45 DAS, 90 DAS, 135 DAS and at harvest. However, it was on par with the treatment where pigeonpea was intercropped with fodder horsegram at 1:2 row proportion. Whereas the treatments where pigeonpea was intercropped with fodder cereals recorded lower values of all the growth parameters.

Keywords: Fodder, growth, intercropping, pigeonpea

Introduction
Pigeonpea is the major pulse crop of the country which accounts for about 72 per cent of the global pigeonpea area and 63 per cent of global production. In India, pigeonpea ranks second in both area and production, next only to chickpea. It is grown over on area of 5.33 m ha producing nearly 4.87 m t with an average productivity of 913 kg ha^{-1} (Anon., 2017) [1]. It is grown predominantly under rainfed conditions either as a sole crop or as an intercrop with cereals such as sorghum, pearlmillet, maize or with other legumes such as peanut, cowpea, fieldbean etc.

Fodder shortage has become the major problem now a days. There is a huge gap between the fodder demand and fodder supply. To curb this fodder shortage problem, improving cropping system can be a probable solution. One can go for intercropping instead of growing sole crop. Intercropping produces the higher yield and economic returns on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height, and nutrient requirements based on the complementary utilization of growth resources by the component crops (Lithourgidis *et al.*, 2011) [5]. Cereal and legume intercropping has been recognized as a beneficial crop production system both for better resource use and higher dry matter production per unit area per unit time (Bhagat *et al.*, 2011) [3]. The choice of the intercrop should be such that it doesn't affect the growth and yield of main crop. Hence, the current investigation was carried out in order to evaluate the suitable fodder intercrop for pigeonpea under rainfed conditions.

Material and Methods

The experiment was conducted during *kharif*-2018 at Agricultural Research Station, Kalaburagi, UAS, Raichur. Soil type of the experimental plot was black clay in texture belonging to the order *vertisols.* The experiment consisted of thirteen treatments *viz.*

T_1- Sole Pigeonpea,
T_2- Sole Fodder Sorghum,
T_3- Sole Fodder Maize,
T_4- Sole Fodder Bajra,
T_5- Sole Fodder Cowpea,
T_6- Sole Fodder Horsegram,
T_7- Sole Fodder Fieldbean,
T_8- Pigeonpea + Fodder Sorghum (1:2),
T_9- Pigeonpea + Fodder Maize (1:2),
T_{10}- Pigeonpea + Fodder Bajra (1:2),
T_{11}- Pigeonpea + Fodder Cowpea (1:2),
T_{12}- Pigeonpea + Fodder Horsegram (1:2) and
T_{13}- Pigeonpea + Fodder Fieldbean (1:2)

These treatments were laid out in randomized complete block design and replicated thrice. The rainfall received during *kharif*-2018 was 402.94 mm which was 46.92 per cent less than the annual average rainfall of the region *i.e.* 759 mm.

Plant height (cm)

The height of the plant was measured from base of the plant to the tip of main shoot from five plants and mean plant height was worked out and expressed in centimetres.

Number of primary branches per plant

The number of branches emerging directly from main stem was counted and the average of five plants was expressed as number of primary branches per plant.

Number of secondary branches per plant

The number of branches emerging from primary branches were counted and the average of five plants was expressed as number of secondary branches per plant.

Leaf area (cm^2 $plant^{-1}$)

The leaf area was worked out by disc method on dry weight basis at 45, 90, 135 DAS and at harvest as per the procedure suggested by Vivekanandan *et al*. (1972) [10].

$$LA = \frac{Wa * A}{Wd}$$

Where,
LA = Leaf area (cm^2 $plant^{-1}$)
Wa = Oven dry weight of all leaves (inclusive of 10 disc weight)
Wd = Oven dry weight of 10 discs in gram
A = Area of the 10 discs (cm^2)

Leaf area index (LAI)

Leaf area index (LAI) was worked out by dividing the leaf area per plant by land area occupied by the plant (Sestak *et al*., 1971) [9].

$$LAI = \frac{A}{P}$$

Where,
A= Leaf area per plant (cm^2)
P= Land area occupied by the plant (cm^2)

Result and Discussion

Plant height

The data on plant height (cm) of pigeonpea as influenced by different fodder intercropping systems at 45 DAS, 90 DAS, 135 DAS and at harvest are presented in table 1. The results of the experiment revealed that plant height of pigeonpea was significantly influenced by different fodder intercropping systems at all the growth stages of the crop.

At 45, 90, 135 DAS and at harvest the plant height of Pigeonpea was significantly taller in sole Pigeonpea than in all the intercropping systems except T_{12} - Pigeonpea + Fodder Horsegram (1:2) where in it was on par. The next best treatment was T_{13}- Pigeonpea + Fodder Fieldbean (1:2) and it was on par with T_{11} - Pigeonpea + Fodder Cowpea (1:2) The shortest plant height of pigeonpea was recorded in Pigeonpea + Fodder Maize at 1:2 row proportion.

It was clear from the results of the experiment that the plant height of pigeonpea was taller in sole pigeonpea than in the intercropped pigeonpea at all the growth stages. It may be due to the more competition between the intercrop and pigeonpea for light, space, moisture and nutrients in intercropping system. Similar results were obtained by Rathod (2002) [6] in pigeonpea intercropping with short duration pulses and Ashwathanarayana (2014) [2] in Pigeonpea + Gum guar intercropping system.

Table 1: Plant height of pigeonpea at different growth stages of the crop as influenced by different fodder crop intercropping systems

Treatments	Plant height (cm)			
	45 DAS	90 DAS	135 DAS	At harvest
T_1 - Sole Pigeonpea	59.91	75.02	114.03	136.84
T_2 - Sole Fodder Sorghum	-	-	-	-
T_3 - Sole Fodder Maize	-	-	-	-
T_4 - Sole Fodder Bajra	-	-	-	-
T_5 - Sole Fodder Cowpea	-	-	-	-
T_6 - Sole Fodder Horsegram	-	-	-	-
T_7 - Sole Fodder Fieldbean	-	-	-	-
T_8 - Pigeonpea + Fodder Sorghum (1:2)	54.73	68.75	105.33	127.86
T_9 - Pigeonpea + Fodder Maize (1:2)	52.33	65.92	102.97	125.21
T_{10} - Pigeonpea + Fodder Bajra (1:2)	54.93	69.00	106.22	129.19
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	57.27	71.98	109.74	132.70
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	59.27	74.67	113.52	136.22
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	57.40	72.08	110.22	133.60
S.Em.±	0.37	0.34	0.46	0.67
C. D. at 5%	1.13	1.05	1.43	2.06

DAS: Days after sowing

Number of primary branches per plant of pigeonpea

The data pertaining to number of primary branches per plant of pigeonpea at 45 DAS, 90 DAS, 135 DAS and at harvest as influenced by different fodder intercropping systems are presented in table 2. The results of the experiment revealed that the number of primary branches per plant of pigeonpea were significantly influenced by different fodder intercropping systems.

At 45, 90, 135 DAS and at harvest, significantly higher number of primary branches per plant were observed in sole pigeonpea compared to rest of the treatments, except T_{12}- Pigeonpea + Fodder Horsegram (1:2) where in it was on par. The next best combination was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) and it was on par with T_{11}- Pigeonpea + Fodder Cowpea (1:2). The lowest number of primary branches per plant was recorded in T_9- Pigeonpea + Fodder Maize (1:2).

Significantly lower number of primary branches per plant

were recorded in intercropping system than the sole crops. This may be due to the increased competition in intercropped system than the sole. The results of the experiment are in conformity with the findings of Sarojani (2018) [8], where in, sole pigeonpea recorded higher number of primary branches than pigeonpea intercropped with fieldbean.

Table 2: Number of primary branches per plant of pigeonpea at different growth stages of the crop as influenced by different fodder crop intercropping systems

Treatments	Number of primary branches per plant			
	45 DAS	90 DAS	135 DAS	At harvest
T_1 - Sole Pigeonpea	7.28	11.86	13.37	14.32
T_2 - Sole Fodder Sorghum	-	-	-	-
T_3 - Sole Fodder Maize	-	-	-	-
T_4 - Sole Fodder Bajra	-	-	-	-
T_5 - Sole Fodder Cowpea	-	-	-	-
T_6 - Sole Fodder Horsegram	-	-	-	-
T_7 - Sole Fodder Fieldbean	-	-	-	-
T_8 - Pigeonpea + Fodder Sorghum (1:2)	6.04	8.99	11.39	12.10
T_9 - Pigeonpea + Fodder Maize (1:2)	5.04	7.27	9.18	11.40
T_{10} - Pigeonpea + Fodder Bajra (1:2)	6.14	9.04	11.25	12.17
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	6.40	10.18	12.28	13.10
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	7.17	11.78	13.17	14.10
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	6.51	10.42	12.39	13.27
S.Em.±	0.04	0.16	0.08	0.17
C. D. at 5%	0.12	0.48	0.24	0.52

DAS: Days after sowing

Number of secondary branches per plant of pigeonpea

The data with respect to number of secondary branches plant^{-1} at 90, 135 DAS and at harvest as influenced by different fodder intercropping systems are presented in table 3. The experimental results indicated that number of secondary branches per plant of pigeonpea was significantly influenced by different fodder intercropping systems.

Among all the treatments, significantly higher number of secondary branches per plant of pigeonpea were observed in T_{1}- sole pigeonpea and it was on par with T_{12} – Pigeonpea + Fodder horsegram (1:2). The next best treatment was T_{13}- Pigeonpea + Fodder Fieldbean (1:2) followed by T_{12}- Pigeonpea + Fodder Cowpea (1:2). Whereas Pigeonpea + Fodder maize (1:2) recorded least number of secondary branches per plant at all the growth stages.

The results of the investigation indicated that the number of secondary branches per plant were more in sole pigeonpea when compared to intercropped pigeonpea. This is because of less competition between the plants for light, nutrients, space and moisture in sole pigeonpea than in the intercropped pigeonpea. These results are in accordance with the findings of Rathod (2002) [6] in pigeonpea + short duration pulses and Gamit (2014) [4] in pigeonpea + sorghum intercropping system.

Leaf area of pigeonepa

The data with respect to the leaf area (dm^2 plant^{-1}) of pigeonpea as influenced by different fodder intercropping systems is presented in table 4.

Different fodder intercropping systems in pigeonpea had shown significant difference in leaf area of pigeonpea at all the growth stages. Among all the treatments, significantly lower leaf area per plant was noticed in T_9- pigeonpea + fodder maize (1:2) at 45, 90, 135 DAS and at harvest (3.57, 11.64, 9.88 and 6.63 dm^2 plant^{-1}, respectively). Whereas T_1- Sole Pigeonpea recorded maximum leaf area per plant over rest of the treatments. However it was on par with T_{12}- Pigeonpea + Fodder horsegram (1:2). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2).

Table 3: Number of secondary branches per plant of pigeonpea at different growth stages of the crop as influenced by different fodder crop intercropping systems

Treatments	Number of secondary branches per plant		
	90 DAS	135 DAS	At harvest
T_1 - Sole Pigeonpea	6.63	9.25	10.67
T_2 - Sole Fodder Sorghum	-	-	-
T_3 - Sole Fodder Maize	-	-	-
T_4 - Sole Fodder Bajra	-	-	-
T_5 - Sole Fodder Cowpea	-	-	-
T_6 - Sole Fodder Horsegram	-	-	-
T_7 - Sole Fodder Fieldbean	-	-	-
T_8 - Pigeonpea + Fodder Sorghum (1:2)	4.36	7.38	8.44
T_9 - Pigeonpea + Fodder Maize (1:2)	3.79	6.48	7.50
T_{10} - Pigeonpea + Fodder Bajra (1:2)	4.44	7.69	8.50
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	5.12	8.51	9.46
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	6.30	9.10	10.51
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	5.42	8.63	9.61
S.Em.±	0.16	0.12	0.16
C. D. at 5%	0.49	0.38	0.48

DAS: Days after sowing

Table 4: Leaf area of pigeonpea at different growth stages of the crop growth as influenced by different fodder crop intercropping system

Treatments	Leaf area (dm^2 plant^{-1})			
	45 DAS	90 DAS	135 DAS	At harvest
T_1 - Sole Pigeonpea	5.47	17.84	14.95	9.82
T_2 - Sole Fodder Sorghum	-	-	-	-
T_3 - Sole Fodder Maize	-	-	-	-
T_4 - Sole Fodder Bajra	-	-	-	-
T_5 - Sole Fodder Cowpea	-	-	-	-
T_6 - Sole Fodder Horsegram	-	-	-	-
T_7 - Sole Fodder Fieldbean	-	-	-	-
T_8 - Pigeonpea + Fodder Sorghum (1:2)	4.31	14.04	11.77	7.78
T_9 - Pigeonpea + Fodder Maize (1:2)	3.57	11.64	9.88	6.63
T_{10} - Pigeonpea + Fodder Bajra (1:2)	4.35	14.20	11.90	7.85
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	4.95	16.21	13.59	8.93
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	5.38	17.51	14.67	9.67
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	5.02	16.37	13.75	9.01
S.Em.±	0.06	0.16	0.22	0.13
C. D. at 5%	0.20	0.50	0.68	0.40

DAS: Days after sowing

Leaf area index of pigeonepa

The data regarding leaf area index of pigeonpea as influenced by different fodder intercropping systems is presented in table 5.

The results of the experiment revealed that different fodder intercropping systems in pigeonpea had significant influence on leaf area index of pigeonpea at all the growth stages. Among all the treatments, significantly lower leaf area index was noticed in T_9 - pigeonpea + fodder maize (1:2) at 45, 90, 135 DAS and at harvest. Whereas T_1- Sole Pigeonpea recorded maximum leaf area per plant over all other treatments. However it was on par with treatment T_{12}-

Pigeonpea + Fodder horsegram (1:2). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2).

Experimental results clearly indicated that the leaf area and leaf area index of pigeonpea grown in intercropping system was significantly influenced by the competition of intercrop. Whereas leaf area and leaf area index of pigeonpea in sole cropping was superior to the intercropped pigeonpea. This might be attributed to the competition between inter and intra row plants for the resources and space in intercropping system which reduced the leaf area and leaf area index of pigeonpea. Reddy *et al.* (2015) [7] also reported higher leaf area and leaf area index of pigeonpea in sole pigeonpea than the pigeonpea intercropped with sesame.

Table 5: Leaf area index of pigeonpea at different growth stages of the crop as influenced by different fodder crop intercropping system

Treatments	Leaf area index			
	45 DAS	90 DAS	135 DAS	At harvest
T_1 - Sole Pigeonpea	0.61	1.98	1.66	1.09
T_2 - Sole Fodder Sorghum	-	-	-	-
T_3 - Sole Fodder Maize	-	-	-	-
T_4 - Sole Fodder Bajra	-	-	-	-
T_5 - Sole Fodder Cowpea	-	-	-	-
T_6 - Sole Fodder Horsegram	-	-	-	-
T_7 - Sole Fodder Fieldbean	-	-	-	-
T_8 - Pigeonpea + Fodder Sorghum (1:2)	0.48	1.56	1.31	0.86
T_9 - Pigeonpea + Fodder Maize (1:2)	0.40	1.29	1.10	0.74
T_{10} - Pigeonpea + Fodder Bajra (1:2)	0.48	1.58	1.32	0.87
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	0.55	1.80	1.51	0.99
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	0.60	1.95	1.63	1.07
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	0.56	1.82	1.53	1.00
S.Em.±	0.01	0.02	0.02	0.01
C. D. at 5%	0.02	0.06	0.08	0.04

DAS: Days after sowing

Conclusion

It can concluded from the experiment that growing sole pigeonpea may record higher values of all the growth parameters but intercropping pigeonpea with fodder crops would add extra fodder yield without affecting much on the growth of pigeonpea. Fodder horsegram was found to be the most suitable fodder intercrop for pigeonpea as in this intercropping pigeonpea recorded taller plant height, higher number of primary branches per plant, secondary branches per plant, leaf area and leaf area index compared to all other treatments.

Conflict of interest: None

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