The Pharma Innovation Journal 2022; 11(1): 1573-1576

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 1573-1576

www.thepharmajournal.com
Received: 08-11-2021
Accepted: 18-12-2021

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Influence of different fodder crops on yield and yield parameters of pigeonpea (*Cajanus cajan* L.) under intercropping systems

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Abstract
Fodder scarcity is the major problem arising now a days in pigeonpea growing areas of Karnataka. Hence, intercropping pigeonpea with fodder crops helps efficient utilization of time, space, soil moisture, nutrients *etc*., and also reduces the fodder scarcity problems. Intercropping fodder crops in pigeonpea will have several benefits. Hence, present investigation is carried out to evaluate the performance of pigeonpea under different fodder intercropping systems. Field experiment was conducted during *kharif* - 2018 at Agricultural Research Station, Kalaburagi. The experiment consisted of thirteen treatments where Pigeonpea was intercropped with different fodder crops in 1:2 row proportion and intercropped treatments were compared with sole crop treatments for yield. The experiment was laid out in randomized complete block design and replicated thrice. When the performance of pigeonpea in different treatments was compared, results of the experiment revealed that sole pigeonpea recorded significantly higher grain yield (1204 kg ha^{-1}), stalk yield (2456 kg ha^{-1}) and husk yield (653 kg ha^{-1}) than the intercropped pigeonpea except the treatment where in pigeonpea was intercropped with horsegram (1:2) with which it was on par. But in the intercropped pigeonpea in addition to pigeonpea grain yield green fodder yield was also there. Hence Pigeonpea intercropping with fodder helps in achieving higher profits.

Keywords: Fodder crop, intercropping, pigeonpea

Introduction
Pigeonpea (*Cajanus cajan* L.) is one of the major grain legume crops of the tropical and subtropical regions. It is grown predominantly under rainfed conditions. It is widely cultivated in more than 25 tropical and subtropical countries, 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*. Karnataka with varied soil and climatic conditions has diverse crops under cultivation. Pulses are the important crops of the state and are being cultivated over an area of 2.96 m ha with production of around 1.7 m t (Anon., 2017) [2]. In Karnataka among different pulse crops grown, pigeonpea is considered as the most important crop of the state. It occupies an area of 1.2 m ha with total production of 0.9 m t and productivity of 749 kg ha^{-1} (Anon., 2017) [3]. India has the largest livestock population, which accounts for 17.5 per cent of the world's livestock population. However, livestock productivity is constrained by an acute shortage of feed and fodder. Annual total forage production is 866.6 million tons (400.6 m t green and 466 m t dry fodders). Whereas, the annual forage requirement is 1706 million tons (1097 m t green and 609 m t dry) to support the existing livestock population. The present feed and fodder resources of the country can meet only 50.8 per cent of the requirement, with a vast deficit of 49.2 per cent (63.5 per cent and 23.56 per cent of green and dry fodder) (Anon., 2015) [1]. It is estimated that there will be a shortage of 24.81 per cent dry fodder and 64.21 per cent green fodder against the requirement of 630 m t and 1134 m t for dry and green fodder, respectively by 2020 (Anon., 2017) [3]. The shortfall can be met by improving the cropping systems and increasing the cropping intensity. Intercropping is a multiple cropping practice involves growing of two or more crops simultaneously on the same piece of land. Growing pigeonpea with fodder crops under intercropping system is a profitable composition in terms of supply of good quantity and quality of fodder as well as food grain.

Materials and Methods
The experiment was conducted during *kharif*-2018 at Agricultural Research Station, Kalaburagi. Soil 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. Hence the yields recorded were comparatively low.

The following genotypes were used for the experiment.

1. Pigeonpea: 'TS-3R'

The variety TS-3R is a short duration, red and bold seeded variety which matures in 145 to 150days. It is resistant to wilt disease. It has high yielding ability and wide adaptability.it was released by the University of Agricultural Sciences, Raichur for general cultivation in central and southern parts of India during *kharif* season.

2. Fodder crops

a. Fodder sorghum-Co-FS 31- It is a multicut fodder variety grows to a height of 260- 280 cm. number of tillers per plant may vary from 10 to 15.
b. Fodder maize- African Tall - Plant is tall (255-265cm), vigorous, sturdy with leafier and well developed stalks roots. Stem thick light green and soft. Leaves long, narrow and dark green. Leaf/ stem ratio 0.45. Tassels are medium large and shed abundance of pollen. Grain white, bold and semi-dent in texture. Resistant to major foliar diseases and insect-pests. Resistant to stem borer, rust, leaf blight and Downey mildew.
c. Fodder bajra- Mahalaxmi – It is high yielding variety. Crop duration varies from 80 to 90 days
d. Fodder cowpea- VKS-69 – crop duration of the variety is 60 to 70 days.
e. Fodder horsegram- Local variety- crop duration varies from 60 to 70 days

Fodder fieldbean- Vijaylaxmi- variety with good vegetative growth. Duration of the crop varies from 60 to 70 days

Results and Discussion

Yield and Yield parameters of pigeonpea

Number of seeds per pod

The number of seeds per pod of pigeonpea was not significantly influenced by different fodder intercropping systems of pigeonpea. However. T_1- sole pigeonpea recorded slightly higher number of seeds per pod (3.97) than all other treatments. The number of seeds per pod of all the treatments ranged from 3.73 to 3.97 (table 2).

Number of pods per plant

Different fodder intercropping systems in pigeonpea had shown significant difference in number of pods per plant of pigeonpea. Significantly more number of pods per plant was noticed in T_1- sole pigeonpea (51.67 plant^{-1}). However it was on par with T_{12}- Pigeonpea + Fodder horsegram (1:2) (50.33 plant^{-1}). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) (45.67 plant^{-1}) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2) (44.67 plant^{1}). T_9- Pigeonpea + Fodder Maize (1:2) recorded least number of pods per plant (36.23 plant^{-1}).

Seed yield (g plant^{-1}) of pigeonpea

Significant difference was noticed with different pigeonpea based fodder intercropping systems in seed yield per plant of pigeonpea. Among all the treatments, significantly higher seed yield per plant was noticed in T_1- sole pigeonpea (26.33 g plant^{-1}). However it was on par with T_{12}- Pigeonpea + Fodder horsegram (1:2) (25.33 g plant^{-1}). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) (23.33 g plant^{-1}) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2) (22.33 g plant^{1}). T_9- pigeonpea + fodder maize (1:2) recorded lowest seed yield per plant (15.50 g plant^{-1}).

Pigeonpea grown in sole cropping recorded higher number of pods per plant, seeds per pod and higher seed yield per plant compared to all other intercropped treatments. Among the intercropped treatments pigeonpea intercropped with horsegram recorded significantly higher yield attributes. Intercropping pigeonpea with fodder legumes like fodder fieldbean and fodder cowpea also recorded higher number of pods per plant than intercropping pigeonpea with fodder cereals. This may be due to the fact that the legume crops helps in better utilization of other resources like light, nutrients and moisture by legume based fodder intercropping system. However number of pods per plant of pigeonpea in intercropped pigeonpea were lesser than the sole pigeonpea. Similar results were obtained by Lingaraju *et al.* (2008) [5], Sharma and Guled (2012) [6] and Singh and Abraham (2017) [7] in pigeonpea based intercropping system.

Hundred seed weight

The hundred seed weight of pigeonpea was not significantly influenced by different fodder intercropping systems of pigeonpea. However hundred seed weight of pigeonpea among all the treatments ranged from 12.15 to 13.10 g.

Stalk yield

Experimental results revealed that stalk yield (kg ha^{-1}) of pigeonpea was significantly influenced by different fodder intercropping systems. Among all the treatment combinations, significantly higher stalk yield was recorded in T_1- sole pigeonpea (2456 kg ha^{-1}). However it was on par with T_{12}- Pigeonpea + Fodder horsegram (1:2) (2402 kg ha^{-1}). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) (2249 kg ha^{-1}) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2) (2245 kg ha^{-1}). T_9- pigeonpea + fodder maize (1:2) recorded lowest stalk yield (1932 kg ha^{-1}) compared to all the treatments.

Husk yield

All the treatments of fodder intercropping systems in pigeonpea had shown significant difference in husk yield (kg ha^{-1}) of pigeonpea. Among all the treatments, significantly higher husk yield was noticed in T_1- sole pigeonpea (653 kg ha^{-1}). However it was on par with T_{12}- Pigeonpea + Fodder horsegram (1:2) (643 kg ha^{-1}). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) (592 kg ha^{-1}) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2) (584 kg ha^{-1}). T_9- pigeonpea + fodder maize (1:2) recorded lowest husk yield (460 kg ha^{-1}) compared to all the treatments.

Grain yield

The results of the experiment indicated that grain yield (kg ha^{-1}) of pigeonpea was significantly influenced by different fodder intercropping systems. Among all the treatment combinations, significantly higher grain yield was noticed in T_1- sole pigeonpea (1204 kg ha^{-1}). However it was on par with T_{12}- Pigeonpea + Fodder horsegram (1:2) (1178 kg ha^{-1}). The next best treatment was found to be T_{13}- Pigeonpea + Fodder Fieldbean (1:2) (1106 kg ha^{-1}) followed by T_{11} - Pigeonpea + Fodder Cowpea (1:2) (1101 kg ha^{-1}). Whereas pigeonpea intercropped with cereal fodder crops recorded significantly lower grain yield *viz.*, T_8 - Pigeonpea + Fodder Sorghum (1:2) (1004 kg ha^{-1}) T_{10} - Pigeonpea + Fodder Bajra (1:2) (1031 kg ha^{-1}). T_9- pigeonpea + fodder maize (1:2) recorded lowest grain yield (947 kg ha^{-1}).

Among all the treatments sole pigeonpea recorded maximum grain yield, stalk yield and husk yield. It may be due to minimum competition for moisture, light, space and nutrients. However when pigeonpea was intercropped with fodder horsegram it recorded significantly higher grain yield, stalk yield and husk yield over the other intercropped treatments. The next best treatment was found to be pigeonpea + fodder fieldbean and pigeonpea + fodder cowpea. This may be due to the reason that legumes as intercrops act as cover crops in wider row spaced pigeonpea resulting in higher *in-situ* moisture conservation and efficient utilization by both the component crops, furthermore helping in increased pigeonpea yields. However when cereal fodder crops were intercropped with pigeonpea significantly lower yields were obtained. This might be due to the tall growing cereal components (Cereal fodder crops) grew faster at the early stage and might have avoided the shading effect of the slow growing pigeonpea. The taller cereal fodder component of the intercropping might have exerted depressive effects of shading on the shorter and slower growing pigeonpea component. Hence, the pigeonpea yield under pigeonpea + maize (1:2) intercropping system, pigeonpea + fodder bajra (1:2) and pigeonpea + fodder sorghum (1:2) was low compared to pigeonpea yields with legume fodder crops. Similar results were obtained by Kathmale *et al*. (2014) [4] and in Pigeonpea + pearlmillet and pigeonpea + sunflower intercropping system.

Harvest index

Results of the experiment revealed that harvest index of pigeonpea were not significantly influenced by fodder intercropping systems.

Table 1: Details of the seed rate, spacing and recommended dose of fertilizer (RDF) of all the crops cultivated under the experiment

Crop	Seed rate (kg ha^{-1})	Spacing (cm^2)	RDF N:P_2O_5:K_2O (kg ha^{-1})
Pigeonpea	15	90 x 20	25:50:0
Fodder Sorghum	6	30 x 10	75:50:25
Fodder Maize	60	30 x 10	150:50:35
Fodder Bajra	10 – 12	30 x 10	60:40:20
Fodder Cowpea	30	30 x 10	15:30:0
Fodder Horsegram	30	30 x 10	15:30:0
Fodder Fieldbean	30	30 x 10	15:30:0

Table 2: Number of pods per plant, Number of seeds per pod, seed yield per plant and 100 seed weight of pigeonpea as influenced by different fodder crop intercropping systems

Treatments	No. of pods per plant	No. of seeds per pod	Seed yield (g plant^{-1})	100 seed weight (g)
T_1 - Sole Pigeonpea	51.67	3.97	26.33	12.15
T_2 - Sole Fodder Sorghum	-	-	-	0.00
T_3 - Sole Fodder Maize	-	-	-	0.00
T_4 - Sole Fodder Bajra	-	-	-	0.00
T_5 - Sole Fodder Cowpea	-	-	-	0.00
T_6 - Sole Fodder Horsegram	-	-	-	0.00
T_7 - Sole Fodder Fieldbean	-	-	-	0.00
T_8 - Pigeonpea + Fodder Sorghum (1:2)	41.00	3.87	18.00	12.33
T_9 - Pigeonpea + Fodder Maize (1:2)	36.23	3.90	15.50	12.42
T_{10} - Pigeonpea + Fodder Bajra (1:2)	41.67	3.87	19.00	13.10
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	44.67	3.73	22.33	12.76
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	50.33	3.93	25.33	12.57
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	45.67	3.80	23.33	12.29
S.Em.±	0.75	0.07	0.80	0.32
C. D. at 5%	2.31	NS	2.47	NS

DAS: Days after sowing
NS: Non significant

Table 3: Grain yield, stalk yield, husk yield and harvest index of pigeonpea as influenced by different fodder crop intercropping systems

Treatments	Grain yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Husk yield (kg ha^{-1})	Harvest index
T_1 - Sole Pigeonpea	1204	2456	653	0.28
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)	1004	2132	511	0.27
T_9 - Pigeonpea + Fodder Maize (1:2)	947	1932	460	0.28
T_{10} - Pigeonpea + Fodder Bajra (1:2)	1031	2152	520	0.28
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	1101	2245	584	0.28
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	1178	2402	643	0.28
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	1106	2249	592	0.28
S.Em.±	22	27	14	0.003
C. D. at 5%	68	83	43	NS

DAS: Days after sowing
NS: Non significant

Conclusions

From the experimental results it can concluded that Among all the pigeonpea based fodder intercropping systems, Intercropping pigeonpea with fodder horsegram at 1: 2 ratio was found to be more beneficial as it recorded higher pigeonpea grain yield, stalk yield and husk yield. However Sole crop yields of pigeonpea and fodder crops individually were higher than the intercrop yields. But combined yield of main crop and component crop in intercropping system was significantly high. The next best fodder intercropping system was found to be pigeonpea + fodder cowpea (1:2) followed by pigeonpea + fodder fieldbean (1:2) as these treatments also recorded higher yield and yield parameters of pigeonpea. this may be due to legumes act as cover crops and helps in *in-situ* moisture conservation and helps in getting the improved yields. But in cereal intercropping systems, the shade of tall growing cereals such as maize, bajra will reduce the pigeonpea yield due to shade effect.

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