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Investigations on Yield Advantage, Light Interception and Crude Protein Content of Fodder Crops as Influenced by Intercropping with Pigeonpea

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ABSTRACT: India is having largest livestock population and is facing serious lack of fodder. This is due to increasing pressure on land for growing food grains, oilseeds, pulses and inadequate attention being given to the production of fodder crops. There is a huge gap between the fodder demand and fodder supply. This gap can be minimized by adapting suitable cropping systems. Pigeonpea is the major crop of northern parts of Karnataka. As pigeonpea is a long duration and widely spaced crop, the inter row space can be used efficiently by adapting intercropping system. Hence, intercropping pigeonpea with fodder crops helps in reducing the fodder scarcity problems without compromising on economic yield of pigeonpea. Hence, present investigation is carried out to evaluate the yield advantage, light interception and crude protein content of fodder crops as influenced by intercropping with pigeonpea. The experiment was laid out in randomized complete block design and replicated thrice, it consisted of 13 treatments where individual fodder crops such as fodder sorghum, fodder maize, fodder bajra, fodder cowpea, fodder horsegram, fodder fieldbean were intercropped with pigeonpea at 1:2 row proportions (Pigeonpea + Fodder crop) and sole crops viz. sole pigeonpea, sole fodder sorghum, sole fodder maize, sole fodder bajra, sole fodder cowpea, sole fodder horsegram, sole fodder fieldbean were also maintained. All these treatments were evaluated for their pigeonpea grain yields, green fodder yields and intercropping advantages. Experimental results revealed that intercropping pigeonpea with fodder legumes have yielded higher pigeonpea grain yield as well as higher green fodder yield. Despite this, higher crude protein content was recorded in legume fodders only. Hence intercropping pigeonpea with legume fodders found to be superior to other treatments.

Keywords: crude protein content, fodder crop, intercropping, LER, PEY, Pigeonpea.

INTRODUCTION

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. Country's annual total forage production is only 866.6 million tons (400.6 million ton green and 466 million ton dry fodders). Whereas, the annual forage requirement is 1706 million ton (1097 million ton green and 609 million ton dry) to support the existing livestock population. The present feed and fodder resources of the nation 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). 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 million tons and 1134 million ton for dry and green fodder, respectively by 2020 (Anon., 2017). 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. Intercropping is a way to increase diversity in an agricultural ecosystem. Ecological balance, more utilization of resources, it also increases the quantity and quality of products and reduces damage by pests, diseases and weeds. (Mousavi and Eskandari, 2011). Intercropping system offers solution to obtain higher

productivity, diversified food products and reduced risk of crop failure under rainfed conditions (Timmegowda *et al*., 2016). Intercropping is more productive than sole cropping (Dahmardeh *et al.,* 2009).

Intercropping system utilises light energy more efficiently than sole crop (Hugar 2006). Cereal-legume intercropping can be used as a suitable management strategy for producing high quality and quantity of forage. Intercropping improves forage quality compared with cereals monoculture, and produces more dry matter compared with legumes sole crop. In the other word, forage with acceptable degree of quality and quantity can be attained by cereal-legume intercropping (Eskandari *et al.* 2009).

Forage intercrops result in improved nutritional quality as legumes contain protein in double quantity than cereals (Iqbal *et al.,* 2018). Inclusion of legume crops as an intercrop would yield higher seed yield of pigeonpea compared to sole (Singh and Abraham, 2017) Intercropping system was found to be efficient in utilizing the growth resources than sole crops (Ashwathanarayana, 2014).

Pigeonpea being a major crop of northern Karnataka gives ample opportunity to practice intercropping system. Intercropping pigeonpea with fodder crops helps in producing good quality of fodder crops without compromising on the economic yield of pigeonpea. Pigeonpea intercropping with fodder crop has several yield advantages. Hence, an experiment was carried out to evaluate different pigeonpea based fodder intercropping system for assessing yield advantage, to study the light interception and crude protein content of fodder crops.

MATERIAL AND METHODS

A field 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.

Land equivalent ratio (LER): It is calculated according to the formula given by Willey, (1979).

$$LER = \frac{\text{Yield of pigeonpea in intercropping system}}{\text{Yield of sole pigeonpea}} + \frac{\text{Yield of fodder crop in intercropping system}}{\text{yield of sole fodder crop}}$$

Area time equivalent ratio (ATER): ATER was calculated according to formula given by Hiebsch (1980).

$$ATER = \frac{(RYf * tf) + (RYp * tp)}{T}$$

Where,

RY = Relative yield of species f and p

$$RY = \frac{\text{Yield of intercrop per hectare}}{\text{yield of monocrop per hectare}}$$

t = duration (days) for species f and p

T = Total duration (days) of the intercropping system

Table 1: Land equivalent ratio (LER), Area time equivalent ratio (ATER) and Pigeonpea equivalent yield (PEY) as influenced by different fodder intercropping systems with pigeonpea.

Treatments	LER	ATER	PEY (kg ha^{-1})
T_1 - Sole Pigeonpea	1.00	1.00	1204
T_2 - Sole Fodder Sorghum	1.00	1.00	586
T_3 - Sole Fodder Maize	1.00	1.00	720
T_4 - Sole Fodder Bajra	1.00	1.00	636
T_5 - Sole Fodder Cowpea	1.00	1.00	841
T_6 - Sole Fodder Horsegram	1.00	1.00	1163
T_7 - Sole Fodder Fieldbean	1.00	1.00	673
T_8 - Pigeonpea + Fodder Sorghum (1:2)	1.52	1.11	1402
T_9 - Pigeonpea + Fodder Maize (1:2)	1.50	1.07	1457
T_{10} - Pigeonpea + Fodder Bajra (1:2)	1.59	1.15	1493
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	1.71	1.24	1767
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	1.68	1.26	1988
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	1.65	1.21	1596
S. Em.±	0.04	0.03	33
C. D. at 5%	0.13	0.08	98

Pigeonpea equivalent yield (PEY): The pigeonpea equivalent yield of intercropping system was calculated by taking into account the seed yield of both crops and the prevailing market price of both the crops.

$$\text{PEY(kg per ha)} = \frac{\text{Yf} * \text{Pf}}{\text{Pp}} + \text{Yp}$$

Where, Yf = yield of fodder crops (kg ha^{-1})
Yp = yield of pigeonpea (kg ha^{-1})
Pp = Price of pigeonpea (Rs. kg^{-1})
Pf = Price of fodder crops (Rs. kg^{-1})

Light Transmission Ratio (LTR): Light interception by the canopies of pigeonpea and fodder crop, respectively was measured at 45 DAS by using Lux meter. The light intensity received above the canopies of the corresponding crops and at ground surface was recorded between 11.30 a.m. and 12.30 p.m. Based on these data, the light transmission ratio (LTR) was calculated by the following formula (Yoshida *et al.*, 1972).

$$\text{LTR}(\%) = \frac{\text{Light intensity at ground surface}}{\text{Light intensity above the canopy}}$$

Where,

Percent light interception = 100 – LTR

Where,

LTR = Light transmission ratio

Crude protein content (%): Crude protein content was determined by multiplying the nitrogen percentage with factor 6.25 as described by AOAC (1975).

$$\text{Crude protien (\%)} = \text{Nitrogen (\%)} * 6.25$$

RESULTS AND DISCUSSION

A. Assessment of yield advantages in intercropping system

Land Equivalent Ratio: Among all the intercropped treatments T_{11}- Pigeonpea + Fodder Cowpea (1:2) recorded maximum land equivalent ratio (1.71) and it was on par with T_{12}- Pigeonpea + Fodder Horsegram (1.68), T_{13}- Pigeonpea + Fodder Fieldbean (1.65) and T_{10}- Pigeonpea + Fodder Bajra (1.59). Whereas T_8- Pigeonpea + Fodder Sorghum (1.52), T_9- Pigeonpea + Fodder Maize (1.5) recorded significantly lower LER.

It has been understood that when two or more crops were raised as intercrops, their yields were generally lower in the intercropping system compared to their sole crop yields. It could be possible to minimize the decrease in yield of component crops cultivated together by choosing compatible plants with distinct growth patterns. However their combined yields will be higher than their individual yields.

The LER obtained under all the intercropped treatments was more than one. Hence all the intercropping treatments are advantageous than the sole cropping. However LER was higher when pigeonpea was intercropped with legume fodder crops *viz.,* fodder cowpea, fodder horsegram and fodder fieldbean this may be due to better moisture conservation because of good canopy cover and better utilization of nutrients. The results are in conformity Kathmale *et al.,* (2014) reported that LER recorded under pigeonpea intercropping with groundnut and soybean was higher than the LER recorded under pigeonpea intercropping with pearlmillet. Similar results obtained by Deolankar *et al.* (2016) in Pigeonpea + Frenchbean (1:3) intercropping system.

Area Time Equivalent Ratio Among all the intercropped treatments T_{11}- Pigeonpea + Fodder Horsegram (1:2) recorded maximum area time equivalent ratio (1.26). However it was on par T_{12}- Pigeonpea + Fodder Cowpea (1.24) and T_{13}- Pigeonpea + Fodder Fieldbean (1.21). Cereal fodder based intercropping system *viz.,* T_8- Pigeonpea + Fodder Sorghum (1.11), T_9- Pigeonpea + Fodder Maize (1.07) and T_{10}- Pigeonpea + Fodder Bajra (1.15) recorded significantly lower ATER than legume fodder intercropping system with pigeonpea.

The results of the experiment indicated that all the intercropped treatments recorded ATER more than one, hence all the intercropped treatments are beneficial. However pigeonpea intercropping with fodder legumes found to be better than pigeonpea intercropping with fodder cereals. This may be due to better utilization of moisture, space, nutrients and light. Similar results were obtained by Sharma and Guled (2012) in pigeonpea + groundnut intercropping systems.

Pigeonpea equivalent yield (PEY): Significantly higher PEY was observed in the treatment T_{12}- Pigeonpea + Fodder Horsegram (1988 kg ha^{-1}) compared to rest of the treatments. The next best treatment was found to be T_{11} - Pigeonpea + Fodder Cowpea (1767 kg ha^{-1}) followed by T_{13} - Pigeonpea + Fodder Fieldbean (1596 kg ha^{-1}). PEY of treatments T_8 - Pigeonpea + Fodder Sorghum (1402 kg ha^{-1}), T_9 - Pigeonpea + Fodder Maize (1457 kg ha^{-1}) and T_{10} - Pigeonpea + Fodder Bajra (1493 kg ha^{-1}) were on par with each other. Sole cropping systems recorded lower Pigeonpea equivalent yield compared to intercropping systems.

The intercropping system had a significant influence in getting higher pigeonpea equivalent yield over sole cropping. The highest PEY was found in pigeonpea intercropped with fodder horsegram. This was due to higher grain yield and fodder yield of component crops coupled with good price of both the crops contributed to higher PEY. Similar reason was quoted by Sekhon *et al.,* (2018) in pigeonpea + maize intercropping system.

B. Light interception

Light interception in pigeonpea (%): Significantly higher light interception was found in T_1- sole pigeonpea (89.03 %) compared to all the treatments. Among all the intercropped treatments, significantly higher light interception was noticed in treatments where pigeonpea is intercropped with legume fodder crops *viz,* T_{11} - Pigeonpea + Fodder Cowpea (87.49 %), T_{12}- Pigeonpea + Fodder Horsegram (88.46 %) and T_{13}- Pigeonpea + Fodder Fieldbean (87.51 %) than in the treatments where pigeonpea is intercropped with cereal

fodder crops *viz*, T_8- Pigeonpea + Fodder Sorghum (82.56 %), T_8- Pigeonpea + Fodder Maize (84.36 %) and T_{10}- Pigeonpea + Fodder Bajra (82.72 %). However highest light interception was recorded in T_{12}- Pigeonpea + Fodder Horsegram.

Light interception in sole pigeonpea was significantly higher than all the intercrops except T_{12}- Pigeonpea + Fodder Horsegram where in it was on par. Pigeonpea in all other intercropping system recorded significantly lower light interception this is due to the competition for light by the intercrops. Similar results were obtained by Sarojani, (2018) reported that higher light absortption was recorded in sole pigeonpea than the pigeonpea intercropped with fieldbean.

Light interception in fodder crops (%): Intercropping fodder crops with pigeonpea influenced the light interception significantly. Sole fodder crops recorded higher light interception *viz*, T_2 - Sole Fodder Sorghum (89.03 %) T_3- Sole Fodder Maize (89.38 %), T_4 - Sole Fodder Bajra (89.23 %), T_5 - Sole Fodder Cowpea (90.15 %), T_6 - Sole Fodder Horsegram (92.46 %) and T_7 - Sole Fodder Fieldbean (90.67 %) than the intecropped fodder crops *viz*, T_8 - Pigeonpea + Fodder Sorghum (88.77 %), T_9 - Pigeonpea + Fodder Maize (88.97 %) and T_{10} - Pigeonpea + Fodder Bajra (88.87 %), T_{11} - Pigeonpea + Fodder Cowpea (88.62 %),T_{12} - Pigeonpea + Fodder Horsegram (90.49 %) and T_{13} - Pigeonpea + Fodder Fieldbean (89.03 %). However among the intercrops, highest light interception was recorded in T_{12}- Pigeonpea + Fodder Horsegram (90.49 %).

Sole fodder crops recorded higher light interception than the intercropped fodder crops. This might be due to less competition for light in sole cropping. Similar results were obtained by Sarojani, (2018) reported that higher light absortption was recorded in sole field bean than the Fieldbean intercropped with pigeonpea. Ashwathnarayana, (2014) also recorded similar results.

Table 2: Per cent light interception in pigeonpea and fodder crops canopies as influenced by different fodder intercropping systems with pigeonpea.

Treatments	Light interception (%) of pigeonpea	Light interception (%) of fodder crops
T_1 - Sole Pigeonpea	89.03 (10.97)	—
T_2 - Sole Fodder Sorghum	—	89.03 (10.97)
T_3 - Sole Fodder Maize	—	89.38 (10.62)
T_4 - Sole Fodder Bajra	—	89.23 (10.77)
T_5 - Sole Fodder Cowpea	—	90.15 (9.85)
T_6 - Sole Fodder Horsegram	—	92.46 (7.54)
T_7 - Sole Fodder Fieldbean	—	90.67 (9.33)
T_8 - Pigeonpea + Fodder Sorghum (1:2)	82.56 (17.44)	88.77 (11.23)
T_9 - Pigeonpea + Fodder Maize (1:2)	84.36 (15.64)	88.97 (11.03)
T_{10} - Pigeonpea + Fodder Bajra (1:2)	82.72 (17.28)	88.87 (11.13)
T_{11} - Pigeonpea + Fodder Cowpea (1:2)	87.49 (12.51)	88.62 (11.38)
T_{12} - Pigeonpea + Fodder Horsegram (1:2)	88.46 (11.54)	90.49 (9.51)
T_{13} - Pigeonpea + Fodder Fieldbean (1:2)	87.51 (12.49)	89.03 (10.97)

*Figures in the parentheses indicate values of light transmission ratio (LTR)

C. Crude protein content

Significantly higher crude protein content was recorded in intercropped fodder crops *viz.*, T_8 - Pigeonpea + Fodder Sorghum (1:2) (9.48), T_9 - Pigeonpea + Fodder Maize (1:2) (9.52 %), T_{10} - Pigeonpea + Fodder Bajra (1:2) (9.32 %), T_{11}- Pigeonpea + Fodder Cowpea (1:2) (11.10 %), T_{12} - Pigeonpea + Fodder Horsegram (1:2) (10.90 %) and T_{13} - Pigeonpea + Fodder Fieldbean (1:2) (11.15 %) than the sole fodder crops T_2 - Sole Fodder Sorghum (8.43 %), T_3 - Sole Fodder Maize (8.53 %), T_4 - Sole Fodder Bajra (8.39 %), T_5 – Sole Fodder Cowpea (10.56 %), T_6 - Sole Fodder Horsegram (10.31 %), T_7 - Sole Fodder Fieldbean (10.60 %).

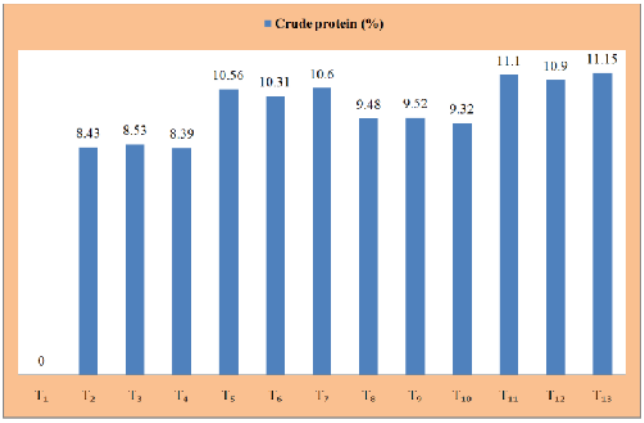

Fig 1. Crude protein content (%) of fodder crops as influenced by intercropping with pigeonpea

The increase in crude protein content in intercropping system may be due to the atmospheric nitrogen fixation by the legume in intercropping makes better uptake of N hence improves the crude protein content considerably. Similar results were obtained by Madhusudan *et al.*, (2004); Bacchi *et al.*, (2021).

CONCLUSION

Fodder scarcity problems of current situation can be minimized by improvement in cropping system such as intercropping system. Pigeonpea being widely spaced and long duration crop gives ample opportunity to utilize inter row space. Hence intercropping fodder crops in pigeonpea can be a better option to utilize light, space and time and profitable also. Under the present investigation when all the treatments were compared intercropping pigeonpea with fodder legumes was found to be better than fodder cereals because of higher intercropping yield advantage and higher protein content.

FUTURE SCOPE

The current study concentrated on the yield advantages, light energy absorptions, and quality indices of fodder crops grown in a pigeonpea intercropping system. Furthermore, research should be done on moisture percentage in the soil and its impact on the growth and yield of the main crop and component crop is required. When compared to cereal intercrops, fast-growing legume crops operate as cover crops, helping to retain moisture and reduce weed density. Weed density and weed competition in pigeonpea-based fodder intercropping systems should also be studied in detail.

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Conflict of interest. None.

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