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Review on Pigeonpea based Fodder Intercropping System

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ABSTRACT: Pigeonpea being a wide spaced and long duration crop gives ample opportunity to practice intercropping. Now-a-days fodder scarcity has become a major problem. There is a huge gap between fodder supply and fodder demand. This gap can be minimised by intensive cultivation of fodder crops. The inter row spacing of pigeonpea can be utilised for cultivating short duration fodder crops. This will not only help in mitigating fodder scarcity issues but also helps in improving the pigeonpea growth and yield. Several research studies have reported that intercropping fodder crops in pigeonpea have numerous benefits such as efficient utilisation of time, space, light and energy. It will also improve the system productivity.

Keywords: Fodder crop, growth, intercrop, PEY and pigeonpea.

INTRODUCTION

Cultivation of two or more crops simultaneously in the same field for higher yield and better economic returns is important in the present agricultural scenario as per capita availability of cultivable land is decreasing day by day due to urbanization, deforestation, industrialization *etc*. Intercropping system offers insurance against the crop risk and increased cropping intensity as two or more crops are grown on the same land simultaneously.

Pigeonpea is a wide spaced and long duration crop hence, the inter row space can be utilised efficiently for cultivating short duration crops. Now-a-days fodder scarcity has become a major problem hence, intercropping fodder crops in pigeonpea helps in minimizing the fodder scarcity problems as well as improves the system productivity.

Intercropping is a multiple cropping practice which involves growing of two or more crops simultaneously on the same piece of land (Andrews and Kassam, 1976). Growing pigeonpea with fodder crops under intercropping system is a profitable composition in terms of supply of good quantity and quality of fodder. It appears to make better use of sunlight, water and land (Kumar *et al.*, 2019). The practice is a kind of informal insurance against risk situations where crop production is subjected to vagaries of weather, pests and diseases which affect the individual crops differently.

Cereal and legume association results in improved yields. Cereal fodder crops such as fodder sorghum, fodder maize and fodder bajra are the good source of feed for the cattle in India. They are the nutritious and palatable feed for the cattle (Azraf-ul-Haq *et al.*, 2007). These fodder crops are of short duration in nature. As pigeonpea is a long duration crop and its initial slow growth offers a great opportunity to include such short duration cereal fodder crops under intercropping. Cereals and legume intercropping has a synergetic effect.

Intercropping systems and their importance. Intercropping plays an important role in improving the system productivity and sustainability. Rao and Mathuva, (2000) revealed that, the annual grain legume-based cropping systems were 32-49 % more profitable than continuous sole maize, making them attractive to small farmers in semi-arid tropics. Whereas Dahmardeh *et al.*, (2009) concluded that intercropping is more productive than sole cropping. Maize + cowpea intercropping system increased the green fodder yield and forage quality of maize.

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. Cereals are important in feeding ruminant animals because of their high dry matter production, quick growing, leafy, rich in carbohydrates and give high tonnage of fodder. Cereals forage is poor in protein content which shows their low quality and nutritive value. A balanced diet of cereal-legume through intercropping should have suitable proportions, mineral matter and protein (Singh *et al*., 2011).

Intercropping produces the higher yield and economic returns on a given piece of land by making more efficient use of the available growth resources by 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. Intercropping provides insurance against crop failure or against unstable market prices for a given commodity, especially in areas which subject to extreme weather conditions such as flood, drought, and frost (Lithourgidis *et al.,* 2011).

Intercropping can be defined as a multiple cropping system in which two or more crops planted in a field during a growing season. Intercropping is a way to increase diversity in agricultural ecosystem, ecological balance, and more utilization of resources; increases the quantity and quality of products and reduces the damage by pests, diseases and weeds (Mousavi and Eskandari, 2011).

Rusinamhodzi *et al*., (2012) Maize-legume intercropping has potential to reduce the risk of crop failure, improves productivity, income and increase food security in vulnerable production systems and is a feasible entry point to ecological intensification. Whereas Timmegowda *et al*., (2016) opined that intercropping system offers solution to obtain higher productivity, diversified food products and reduced risk of crop failure under rainfed conditions.

Effect of different fodder crops on growth parameters of pigeonpea. The growth and growth parameters of pigeonpea would be significantly affected when grown in intercropping system. Rathod, (2002) reported that when compared to intercropped pigeonpea, sole crop of pigeonpea recorded significantly more plant height (170 cm), primary branches and secondary branches. While Ashwathanarayana, (2014) recorded significantly higher plant height (172.00 cm), number of primary branches (14.27), secondary branches (11.14) and total dry matter production (169.72 g) in sole pigeonpea as compared to gum guar intercropped pigeonpea. Gamit, (2014) also recorded significantly higher number of branches per plant in sole pigeonpea *var.* AGT-2 (11.8) than in the pigeonpea intercropped with sorghum (10.45).

Dhandayuthapani *et al.,* (2015) concluded that pigeonpea (120 × 30 cm) + greengram 1:3 row ratio achieved significantly higher plant height (192.1 cm), stem girth (7.9 cm), number of branches (23.3), dry matter production (6342 kg ha^{-1}) and yield of pigeonpea (1741 kg ha^{-1}) when compared to other treatment combinations. Further Reddy *et al,*. (2015) revealed that the application of 100 per cent recommended dose of fertilizers to sole pigeonpea and sole sesame significantly found higher leaf area at 90 days (42.49 dm^2 $plant^{-1}$ and 256.13 cm^2 $plant^{-1}$, respectively), leaf area index (1.574 and 0.569) and dry matter production at harvest (166.33 g $plant^{-1}$ and 29.93 g $plant^{-1}$) compared to other intercropped treatments.

Singh and Abraham, (2017) quoted that intercrops significantly increased plant height, dry matter production and crop growth rate of pigeonpea during two years of their study. On pooled data basis significantly higher plant height (118.17 cm and 173.74 cm at 60 and 90 DAS stage) and dry matter production (1435.50, 4120.90 and 5748.20 kg ha^{-1} at 60, 90 DAS and harvest stage, respectively of pigeonpea were recorded with the association of fodder cowpea followed by greengram and blackgram.

Sarojani, (2018) revealed that significantly lower dry matter accumulation in leaves (5.62 to 7.95, 11.84 to 14.70, 9.66 to 11.18 and 4.91 to 6.85 g $plant^{-1}$ at 60, 90,120 DAS and at harvest, respectively) recorded in Pigeonpea + Fieldbean compared to sole pigeonpea (9.40, 22.26, 18.24 and 9.32 g $plant^{-1}$ at 60, 90, 120 DAS and at harvest, respectively). It may be due to more competition between intercrop that supressed the dry matter accumulation and photosynthetic ability in pigeonpea.

Kumar *et al.,* (2019) opined that intercropping of legumes fodder improve the soil condition and add nitrogen as well as enhance availability of nutrients and which results into taller plant height of pigeonpea as well as better yield.

Effect of different fodder crops on yield and yield parameters of pigeonpea. The intercropping system affects the yield and yield parameters of pigeonpea significantly. The grain yield of pigeonpea and soybean in intercropping system significantly decreased as compared to their sole crop yields. In the intercropping system, planting patterns of 2:6 (23.76 q ha^{-1}) and 3:9 (23.18 q ha^{-1}) gave significantly higher yield of base crop of pigeonpea and intercropping soybean. The yield of intercrop of soybean increased as the number of rows of soybean in the intercropping systems increased from 6 to 9. The pigeonpea grain yield equivalent was significantly higher with intercropping 2 :6 (30.86 q ha^{-1}) and 3:9 (30.56 q ha^{-1}). Net returns obtained due to 2:6 row was maximum, which was higher by Rs. 4,355 ha^{-1} over sole pigeonpea. The net returns per rupee invested was also maximum (3.95 and 3.66) at 2:6 and 3:9 row ratios (Shrivastava *et al.,* 2000).

Rathod, (2002) found that cropping systems influenced on the yield parameters of pigeonpea significantly. Growing of pigeonpea as sole crop with normal planting geometry (90 cm × 30 cm) and wider planting geometry (120 cm × 22.5 cm) recorded higher grain yield (1543 kg ha^{-1} and 1447 kg ha^{-1} respectively) over pigeonpea in intercropping system. Further, sole pigeonpea recorded significantly higher yield components *viz*., number of pods per plant and seed yield per plant as compared to intercropped pigeonpea.

Sharma *et al*., (2010) conducted experiment to study the effect of pigeonpea based intercropping with small millets, pearl millet and greengram on grain yield, LER, equivalent yield of pigeonpea (PEY) and economics. Among the intercropping treatments pigeonpea + little millet (2:1), pigeonpea + foxtail millet (2:1) and pigeonpea + pearl millet (2:1) performed better than the sole crop cultivation of little millet, foxtail millet and pearl millet. The highest yields were recorded with pigeonpea + greengram intercropping system as compared to pigeonpea + pearl millet and pigeonpea + foxtail millet intercropping systems. The reason for higher yield may be attributed to better utilization of other resources like light, nutrients and moisture by pigeonpea + greengram intercropping system.

Chaudhary and Thakur, (2005) conducted the experiment on sandy loam soil and found that intercropping did affect the grain yield of pigeopea and component crops but it increased the total productivity in terms of pigeonpea equivalent yield. Highest land equivalent ratio of 1.55 was in pigeonpea + maize followed by pigeonpea + blackgram (1.52). Kantwa *et al*., (2005) reported that intercropping of pigeonpea with urdbean had no effect on pigeonpea yield, but the additional urdbean yield in intercropping resulted in markedly higher total productivity in terms of pigeonpea-equivalent yield.

Chaudhari *et al.,* (2006) reported that intercropping of soybean (JS – 335) + pigeonpea (BSMR-736) with 3:1 row proportion produced highest soybean equivalent yield (24.06 q ha^{-1}) compared to other intercropping system. Whereas Marer *et al*., (2007) conducted an experiment involving pigeonpea intercropping system with different crops at different row proportions. Experimental results revealed that sole crop of maize and pigeonpea recorded significantly higher grain yield (6337 and 1090 kg ha^{-1}, respectively) over intercropping systems. Lingaraju *et al.*, (2008) reported higher number of pods per plant in sole pigeonpea (192.4) than the pigeonpea intercropped with maize (ranged from 130.7 to 165.9) and significantly higher grain yield per plant in sole pigeonpea (38.9) than the intercropping system.

Dudhade *et al.*, (2009) opined that higher grain yield of pigeonpea (1988 kg ha^{-1}) obtained in sole pigeonpea and lowest yield in pigeonpea intercrop with rajmah (1060 kg ha^{-1}) among intercrops, three rows of mungbean intercropped in pigeonpea gave highest grain yield (1391 kg ha^{-1}) than three rows of rajmah intercropped in pigeonpea (1332 kg ha^{-1}). Further Sharma and Guled, (2012) studied that significantly higher seed yield (16.85 q ha^{-1}) and stalk yield (36.57 q ha^{-1}) obtained in pigeonpea + greengram (1:2) intercropping system under set-furrow with vermicompost @ 2.5 t ha^{-1} as compared to flatbed method (13.58 and 29.60 q ha^{-1}, respectively). However Ashwathanarayana, (2014) recorded significantly higher pigeonpea seed yield (1574 kg ha^{-1}) and stalk yield (4712 kg ha^{-1}) in sole pigeonpea as compared to gum guar intercropped pigeonpea.

Kathmale *et al.,* (2014) reported lower pigeonpea yield under pigeonpea + sunflower (1:2) intercropping system and pigeonpea + pearl millet (1:3) (412 and 548 kg ha^{-1}, respectively) compared to pigeonpea yields with other intercrops *i.e*. soybean, groundnut and kidneybean (739, 633 and 754 kg ha^{-1}). Whereas a field experiment conducted at Akola by Kumar *et al*., (2014) revealed that, higher pigeonpea seed yield (40.96 g $plant^{-1}$), straw yield (31.48 g $plant^{-1}$), stalk yield (65.02 g $plant^{-1}$) leaf biomass (3043 kg ha^{-1}), *in-situ* recycling (5221 kg ha^{-1}) were obtained in pigeonpea + soybean (1:2) followed by pigeonpea + soybean (1:5) and found lowest in sole pigeonpea.

Timmegowda *et al*., (2016) concluded that finger millet (*Eleusine coracana* L.) + pigeonpea (*Cajanus cajan* L.) (8:2) with moisture conservation furrow between paired rows of pigeonpea intercropping recorded higher yield and economics as compared to the farmers' practices of growing finger millet with *akkadi* crops.

In groundnut (*Arachis hypogaea* L.) based cropping, groundnut + pigeonpea (8:2) intercropping with moisture conservation furrow between paired rows of pigeonpea proved to be the better climate resilient intercropping system with higher yields in red soils of southern Karnataka. Under pulse based cropping systems, pigeonpea + cowpea (*Vigna unguiculata* L.) and pigeonpea + field bean (*Phaseolus vulgaris* L.) were remunerative when grown in additive series compared to sole crop of pigeonpea.

Barod *et al*., (2017) quoted that the effect of intercropping systems under different spacing influenced the pigeonpea grain yield. Grain yield per hectare is function of number of plants, pods per plant, and number of grains per pod and grain yield per plant. Under different intercropping systems, the higher grain yield (1454 kg ha^{-1}) of pigeonpea was recorded in pigeonpea (75 cm) + greengram in 1:2 row ratio. However; it was at par with the intercropping systems pigeonpea (75 cm) + greengram in the row ratio of 1:1 (1417 kg ha^{-1}).

Singh and Abraham, (2017) reported that inclusion of cowpea, greeengram and blackgram as an intercrop with pigeonpea increased the seed yield of pigeonpea and pigeonpea equivalent yield and proved significantly superior over pigeonpea sole. The highest growth and yield attributes as well as seed yield of pigeonpea were recorded with pigeonpea in association with fodder cowpea.

Madembo *et al*., (2020) reported higher system productivity in pigeonpea + maize intercropping than the sole crops.

ASSESSMENT OF YIELD ADVANTAGE

Land equivalent ratio. The land equivalent ratio is a concept in agriculture that describes the relative land area required under sole cropping (monoculture) to produce the same yield as under intercropping (Mead and Willey, 1980).

Itnal *et al.,* (1994) reported higher LER (1.41) in intercropping system of pearlmillet + pigeonpea in row proportion of 4:2 with additive series followed by the same plant density series in 3:1 row proportions (1.36). Whereas Owere *et al.,* (2001) recorded higher land equivalent ratio (LER) up to 1.30 and 1.29 in fingermillet + pigeonpea and sorghum + pigeonpea intercropping at 2:2 row ratio.

Abdur *et al*., (2002) carried out an experiment at Arid Zone Research Farm, Ratta Kulachi to study the land equivalent ratios as influenced by legumes intercropping system. They recorded highest LER of 1.55 with double row strip of sorghum + two rows of mungbean as intercrop between 90 cm space of sorghum strips. Furthermore research was conducted by Patel and Rajagopal, (2003) on nitrogen management in the Anjora (Durg) intercropping system for the production of sorghum and cowpea forage. The land equivalent ratio (LER) was reported to be higher in the first year under sorghum + cowpea at 100 kg N ha^{-1} (4:3 row ratio) with LER 1.47. Although in the second year it was maximum (1.29) with its 4:2 row ratio.

Kumar, (2004) revealed that pearl millet + clusterbean (6:3) and pearl millet + blackgram (4:2) strip cropping systems recorded highest land equivalent ratio in first year and second year of experiment. whereas Sharma *et al.,* (2010) obtained highest LER of 1.49 and 1.47 was in ICP-8863 + greengram and ICPL-87119 + greengram intercropping system followed by ICP-8863 + pearl millet (1.43) and ICP-8863 + foxtail millet (1.43) and is due to greengram matures very early and less competitive compared to foxtail millet and pearl millet.

Verma *et al.,* (2005) found that intercropping of fodder sorghum in narrow row space of pigeonpea (75 cm) with a row ratio of 1:2 recorded the highest land-equivalent ratio (1.583). Further Chaudhari *et al.,* (2006) observed significantly higher LER (1.38) in soybean (JS – 335) + pigeonpea (BSMR-736) at 3:1 row proportion as compared to soybean intercropping with other crops. And then Premsing *et al.,* (2007) opined that intercropping of pearl millet + mothbean planted at 2:1 row ratio produced significantly higher LER (1.47).

Surve *et al.,* (2012) indicated that land equivalent ratio significantly influenced under various intercropping systems. Treatments (T_6) sorghum + cowpea (2:1), (T_9) maize + cowpea (2:1) and T_5 sorghum + cowpea (1:2) were statistically at par and recorded higher values of LER compared to other systems. The treatments (T_7) maize + cowpea (1:1) and (T_8) maize + cowpea (1:2) were statistically at par and recorded lowest values of LER than other systems.

Sharma and Guled, (2012) found that pigeonpea + greengram (1:2) intercropping system under set-furrow with application of vermicompost @ 2.5 t ha^{-1} recorded significantly higher pigeonpea equivalent yield (24.60 q ha^{-1}), LER (1.96) and ATER (1.55) over other intercropping systems. Furthermore research carried out by Dhar *et al.,* (2013) at Bangladesh to study the interspecific competition and productivity of maize and pea in intercropping mixture. The single and double row combined intercropping mixtures gave the highest land equivalent ratio (1.31 and 1.47). In both 1M : 1P and 1M : 2P intercropping mixtures, maize population exhibited strongly higher competition over pea. Ashwathanarayana, (2014) also recorded significantly higher LER (1.44) under pigeonpea intercropping with gumguar *cv.* HG-365 in 1:2 proportion.

Pigeonpea equivalent yield. Shrivastava *et al.,* (2000) reported that the pigeonpea grain yield equivalent was significantly higher with soybean intercropping system at the row proportion of 2:6 (30.86 q ha^{-1}) and 3:9 (30.56 q ha^{-1}). Whereas Verma *et al.,* (2005) found that intercropping of fodder sorghum in narrow row space of pigeonpea (75 cm) with a row ratio of 1:2 recorded the highest pigeonpea equivalent yield (34.36 q ha^{-1}) compared to other intercropping treatments.

Dutta and Bandyopadhyay, (2006) carried out field experiment at West Bengal to evaluate the production potential and economic feasibility of intercropping of groundnut with pigeon pea and maize. They found that all the intercropping systems showed superiority to sole groundnut in terms of groundnut equivalent yield. The higher groundnut equivalent yields were obtained with ground nut intercropping with pigeon pea in 5:2 row ratio (14.42 q ha^{-1}) and with maize 4:2 row ratio (13.56 q ha^{-1}).

A field experiment conducted by Kumar and Rana, (2007) indicated that, the planting of one row of greengram between paired rows (30.70 cm) of pigeonpea proved superior to the sole pigeonpea in terms of pigeonpea-equivalent yield (18.25 q ha^{-1}) and water use (5.12 kg ha^{-1} mm). It could be attributed to the fact that both the crops efficiently used moisture for dry-matter production than sole pigeonpea, which resulted in higher rate of moisture use in pigeonpea + greengram intercropping system than in sole pigeonpea.

Premsing *et al.,* (2007) opined that intercropping of pearl millet + mothbean planted at 2:1 row ratio produced significantly higher pearl millet grain equivalent yield (36.62 q ha^{-1}) than all other intercropping systems and sole cropping, however, it was at par with pearl millet + cowpea (33.56 q ha^{-1}). However Ashwathanarayana, (2014) recorded significantly higher pigeonepa equivalent yield (2001 kg ha^{-1}) under pigeonpea intercropping with gumguar *cv.* HG-365 in 1:2 proportion.

Gamit, (2014) concluded that sorghum intercropping with pigeonpea genotype Vaishali in 2:1 row proportion provided higher sorghum equivalent yield in sorghum and pigeonpea intercropping system under South Gujarat condition. Further, Sekhon *et al.,* (2018) evaluated that significantly higher PEY (1.84 and 1.9 t ha^{-1}) in pigeonpea (50 cm × 25 cm) + maize fodder intercropping system during both the years, respectively, than other intercrops. This may be due to higher yield of maize fodder intercrop as compared to other intercrops and yield of pigeonpea was also not affected by maize fodder crop.

CONCLUSION

After reviewing many articles, it could be derived that intercropping pigeonpea with fodder crops would result in recording slightly lower pigeonpea growth and yields than the sole pigeonpea due to higher competition for space, light and nutrients however the decrease in yield would be compensated by the component crop yield. Most of the studies revealed that intercropping system has higher yield advantage than sole cropping by recording higher land equivalent ratio as well as crop equivalent yield. Hence, intercropping pigeonpea with fodder crops is found to be advantageous than sole cropping.

FUTURE SCOPE

Profound amount of research has been conducted on nutrient management studies in sole pigeonpea as well as pigeonpea based intercrops but research regarding nutrient management aspects in pigeonpea based fodder intercropping system is less. Hence, Furthermore studies need to be done on the nutrient management aspects of pigeonpea + fodder intercropping systems.

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