PRODUCTION AND NUTRITIONAL QUALITY ENHANCEMENT OF NUTRI-CEREALS THROUGH AGRONOMIC MANIPULATIONS

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CERTIFICATE

This is to certify that the thesis entitled **"PRODUCTION AND NUTRITIONAL QUALITY ENHANCEMENT OF NUTRI CEREALS THROUGH AGRONOMIC MANIPULATIONS"** submitted by **Mr. MALLIKARJUN** for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **AGRONOMY,** College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, is a record of research work carried out by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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AFFECTIONATELY DEDICATED

TO

MY BELOVED PARENTS
LATE SHRI. DEVINDRAPPA AND
SMT. SHIVABASSAMMA

AND
BROTHERS AND SISTERS

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Raichur

November, 2017 **(MALLIKARJUN)**

LIST OF ABBREVIATIONS

Abbreviation		Expansion
%	:	Per cent
B:C	:	Benefit Cost ratio
C.D.	:	Critical Difference
cm	:	Centimetre
DAS	:	Days After Sowing
dm	:	deci meter
Fig	:	Figure
g	:	gram
ha	:	hectare
kg	:	Kilogram
Mg	:	mega gram
Sq.m	:	Squre meter
mg	:	milligram
ml	:	millilitre
mm	:	millimetre
NS	:	Non Significant
q	:	quintal
RH	:	Relative Humidity
Rs.	:	Rupees
S.Em.	:	Standard Error mean
fb	:	Followed by
ds	:	deci-siemens
N	:	Nitrogen
P	:	Phosphorus
K	:	Potassium
et al.	:	Et alii, and others

Contd….

Abbreviation		Expansion
DAP	:	Di-ammonium phosphate
SSP	:	Single super phosphate
MOP	:	Muriate of potash
Zn	:	Zinc
Fe	:	Iron
NS	:	Non significant
No.	:	Number
pH	:	Power of Hydrogen
RDF	:	Recommended dose of fertilizer
viz.,	:	*Videlicet*, namely
EC	:	Electrical conductivity

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INTRODUCTION

I. INTRODUCTION

The year 2016 was declared as the International Year of Pulses by the sixty eighth session of the United Nations General Assembly intending to make people more aware of the nutritional value of pulses, of their contribution to sustainability, and more reliable food. The year should facilitate cooperation within food production systems to use protein in pulses better. Also the year should promote production of pulses worldwide, improve crop rotation and improve trade in pulses. Pigeonpea [*Cajanus cajan* (L.) Millsp] is an important food legume of the semi-arid tropics of Asia and Africa. It occupies a prime niche in sustainable farming systems of small and marginal rainfed farmers. It occupies a prominent place in Indian rainfed agriculture. It is an integral component in various agro ecologies of the country, mainly inter cropped with cereals, pulses, oilseeds and millets. It is mainly consumed as dry split dhal throughout the country, besides several other uses of various parts of pigeonpea plant. Enhancing the productivity of the crop assumes specific significance in India mainly to combat protein malnutrition as it is the main source of protein to the predominant vegetarian population.

Pulses and small millets are considered as second and first major agricultural crops in Indian agrarian economy. Normally pigeonpea and small millets are raised under rainfed condition with low input and poor management practices leading to lower productivity level. Pigeonpea being rich source of protein, form an integral part of vegetarian diet in Indian sub continent. It maintain soil fertility through biological nitrogen fixation, improve soil organic matter content by leaf fall at the time of maturity and occupy prominent place in various cropping systems and crop mixtures. Thus, pigeopea play a vital role in providing protein rich food to human beings and in sustaining both soil health and crop production on long-term basis.

India has the distinction of being the largest producer of pulses in the world, accounting for 37 per cent of the area and 27 per cent of the world's production. Further, 90 per cent of the total global pigeonpea area falls in India accounting 93 per cent of the global production (Lal *et al*., 1996).

Pigeonpea is an important grain legume crop of the semi-arid tropics occupying about 4.42 million ha (occupying about 14.5% of area under pulses) with an annual grain production of 2.89 million tonnes (contributing to 16% of total pulse production) and

productivity being 655 kg ha^{-1}(Anon., 2012). In Karnataka, among the pulses, pigeonpea stands first in both area and production. The crop is grown in an area of 8.91 lakh hectares with a production of 5.09 lakh tonnes and productivity of 571 kg ha^{-1} (Anon., 2012). To alleviate the problem of protein malnutrition in the country, it is very much imperative to enhance the production of pigeonpea, as it is an important pulse crop in the country as well as in the state. It is mainly grown in almost all the states and larger portion of the area is in the states like Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka and Gujarat.

In Karnataka around 90% of the pigeonpea area comes under northern Karnataka, especially in Gulbarga and Bidar districts covering 79 percent of the total pigeonpea area of the state, while Gulbarga district alone covers 65 per cent of the state's share. Gulbarga district ranks first in both area (0.28 m ha) and production (0.18 mt) and also it ranks first in the area under pigeonpea in the state. Gulbarga is the most important pigeonpea growing district of Karnataka with an area of 55 per cent and production of 45 per cent of the state. The productivity of pigeonpea in Gulbarga is 750 kg ha^{-1}, while the productivity in Karnataka and India is 543 and 640 kg ha^{-1}, respectively. However, the productivity of pigeonpea in Karnataka and India is far below than the average productivity of the world (848 kg ha^{-1}).

Generally coarse cereals constitute about 22 per cent of production and 38 per cent of area under cereals, and among coarse cereals in India, sorghum and bajra being grown in an area of 5.79 and 7.81 million hectares with annual production of 5.54 and 9.25 million tonnes and productivity being 957 and 1184 kg ha^{-1}, respectively. Further in India, area under small millets is 0.68 million ha with annual production of 0.42 million tonnes and average productivity being 630 kg ha^{-1} (Anon., 2015). Karnataka with varied soil and climatic conditions has diverse crops under cultivation. Coarse millets and small millets are the important crops of the state and are being cultivated over an area of 14.19 and 0.24 lakh hectares with production of around 16.48 and 0.13 lakh tonnes, respectively.

Pigeonpea as soil ameliorant is known to provide several benefits to soil in which it is grown. Being a legume, it fixes atmospheric nitrogen and the leaf fall at maturity adds organic matter to soil. Its deep penetration and lateral spread of root system in the soil profile enables it to tolerate drought. It can adopt to a wide range of soils and its deep

root system enables the crop to utilize the moisture and nutrients optimally. Its tap root system is reported to break the plough pans, thus often called as “biological plough”. Extensive ground cover by pigeonpea prevents soil erosion by wind and water, encourages infiltration of rain water and smothers the weeds.

Emerging imbalances in Indian agriculture reflected in the differences in production performance of different crops is now well recognized. One of the causes of these uneven agricultural situations is the relatively poor performance or complete stagnation of the important coarse cereals. Coarse cereals are the staple diet of millions of peasants and labourers. Not only are these cereals cultivated under rainfed conditions but they are also grown in drought-prone areas. Consequently, their production is subject to violent fluctuations. The proportion of these cereals has been declining over the years and the yields of these crops are quite low. Growth rate analysis indicates that the performance of coarse cereals has not at all been satisfactory particularly after the major technological breakthrough in Indian agriculture during the mid 60s.

Coarse cereals are ancient super grains and the reservoirs of nutrition for a better health. Coarse cereals (sorghum, pearl millet and small millets) are the important food and fodder crops in semi-arid regions and are predominantly gaining more importance in a world that is increasingly becoming populous, malnourished and facing large climatic uncertainties. These crops are adapted to wide range of temperatures, as intercrop in intercropping systems, moisture-regimes, and input conditions supplying food and feed to millions of dryland farmers, particularly in the developing world. Besides they also form important raw material for potable alcohol and starch production in industrialized countries. Millets are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture and are stable yielders.

The Indian Council of Medical Research has worked out the nutritional superiority of millets. Compared to rice (on a 100 gram weight basis), foxtail millet has 81 per cent more protein and pearl millet has 85 per cent higher phosphorus. In addition, these millets are also very rich in vitamins such as thiamine, riboflavin and folic acid. By virtue of being highly nutritious, millets posses several medicinal properties such as improving digestibility, curing coronary heart diseases and diabetes *etc*. Hence with these special nutrient composition, millets can be introduced in intercropping systems for

analyzing their nutrient content after being well examined with better agronomic practices.

Intercropping of short duration crops in the inter space between two rows of a wide spaced crop like pigeonpea that initially grows slowly, can help in better resource utilization and stabilize crop productivity by reducing impact of weather vagaries and increase the cropping intensity.

Intercropping is a common practice among farmers in many parts of dryland agroeco systems of the world. Apart from providing biological insurance, it ensures higher total yield advantages than sole cropping of component crops due to efficient utilization of resources (Andrews, 1972).

The main concept of intercropping is to get increased total productivity per unit area and time, besides equitable and judicious utilization of land resources and farming inputs including labour. One of the main reasons for higher yields in intercropping is that the component crops are able to use growth resources differently and make better overall use of growth resources than grown separately (Willey, 1979). A careful selection of crops can reduce the mutual competition for moisture and nutrients to a considerable extent, *i.e.*, by including fast growing early maturing crop with a slow growing, late maturing one. Pigeonpea is a late maturing, tall growing, wide spaced crop with deep root system which makes it suitable for intercropping system. Besides, the growth of pigeonpea is very slow in the early stages, during which time the more rapidly growing short duration millets like foxtail millet, pearl millet and sorghum can be conveniently intercropped to utilize the natural resources most efficiently in the early stages of pigeonpea.

Since the overall productivity under traditional intercropping is quite less due to shading and severe competition for nutrients, efforts were made to develop alternative systems which will minimize shading and maximize gains from limited application of fertilizer and agrochemicals. Strip cropping like any other intercropping system is based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients. Hence, the present investigation was carried out to study the performance of pigeonpea and nutri-cereals in traditional intercropping systems under rainfed condition and performance of

different nutri-cereals in strip cropping with pigeonpea under varied fertility levels with following objectives.

1. To assess the growth and yield performance of pigeonpea and nutri-cereals in inter cropping and strip cropping systems.
2. To study the effect of agronomic manipulations on nutritional quality of nutri-cereals and processed products.
3. To workout economics of pigeonpea and nutri-cereals as influenced by intercropping, strip cropping systems and fertility levels under rainfed condition.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Field experiments were conducted to evaluate the production and nutritional quality enhancement of nutri-cereals through agronomic manipulations during the *kharif* season of 2015 and 2016. The relevant research information pertaining to pigeonpea based intercropping systems has been reviewed and presented in this chapter under the following subheadings.

2.1 Intercropping systems and their importance

2.2 Strip cropping and their importance

2.3 Influence of intercrops on pigeonpea

2.4 System productivity

2.5 Intercropping of pigeonpea with nutri-cereals and other crops

2.6 Response of sole pigeonpea and nutri-cereals to nutrients

2.7 Effect of agronomic manipulations on nutritional quality of nutri-cereals and processed products

2.8 Economics of intercropping systems

2.1 Intercropping systems and their importance

Intercropping refers to growing of two or more generally dissimilar crops simultaneously on the same piece of land in distinct row arrangement. The recommended optimum plant population of the base crop is suitably combined with an appropriate additional plant density of the associated crop and there is crop intensification in both time and space dimensions.

It is mainly practiced to cover the risk of failure of one of the component crops due to vagaries of weather or pest incidence and to get higher net returns (Ayyangar and Ayyer, 1942).The basic concept of intercropping is that two or more species intercropped can utilize the environmental resources better than each of the component species grown separately (Donald, 1962).

The duration of a crop in an intercropping system plays a useful role in achieving yield advantage. Higher yield advantage can be expected when the maturity period of the component crops are different (Nambiar *et al*., 1983).

Tobita *et al*. (1996) opined that it is necessary to consider nutrient competition in an intercropping system that involves crops of different maturity such as pearlmillet with pigeonpea, whose peak demand for resources do not coincide.

The cereal + legume intercropping system has still not been understood adequately as compared to sole cropping in terms of system efficiency, more so regarding the concept of nutrient management where both crops have different growth habits and input requirements (Myaka *et al*., 2006 and Kimarao *et al*., 2009).

Cereal-legume intercropping has a pivotal role for increasing land use efficiency, land productivity of the cereal crop and atmospheric nitrogen (N) fixation (Banik and Sharma, 2009).

Pigeonpea, a deep rooted crop with slow initial growth rate between 45 and 60 days after sowing is well suited for intercropping. Intercropping is an intensive land use system with an objective to utilize the space between the rows of main or base crop and to produce more/unit area. The space between the rows could be effectively utilized by growing a short duration crop, which may generate an additional income without adversely affecting the yield of pigeonpea (Jat and Ahlawat, 2010).

2.1.1 Resource use

The intercropping of cereal-legume may lead to reduction in yield of the legume component because of the adverse competitive effects (Willey *et al*., 1983).

Intercropping a legume with a non-legume would be more valuable because of the advantage to the non-legumes from nitrogen fixed by the legumes. Furthermore, two crops differing in height, canopy, adaptation and growth habits grow simultaneously with least competition (Keerio and Aslam, 1986; Bhatti *et al*., 2006). Greater yield stability over different seasons, better use of land resources, possibility of better control of weeds, pests and diseases (Benites *et al*., 1993; Jensen, 1996; Chu *et al*., 2004).

Intercropping finger millet (non-legume) with legumes often results in higher resource use efficiency compared to sole cropping (Maikhuri *et al*., 1996; Maikhuri *et al*., 1997; Chandra, 2007).

Maize–legume intercropping in a rainfed, upland system is the best practice for increasing resource use and production of legumes. However, the greatest benefit could

be obtained when the component crops have least competition with widely spaced rows without reducing their population density (Hauggaard *et al.*, 2001).

Energy parameters such as energy input, net energy, energy output: input ratio and energy productivity are meaningful indicators for assessing the efficiency of production systems (Pervanchon *et al*., 2002).

Intercropping also improves system productivity per unit area and time and helps to promote equitable and judicious utilization of land resources and farming inputs including labour (Marer *et al*., 2007).

Maize–legume-based intercropping is considered a better alternative to monoculture for securing available nutrients and contributing to higher system productivity (Thayamini and Brintha, 2010).

The efficiency of conversion of solar to chemical energy in agriculture is becoming more important with the change in traditional cropping patterns in resource-scarce situations (Choudhary *et al*., 2013).

Intercropping systems have been evaluated extensively, and it has been shown that intercropped systems have yield advantages over single crops (Awal *et al*., 2006; Zhang *et al*., 2007).

This might be due to change in the architecture of plant species in the system, providing better conditions for utilization of resources below soil surface (soil moisture, nutrients) and aboveground canopy solar radiation interception in the intercropping system (Xia *et al*., 2013; Gong *et al*., 2014).

2.1.2 Spatial complementarity

Spatial complementarity is the combined leaf canopy or root system of intercrops that makes better use of available resources when grown together, such as total light interception, water and nutrient uptake, because component crops exploit different soil layers or canopy heights in intercropping. Component crops differ in their nutrient requirements, the form of nutrients which they can readily exploit and their ability to extract them from the soil. The total quantities of resource captured is relatively similar, the efficiency of utilization of the resources captured is increased in intercrops compared to the sole crops.

Willey (1979) opined that yield advantage in multiple cropping occurs when component crops differ in their use of growth resources in such a way that when they are grown in combination they are better able to complement each other and so make better overall use of resources than when grown separately in terms of competition. The component crops are not competing for exactly the same resources (in space or time) and intercrop competition is less than intra-crop competition.

Another important feature is difference in time of maturity and hence in nutrient demand among different species in intercropping which will create the time dimension of the system. The difference in time dimension will lead to efficient utilization of resources by lessening competition among the intercrop components (Trenbath, 1986).

For high intercrop productivity, plants of the early maturing component should grow with little interference from the late maturing crop. The latter may be affected by the associated crop, but a long time period for further growth after the harvest of the first crop should ensure good recovery and full use of available resources (Fukai and Trenbath, 1993).

In many soils, including the ones we simulated, the greatest heterogeneity occurs with depth. Trade-offs exist for uptake of shallow and deep resources (Ge *et al.*, 2000; Dunbabin *et al.*, 2003; Ho *et al.*, 2005) and as a consequence different species have evolved differences in root placement in shallower and deeper soil strata.

Anitha *et al*. (2001) reported that to have yield advantages in intercropping system, there should be minimum of 25 percent difference in duration of crops.

Intercropping of cereals with a legume often increases cereal production without substantial reductions in legume yield (Li *et al.*, 2007).

2.1.3 Effect of intercropping on light interception

Light is one of the important growth factors affecting crop yield. Unlike other resources, light is instantaneously available and has to be instantaneously intercepted, if it is to be used for photosynthesis (Donald, 1961). Low availability of light for a component crop in the mixtures reduces the photosynthetic rate and crop growth rate, finally leading to drastic reduction in grain and straw yields of component crops.

Reddy *et al*. (1980) reported that millet-groundnut intercrop system was 28 percent more efficient in light use than their monocrops, which was attributed to approximately 30 percent greater LAI of the intercrop than the sole crops.

Keating and Carberry (1993) reported that improved productivity per unit incident radiation could be achieved by the adoption of an intercropping system that either increases the interception of solar radiation and/or had greater radiation use efficiency. Minimizing the proportion of radiant energy reaching the ground is a simple means of promoting efficient utilization of incident solar radiation.

Any interventions that lead to increased amount of PAR interception by the minor crop have potential to increase the yield of the minor crop and increase productivity of the intercropping system (Mashingaidze, 2004).

The cereal component with relatively higher growth rate, height advantage and a more extensive rooting system is favored in the competition with the associated legume crop. Thus, the greater yield loss of the minor crop is mainly due to reduced photosynthetically active radiation (PAR) reaching the lower parts of the intercrop canopy, occupied by the minor legume (Liu *et al*., 2010).

Light levels during the late flowering to mid pod formation stages of growth have been found to be more critical than during vegetative and late reproductive periods (Liu *et al*., 2010; Schou *et al*., 1978).

Intercropping can increase light interception by as much as 30 to 40 per cent. When one component crop is taller than the other in an intercropping system, the taller components intercept most of the solar radiation. The pattern of light interception varies according to the age of the crop. In an intercropping situation where the component crops have different growth duration, the peak demand for light would occur at different times (Panda, 2014).

2.1.4 Water and nutrients

The performance of companion crops in intercropping is determined by competitive use of the limited resources (Ofori and Stern, 1987; Morris and Garrity, 1993).

The researchers stated that the superior performance in mixed cultures may be caused by a combination of various factors such as better use of soil moisture, light and nutrients (Pandita *et al.*, 2000).

In intercropping, due to increased root density and the possibility of some nutrients that are not available in pure culture, nutrient absorption is increased and used more efficiently. Intercropping cereals and legume is an example of increasing nutrient uptake (Ghanbari, 2000).

Differences in root morphology in mixed cultures is attracting more water than monoculture (Zhang and Li, 2003).

Agronomic package like plant population is recognized to affect crop environment which determine the yield components. Optimum plant population levels should be maintained to tap utmost natural resource such as nutrient, sunlight, soil moisture and to assure satisfactory yield (Sharifi *et al*., 2009).

The spatial arrangement of crops helps in the effective utilization of land, soil moisture, nutrients and solar radiation. This is brought about by choosing appropriate crops of varying morpho-physiological nature and planning their planting geometry to reduce mutual competition for resources and enhance complementarities to increase overall productivity. In general, this is achieved by intercropping systems (Gurigbal, 2010).

Farmers practice intercropping with a wide array of crops, consisting ordinarily of a major crop and other insignificant crops, however, it is pertinent that the selection of compatible crops be given priority as this depends on their growth habit, land, light, water and fertilizer utilization (Thayamini and Brintha, 2010).

2.2 Strip cropping and their importance

Strip intercropping is defined as the production of two or more crops within the same field in strips wide enough that each can be managed independently by existing machinery and yet narrow enough that the strip components can interact.

Strip cropping is like any other intercropping based on the management of plant interactions to maximize growth and productivity caused by efficient use of plant growth resources such as light, water and nutrients (Hauggaard *et al.*, 2009)

Strip cropping is a form of intercropping used in different climate zones. It protects soil from water and wind erosion and reduces nutrient leaching (Rogobete and Grozav, 2011).

2.3 Influence of intercrops on pigeonpea

Rathod *et al*. (2004) revealed that cropping systems significantly affected the yield of pigeonpea. The highest grain yield was recorded with sole pigeonpea (1495 kg ha^{-1}). Intercropping with different pulses and oilseeds significantly decreased the pigeonpea yield. The highest reduction in yield was noticed when intercropped with cowpea and sesame (723 kg ha^{-1} and 762 kg ha^{-1}, respectively).

Marer *et al*. (2007) revealed that pigeonpea yield also varied significantly due to different row proportions. Maize + Pigeonpea at 2:2 row ratio with 100 per cent pigeonpea population recorded significantly higher grain yield (814 kg ha^{-1}) over other systems but was on par with same row ratio at 50 per cent pigeonpea population and 1:1 row ratio at 100 per cent pigeonpea population.

Among the intercropping treatments little millet and pigeonpea intercroped in 6:2 row ratio or 6:2 row ratio of little millet + pigeonpea- horsegram sequence produced significantly higher dry matter production, ear length, grain weight, grain yield of little millet and pigeonpea. With regard to sole and intercropping systems, yield of little millet and pigeonpea was highest in sole cropping. Higher little millet equivalent yield (LMEY) was recorded in intercropping of little millet and pigeonpea in 6:2 row ratio with or without horsegram sequence, as compared to rest of the treatments (Prasanna Kumar *et al*., 2008).

High intercrop productivity is attained if early maturing constituent is grown with little interference from the late growing crop. Thus, the choice of accurate cultivars and agronomic manipulations to certify the most effective use of limiting resources is key part for high crop yield (Thayamini and Brintha, 2010).

Varshney *et al*. (2010) reported reduction in dry matter accumulation and yield of pigeonpea in association with fingermillet due to crop incompatibility. But length of pods, number of seeds per pod as well as 1000 seed weight being the varietal characteristics that were not much influenced by any of the intercrops.

Intercrops are productive when the component crop varies greatly in growth duration so that their maximum condition for growth resources occurs at different periods (Ijoyah, 2012).

Narendra *et al*. (2013) recorded maximum growth, yield attributes and yield except plant height under sole pigeonpea. However, intercropping system of pigeonpea + blackgram did not affect the growth, yield attributes and yield of pigeonpea.

Udhaya *et al*. (2015) reported higher plant height (192.1 cm), stem girth (7.9 cm), number of branches plant^{-1} (23.3), dry matter production (6342 kg ha^{-1}) and yield of pigeonpea (1741 kg ha^{-1}) in pigeonpea (120 x 30 cm) + greengram with 1:3 row ratio.

Swagatika Srichandan and Alok Kumar Mangaraj (2015) reported that plant height of pigeonpea at harvesting stage was highest when intercropped with groundnut (270 cm). Horizontal spread at 90 DAS (152.7 cm) and dry matter accumulation at 210 DAS were also highest (315.7g/plant) under the intercropping system. Intercropping with sesamum, black gram, groundnut and fingermillet decreased the seed yield of pigeonpea by 20.5, 18.7, 14.1 and 12.3 per cent, respectively.

Pal *et al*. (2016) reported lower yield attributes *viz*., no. of pods (131.40 plant^{-1}), no. of grains (3.46 pod^{-1}), test weight (103.07 g), pod weight (110.96 g plant^{-1}) and weight of grains (110.90 g plant^{-1}) of pigeonpea under intercropping system with sorghum

Ansari *et al*. (2016) reported significantly higher grain yield of pigeonpea as sole crop as compared to its intercropped stand with pearlmillet in 2:1 ratio. Grain yield of pigeonpea in intercropping system decreased by 59.2 and 57.8 percent as compared to the sole cropping in 2009 and 2010, respectively.

Niranjan Kumar Barod *et al.* (2017) found that grain, straw and biological yield were significantly higher in sole crop of pigeonpea (1983 and 2059, 2059 and 5947 and 7777 and 8006 kg ha^{-1}), sole crop of pearl millet (2122 and 2218, 5999 and 6200 and 8121 and 8418 kg ha^{-1}) and sole crop of greengram (1319 and 1402, 3925 and 4175 and 5244 and 5576 kg ha^{-1}), respectively, during 2011 and 2012 crop seasons.

2.4 System productivity

Ved Prakash *et al*. (2004) recorded the highest pigeonpea equivalent yield (25.11 q ha^{-1}), land equivalent ratio (1.42), gross returns (Rs.45,198 ha^{-1}) and net returns (Rs.25,443 ha^{-1}) under pigeonpea + soybean (2:2) intercropping system.

Patil *et al.* (2010) recorded significantly higher land equivalent ratio (1.40) under 4:2 row proportion which was at par with 2:1, 6:2 and 3:1 row proportions (1.36, 1.30 and 1.28, respectively). Significant reduction in land equivalent ratio was observed in 5:1 row proportion (1.21). Area time equivalent ratio (ATER) differed significantly due to various treatments. Among different row proportions, intercropping of little millet and pigeonpea in 4:2 row ratio recorded significantly higher area time equivalent ratio value (1.06) which was at par with 2:1 row proportion (1.04). Row proportions of 5:1, 3:1 and 6:2 recorded area time equivalent ratio value less than unity (1.00) that obtained under sole crops. Intercropping of little millet and pigeonpea in 4:2 row proportion recorded significantly higher gross and net returns (Rs.12095 ha^{-1} and Rs.6608 ha^{-1}, respectively) followed by 2:1 row proportion (Rs.11854 and 6367 ha^{-1}, respectively) and lowest gross and net returns were recorded with sole little millet (Rs.6316 and 2610 ha^{-1}, respectively).

Pandey *et al*. (2013) recorded higher yield of pigeonpea (1.85 t ha^{-1}), pigeonpea equivalent yield (2.17 t ha^{-1}), LER (2.29), production efficiency (8.56 kg ha^{-1} day^{-1}), WUE (2.96 kg $grain^{-1}ha^{-1}$ mm^{-1}), fruiting efficiency (17.16 %), net returns (Rs $10.38x10^3$ ha^{-1}) and net return per rupee investment (3.05) under pigeonpea + urdbean intercropping system as compared to pigeonpea + maize intercropping and sole pigeonpea.

Ansari *et al*. (2014) reported higher pearlmillet equivalent yield, land equivalent ratio and economics (net returns and B: C ratio) in pearlmillet/pigeonpea intercropping system as compared to their sole cropping. Over the period of time, 50 kg N + 17.2 kg P ha^{-1} recorded higher crop performance ratio, agronomic and physiological efficiency of N and P over other fertility treatments.

Udhaya and Kuzhanthaivel (2015) revealed that sowing of pigeonpea at 120 cm × 30 cm with greengram at 1:3 row proportion recorded significantly higher LER (1.52), ATER (1.15) and IER (1.29). The lowest light transmission ratio of 34.7 per cent was recorded with above said treatment.

2.5 Intercropping of pigeonpea with nutri-cereals and other crops.

Lingaraju *et al*. (2008) from the pooled data over two years indicated that intercropping of maize and pigeonpea at 4:2 row ratio with 100:50 population recorded significantly higher maize equivalent yield (8970 kg ha^{-1}), net returns (Rs.36008 ha^{-1}) and B:C ratio (3.25) over sole and other intercropping systems except 2:2 and 3:1 row ratios with 100:50 population of maize and pigeonpea. Though intercropping resulted in significant reduction in the yield of sole crops, it was better compensated by component crops in terms of total yield and income.

Poornima *et al*. (2010) reported that transplanting of 5 week old pigeonpea seedlings as sole crop resulted in significantly higher grain yield (2669 kg ha^{-1}), net returns (Rs.39983 ha^{-1}) and B:C ratio (1.99) than direct sowing (1575 kg ha^{-1}, Rs.21817 ha^{-1} and 1.77, respectively). Finger millet + transplanted pigeonpea (8:2) intercropping with transplanting of 4 week old seedlings produced significantly higher pigeonpea grain yield (1347 kg ha^{-1} with finger millet grain yield of 1880 kg ha^{-1}) compared to finger millet + direct sown pigeonpea (391 kg ha^{-1} with finger millet grain yield of 1992 kg ha^{-1}). Finger millet + transplanted pigeonpea (8:2) with 4 week old seedlings gave higher net returns (Rs.31874 ha^{-1}) and B:C ratio (1.90) than finger millet + direct sown pigeonpea (Rs.16176 ha^{-1} and 1.28, respectively) and sole crop of finger millet (net returns of Rs.14910 ha^{-1} and B:C ratio of 1.64).

Dinesh Tiwari *et al*. (2011) recorded the highest system productivity under pigeonpea + urdbean intercropping system. Similarly, significant improvement in grain yield of pigeonpea, urdbean and maize and PEY were recorded with application of PSB and FYM (5.0 t ha^{-1}). The highest net returns and B: C ratio was obtained under pigeonpea + urdbean cropping system and with the application of PSB + FYM.

Pandey *et al*. (2013) reported that pigeonpea+urdbean intercropping system recorded higher yield of pigeonpea (1.85 t ha^{-1}), pigeonpea equivalent yield (2.17 t ha^{-1}), LER (2.29), production efficiency (8.56 Kg ha^{-1} day), water use efficiency (2.96 kg grain ha^{-1} mm), fruiting efficiency (17.16 percent), net returns (Rs.67.3×103 ha^{-1}) and net returns, per rupee investment (Rs.3.05) as compared to pigeonpea + maize intercropping and sole pigeonpea.

Adikant *et al*. (2014) revealed that plant height was comparatively higher (112.15 cm) in finger millet alone whereas lowest was recorded under finger millet + niger (91.55

cm). The maximum number of fingers (3.58), finger length (5.68 cm) and 1000 grain weight (6.36 g) was observed in sole finger millet, which was superior and at par with that recorded in finger millet + pigeonpea intercropping while lowest was recorded in finger millet+ niger intercropping.

Ansari *et al*. (2016) revealed that sole cropping of both pearlmillet and pigeonpea had significantly higher grain yield and uptake of N and P than their respective intercropped stand. The intercropping system recorded significantly higher peralmillet equivalent yield, total system uptake of N and P and nutrient use efficiency, consumptive use, water use efficiency over the sole stand of component crops.

2.6 Response of pigeonpea intercropping with nutri-cereals to nutrients

Velayutham *et al*. (2003) reported that among the intercrop combinations tried, growing pigeonpea in paired rows with full RDF (25:50) in combination with green gram as intercrop which was applied with 1/3rd of RDF 5:10 NP kg ha^{-1} registered significantly higher growth, yield attributes and yield of both pigeonpea and green gram as compared to growing of pigeonpea with green gram as mixed cropping with RDF (25:50 N, P kg ha^{-1}).

Singh and Agrawal (2004) observed maximum pearlmillet-grain equivalent yield, net returns and benefit: cost ratio with pearmillet + pigeonpea followed by pearlmillet + castor. Sole pearlmillet recorded the lowest pearlmillet-grain equivalent yield, net returns and benefit cost ratio. The yield and yield attributes of pearlmillet, pearlmillet-grain equivalent yield, N and P uptake and net returns were higher with higher dose of 80 kg N + 60 kg P_2O_5 ha^{-1}. However, the maximum benefit cost ratio was obtained with 40 kg N + 30 kg P_2O_5 ha^{-1} (3.2) and 80 kg N + 60 kg P_2O_5 ha^{-1} (3.5).

In an experiment conducted during kharif season on pigeonpea + greengram intercropping under rainfed condition, it was found that application of 40 kg P_2O_5 + 25 kg S + PSB significantly increased the seed and stalk yield of pigeonpea (16.96 and 19.03 q ha^{-1}, respectively) over control. The percentage increase was 37.1 and 33.0, and 32.6 and 27.8 over control during the both the years respectively, however, it was at par with 40 kg P_2O_5 + 25 kg S ha^{-1} (16.40 and 18.29 q ha^{-1}, respectively) (Kumar and Rana, 2007).

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,

water use and economics. Application of soil mulch + farmyard manure @ 5 tonnes ha^{-1} + kaolin (6 %) spray was found to be the best moisture-conservation practice by recording the maximum pigeonpea-equivalent yield, nutrient uptake and water-use efficiency. Application of 40 kg P_2O_5 ha^{-1} + 25 kg S ha^{-1} + phosphate-solubilizing bacteria (PSB) recorded the maximum pigeonpea-equivalent yield, nutrient uptake, water-use efficiency and net returns (Kumar and Rana, 2007).

Patil *et al*. (2008) recorded maximum productivity and net returns, improvement in fertility status and chemical properties of soil from pigeonpea+ pearlmillet intercropping system with application of 50 percent RDF of the respective crops on the basis of area.

Arjun Sharma *et al.* (2012) reported that seed yield of pigeonpea, pearlmillet and greengram increased significantly due to combined application of FYM, RDF and biofertilizer as compared to control. Among the integrated fertilizer levels, application of FYM @ 5 t ha^{-1} + 100 percent RDF + seed inoculation of biofertilizers recorded significantly higher pigeonpea yield (15.74 q ha^{-1}), pigeonpea equivalent yield (18.29 q ha^{-1}), gross returns (Rs.43,930 ha^{-1}) , net returns (Rs.34,650 ha^{-1}) and B:C ratio (3.72) over other INM practices but it was found to be on par with application of FYM @ 5 t ha^{-1} + 50 percent RDF + seed inoculation of biofertilizers (15.38 q ha^{-1}, 17.83 q ha^{-1}, Rs.42,847 ha^{-1}, Rs.34,032 ha^{-1} and 3.85, respectively).

2.6.1 Response of sole pigeonpea to nutrients

Pasricha *et al*. (1995) found that pigeonpea responded significantly to the direct application of phosphorus during *kharif* season. They observed 52 and 82 per cent higher seed yield with the application of 20 and 40 kg P_2O_5 ha^{-1}, respectively when compared to control.

Sarkar *et al.* (1997) observed significantly higher yield attributing characters with the application of farmyard manure as compared to control. The grain yield (12.23 q ha^{-1}) followed the same trend when compared to control (10.40 q ha^{-1}). The mean grain yield recorded with 10 t FYM ha^{-1} was 18 per cent higher than control in *kharif* pigeonpea.

Srinivas and Srinivas Raju (1997) reported that the application of 60 kg P_2O_5 ha^{-1} recorded significantly higher growth attributing characters like plant height (147.4 cm) and dry matter production per plant (123.3 g) during *kharif* season pigeonpea as

compared to plant height (133.8 cm) and dry matter production per plant (86.17 g) with the treatment which did not receive phosphorous.

Subbaiah and Sudhakar Rao (1998) noticed that *rhizobium* inoculation with 20 kg N ha^{-1} had a profound influence in increasing the plant height (101.2 cm), number of branches (7.5 $plant^{-1}$) and dry matter production (22.3 g $plant^{-1}$) over control during *kharif* season. But the harvest index of pigeonpea did not differ significantly with the application of different levels of nitrogen. With respect to phosphorus levels, they observed that seed yield of pigeonpea differed significantly due to graded levels of phosphorus application. The relative increase in seed yield was 19 and 23 per cent with the application of 40 and 80 kg P_2O_5 ha^{-1}, respectively over control. Besides, maximum harvest index was recorded with the application of 80 kg P_2O_5 ha^{-1} (0.31) which was on par with 40 kg P_2O_5 ha^{-1} (0.30) and both have recorded significantly higher harvest indices over control (0.28), which did not receive any phosphorus.

Pujari and Gaddankeri (1998) opined that application of farm yard manure @ 500 kg per ha^{-1} along with recommended inorganic fertilizers in the seed line resulted in 15 per cent higher grain yield of *kharif* season pigeonpea compared to recommended inorganic fertilizers and FYM applied in traditional method.

Tejpal Singh and Mahendra Pal (2003) reported that nitrogen + phosphorus application significantly improved the growth parameters, yield attributes and yield of pigeonpea only up to 100 per cent of recommended dose. However, no significant improvement was observed between the yield obtained from the plots supplied with 100 and 125 per cent of the recommended dose of N + P. It could be assigned to the fact that there was no improvement in yield attributes due to the application of 125 per cent of the recommended dose of N + P.

Patil and Padmani (2007) revealed that application of 100 per cent RDF ha^{-1} along with FYM @ 5 t ha^{-1} gave significantly higher grain yield (1,436 kg ha^{-1}), number of pods per plant (178.96) and number of grains per pod (4.13) in pigeonpea but found on par with 75 per cent RDF ha^{-1} along with FYM at the rate of 5 t ha^{-1} and was significantly superior to control.

Arjun Sharma *et al.* (2009) reported that application of FYM @ 5 t ha^{-1} + seed inoculation with *Rhizobium* + $ZnSO_4$ @ 15 kg ha^{-1} + crop residues @ 5 t ha^{-1} recorded significantly higher plant height (184.09 cm), primary branches per plant (12.34),

secondary branches per plant (7.86) , seed yield (15.81 q ha^{-1}) of pigeonpea and was on par with the treatment receiving FYM + seed inoculation with *Rhizobium* + $ZnSO_4$ @ 15 kg ha^{-1} during *kharif* season at ARS, Gulbarga.

Bhanu Kumar Meena (2010) revealed that the treatment combination of S_3F_3 (90 cm x 45 cm + 50:100 N, P kg ha^{-1}) recorded significantly higher grain yield of pigeonpea (25.65 q ha^{-1}) and it was 42.8 per cent higher than the control (16.79 q ha^{-1}). The growth and yield parameters were higher with S_3F_3 treatment combination compared to other treatment combinations.

Deshbhratar *et al*. (2010) revealed significant increase in grain yield (14.81 q ha^{-1}) and straw yield (41.26 q ha^{-1}) of pigeonpea with 20 kg S $ha^{-1}$and 50 kg P_2O_5 ha^{-1} with common dose of nitrogen @ 30 kg ha^{-1}. The increase in grain and straw yield was to the tune of 102.77 and 52.87 per cent, respectively over control. Maximum number of pods $plant^{-1}$, grains pod^{-1} and test weight was also observed in this treatment.

Subba Rami Reddy *et al.* (2011) reported that application of 50 % RDF + seed treatment with *Rhizobium* @ 200 g kg^{-1} seed to pigeonpea crop recorded significantly higher number of branches (16.3 $plant^{-1}$), pods (151.3 $plant^{-1}$) and grain yield (1358 kg ha^{-1}) followed by 50 percent RDF + *Rhizobium* inoculation (14 $plant^{-1}$, 142 $plant^{-1}$and 1,325 kg ha^{-1}) and 50 per cent RDF+dual inoculation with *Rhizobium* and PSB (14 $plant^{-1}$, 133 $plant^{-1}$ and 1,305 kg ha^{-1}), respectively.

Srikanth Babu *et al*. (2012) reported that grain yield recorded with the application of poultry manure (1,342 kg ha^{-1}) to pigeonpea was significantly superior over the grain yield recorded with the application of farmyard manure (1,160 kg ha^{-1}) and control (1,038 kg ha^{-1}) and was on par with the yield obtained in treatment receiving vermicompost (1,299 kg ha^{-1}).

Meena *et al*. (2012) reported that in pigeonpea, application of fertilizer NPK at soil-test based recommended rates produced 1.44 t/ha grain yield which was significantly higher as compared with unfertilized control. The highest grain yield (1.79 t/ha) was recorded with NPK + FYM (2.5 t ha^{-1}).

Lakshmi (2014) revealed that 125 per cent recommended dose of N + sub soiling + TNAU micronutrient mixture @ 12.5 kg ha^{-1} + dhaincha recorded higher pigeonpea biometric characters, yield attributes (number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight) and yield (456 kg ha^{-1}) with higher soil organic carbon content (0.24 per cent)

and available N (282.5 kg ha^{-1}). The B: C ratio (1.63) was also higher under the same treatment.

Layek *et al*. (2015) reported that incremental N levels to cereal crops showed negative impact on the yield of soybean. While the yield of intercropped maize significantly increased with up to 100 percent recommended dose of nitrogen (RDN), the yield of intercropped sorghum [*Sorghum bicolor* (L.)] and pearlmillet [*Pennisetum glaucum* (L.)] increased only up to 75 and 50 percent RDN respectively. Soybean + maize intercropping supplied with 100 percent RDN gave the highest net returns and soybean equivalent yield.

Pandey *et al*. (2015) revealed that application of FYM @ 5.0 t ha^{-1} together with 50 percent RDF resulted in significantly higher grain yield of pigeonpea (2.08 t ha^{-1}) than RDF alone (1.90 tonnes ha^{-1}). Likewise, seed inoculation with *Rhizobium* + PSB (1.95 t ha^{-1}) and *Rhizobium* + PSB + PGPR (2.02 t ha^{-1}) fertilized with 50 percent RDF recorded similar grain yield to that of RDF alone (2.01 t ha^{-1}). Application of RDF, FYM 5.0 t ha^{-1} and seed inoculation with biofertilizers, increased organic carbon, available N, P and K contents and reduced the bulk density of the soil compared with initial soil value.

Pal *et al.* (2016) reported that application of 100 percent recommended dose of fertilizer (RDF)+ VC @ 2.5 tonnes ha^{-1} recorded its superiority by recording higher growth attributes *viz.*, plant height (232.42 cm), number of branches (19.07 $plant^{-1}$), dry matter accumulation (214.65 g $plant^{-1}$), LAI (3.62) and yield attributes *viz*., number of pods (141.42 $plant^{-1}$), number of grains (4.13 pod^{-1}) and test weight (108.22 g), and grain yield (1831.82 kg ha^{-1}) and stalk yield (8221.61 kg ha^{-1}) over all other fertility levels.

2.6.2 Response of nutri-cereals and other relevant cereals to nutrients

Singh and Arya (1993) recorded significantly higher grain yield (16.47 q ha^{-1}) of barnyard millet (*Echinochloa frumentacea*) due to application of FYM @ 5 tonnes ha^{-1} over control and was on par with yield under enriched FYM @ 750 kg ha^{-1} (14.9 q ha^{-1}). Significantly higher number of effective tillers (35.5/m) and ear weight (5.0 g) were recorded with 5 t ha^{-1} of FYM.

Singh (1999) recorded significant increase in grain yield with successive increase in FYM level as compared to lower levels of FYM in finger millet (*Eleusine coracana*). The increase in grain yield was significant up to 7.5 t ha^{-1}. Application of FYM @ 5.0,

7.5 and 10.0 t ha^{-1} increased grain yield of finger millet by 24, 42 and 50 per cent, respectively over control. The increase in grain yield was attributed to increased number of ear heads per square meter in sandy loam soils of Majhera (U. P.).

The highest values of N uptake (94.52 kg ha^{-1}), available N (252.08 kg ha^{-1}), available P (27.25 kg ha^{-1}) and available K (306.50 kg ha^{-1}) in soil were recorded after harvest of sorghum with application of vermicompost @ 3.0 t ha^{-1} (Bhalerao *et al*., 2001).

Reddy and Okhura (2004) from ICRISAT revealed that the growth of sorghum (*Sorghum bicolor* L.) in terms of plant height, shoot biomass, root length, root biomass, leaf number and area in a mixture of 75 per cent of vermicompost + 25 per cent of soil was higher than that of normal compost, soil mixed with chemical fertilizers and soil alone.

Kumawat and Jat (2005) reported that, application of vermicompost @ 4.5 t ha^{-1} in barley recorded significantly higher number of effective tillers, spike length, grain and straw yield over vermicompost @ 1.5 t ha^{-1} and FYM @ 7.5 and 10 t ha^{-1} in sandy loam soil of Jobner, Rajasthan. Further, the vermicompost @ 1.5 t ha^{-1}, FYM @ 7.5 t ha^{-1} and 10 t ha^{-1} were equally effective.

Narolia *et al*. (2009) revealed that plant height, dry matter accumulation at harvest, total number of tillers at 40 DAS, yield attributes, seed and stover yield, harvest index, nutrient uptake (N, P and K) by grain and stover, net returns and B:C ratio increased significantly due to drilling of vermicompost @ 2 tonnes ha^{-1} over control where as its drilling @ 1 tonne ha^{-1} remain at par with soil incorporation @ 2 tonne ha^{-1}. Maximum and significantly higher growth parameters, yield attributes, yield, harvest index, nutrient uptake, net returns and B:C ratio were recorded with application of 90 kg N + 45 kg P_2O_5 ha^{-1} as compared to control (N_0 P_0) in pearl millet.

Study conducted at All India Co-ordinated Small Millet Improvement Project, Bangalore, indicated that application of organic manures recorded lower grain yields (999 to 1,200 kg ha^{-1}) as compared to inorganic nutrients (1495 to 1520 kg ha^{-1}) of foxtail millet (Anon., 2009).

Jagadeesha *et al*. (2010) reported that application of either sewage sludge or poultry manure compost produced significantly higher grain yield (2498 and 2475 kg ha^{-1}, respectively) and straw yield of finger millet (4065 and 4009 kg ha^{-1}, respectively)

and redgram grain and stalk yield (370 and 355 kg ha^{-1}, respectively). The study clearly revealed that sewage sludge and poultry manure compost application at equivalent recommended nitrogen dose could be successfully used for fingermillet and redgram intercropping system to substitute the chemical fertilizers and found to be sustainable.

Patil *et al*. (2014) revealed that among different nitrogen management treatments, application of 50 per cent RDN + 25 percent FYM + 25 percent castor cake + zospirillum + PSB produced significantly higher values of number of effective tillers/metre row length, length of earhead, straw yield, dry matter accumulation and grain yield of pearl millet.

Mishra *et al*. (2014) revealed that **a**pplication of recommended dose of nutrients (80: 40: 40 NPK kg ha^{-1}) through inorganic fertilizers to sorghum proved significantly superior in terms of grain yield (3.32 t ha^{-1}), net returns (Rs.26.6 × 103 ha^{-1}) and output energy (267 × 103 MJ ha^{-1}) over rest of the treatments.

2.6.3 Uptake of nutrients in intercropping systems involving pigeonpea

Raghavulu and Ramarao (1994) found that nitrogen uptake was higher in intercropping system than in sole crop. Maximum nitrogen uptake was observed when the cereal and pulse crops (Setaria + pigeonpea) were intercropped in 5:1 (192 kg ha^{-1}). Potassium uptake was similar to that of nitrogen, and it was maximum in 5:1 row ratio of cereal + pulse intercropping system.

Tolanur and Badanur (2003) noticed significant increase in organic carbon content, available N, P and K in soil due to application of 50 per cent N through organic manure in conjunction with 50 per cent RDF under pearlmillet + pigeonpea intercropping system in an inceptisol. They recorded higher seed yield of pigeonpea (801 kg ha^{-1}) with 50 per cent N through FYM + 50 per cent N through urea and entire P and K through inorganic sources.

Kujur *et al*. (2010) reported that row ratio of 1:1 of pigeonpea + fingermillet produced significantly higher pigeonpea equivalent yield irrespective of duration of fingermillet. However short duration fingermillet + pigeonpea in 1:1 row proportion was most remunerative (Rs 15,091 ha^{-1}) with high land equivalent ratio (1.46) and monetary advantage (6,204 Rs/ha). Nutrient uptake (N, P and K), available soil moisture, available NPK content of soil was higher when pigeonpea was grown with fingermillet in 1:1 ratio.

The intercropping of pigeopea with fingermillet at higher row proportion (1:4) was found less remunerative.

Blaise *et al.* (2014) compared application of recommended dose of fertilizer (RDF) + conservation tillage with *in situ* green manure (CT1) and CT1 + application of ZnSO4 (CT2) with farmers' practice (FP) in cotton (*Gossypium hirsutum* L.) + pigeonpea (*Cajanus cajan* (L.) system. They revealed that nutrient uptake, in general, was higher in deep soil than in medium deep soil. Among the interventions, N, P and K uptake of cotton and pigeonpea followed the order: CT2 > CT1 > RDF > FP. Mean N and P balance was positive in all the treatments.

Nagar *et al.* (2015) revealed highest uptake of N and P (105.8 and 19.3 kg ha^{-1}, respectively) with pigeonpea+ blackgram intercropping system over other intercropping systems, however, uptake of potassium was higher (58.4 kg ha^{-1}) with sole pigeonpea. Among nutrient management practices, application of inorganic fertilizer (25:50 kg $N:P_2O_5$ ha^{-1}) and organic manures in combination with phosphocompost recorded statistically equivalent growth and yield attributes and NPK uptake.

2.6.4 Nutrient uptake of sole pigeonpea

Vasanthi and Subramanian (2004) from field experiment on blackgram at Madurai, found the highest crude protein, N, P and K concentration and uptake in the treatment that received vermicompost @ 2 t ha^{-1} along with 100 % recommended level of NPK over 100 % NPK, 100 % NP and different combinations of chemical fertilizers.

Singh (2007) observed that application of 50 percent RDF + 5 t FYM ha^{-1} to pigeonpea recorded higher uptake of N (150 kg ha^{-1}), P(31.9 kg ha^{-1}) and K (98.7 kg ha^{-1}) and remained at par with 10 t FYM ha^{-1} and 100 % RDF treatment.

Sudhir Kumar *et al*. (2014) reported that in pigeonpea, uptake of N, P, K and S increased with application of phosphorus (upto 80 kg P_2O_5 ha^{-1}) and sulphur (upto 60 kg ha^{-1}) and PSB inoculation. Mean increases in seed and straw yield with 80 kg phosphorus ha^{-1} were 27.72 and 14.10 percent, respectively, over control. Similarly, 30 kg sulphur ha^{-1} increased the seed and straw yield by 21.02 and 10.20 per cent over control, respectively.

Pandey *et al*. (2015) reported that fruiting efficiency (15.6 %), grain yield (2.01 t ha^{-1}), water use efficiency (2.9 kg grain/ha mm), production efficiency (8.3 kg ha^{-1} day^{-1}),

net returns (Rs.67.55 × 10^3 ha^{-1}) and BC ratio (2.9) were significantly higher at recommended dose of fertilizer (RDF) than 50 per cent RDF.

2.7 Effect of agronomic manipulations on nutritional quality of nutri-cereals and processed products

Veeranagappa *et al*. (2010) observed significantly higher growth and yield attributes, grain and straw yield with addition of NPK + Zn-enriched compost at 15 kg ha^{-1} as compared to rest of treatments in paddy.

Yadav *et al*. (2011) reported that application of 100 per cent recommended dose of NP along with 4 kg Fe + 2 kg Zn ha^{-1} in 500 kg FYM ha^{-1} with pre sowing application of 2.5 t FYM ha^{-1} recorded higher grain yield of wheat.

Pawar *et al.* (2011) reported that application of RDF + 15 kg $ZnSO_4$ +15 kg $FeSO_4$ ha^{-1} recorded the highest zinc concentration in sorghum fodder at flowering which ranged from 35.88 to 47.93 ppm, while iron from 270.27 to 491.20 ppm. The uptake of iron was more at harvesting stage rather than at flowering. The uptake of zinc was also more (252.59 g ha^{-1}) at harvesting stage.

Ansari *et al*. **(**2012) revealed that protein content in grain was enhanced by 7.3 percent and N and P concentration increased by 7.4 and 9.2 percent in grain, and 40.9 and 51.1 percent in stover of pearlmillet with the application of 50 kg N + 17.2 kg P ha^{-1} over control, respectively. The maximum protein content in grain (20.40 %) and N (3.26 and 1.38 %) and P (0.44 and 0.14 %) in grain and stover, respectively was noticed with the application of 50 kg N + 17.2 kg P ha^{-1} as compared to other fertility levels.

Sandhya Rani and Patro (2014) conducted field experiment at Agricultural Research Station, Vizianagaram during *Kharif* 2013-14 to verify the stability of bio-fortification of zinc on the grain yield and grain zinc content in finger millet. The results indicated that soil application of $ZnSO_4$ @ 12.5 kg ha^{-1} at the time of sowing enhances the grain yield by 13.3 per cent and grain zinc content by 8.95 percent, while foliar spray of $ZnSO_4$ @ 0.5 per cent increased the grain zinc content by 10.2 per cent.

2.8 Economics of intercropping systems

Koli *et al.* (2003) at Solapur revealed that the mean grain yield of sole pigeonpea was 713 kg ha^{-1} which was more than rest of the intercropping systems and next best was

pigeonpea + clusterbean at 630 kg ha^{-1}. Intercropping of pigeonpea + clusterbean (1:2) recorded significantly higher monetary returns of Rs. 19,459 ha^{-1}as compared to standard check with sole pigeonpea (Rs. 10,820 ha^{-1}) and intercropping of pigeonpea + pearlmillet (1:2) (Rs. 12, 833 ha^{-1}).

An experiment of pigeonpea + fodder sorghum intercropping system conducted at livestock research centre, Pantanagar, during the rainy seasons of three consecutive years from 2000 to 2002 revealed 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}), net returns (Rs. 30,179 ha^{-1}), benefit cost ratio (4.96), aggresivity index (0.533), area time equivalent ratio (1.21), land equivalent ratio (1.58) and relative crowding co-efficient of 15.07 (Verma *et al.*, 2005).

Suresh (2005) reported that higher maize equivalent yield was recorded with 4:2 row ratio (8,076 kg ha^{-1}) at 50 per cent pigeonpea population and was on par with remaining intercropping treatments except maize + pigeonpea (100 per cent) at 1:1 row ratio. All the intercropping treatments recorded significantly higher maize equivalent yield over their respective sole crops. Net returns were also highest with maize + pigeonpea (50 per cent) at 4:2 row ratio (Rs. 30,492 ha^{-1}) and was found on par with the same row ratio with 100 per cent pigeonpea population and 2:1, 2:2 and 3:1 row ratio at 50 per cent population levels of pigeonpea. B:C ratio was also highest (2.75) with intercropping of maize + pigeonpea (50 per cent) at 4:2 row ratio and was on par with 2:1, 2:2 and 3:1 row ratio having 50 per cent pigeonpea population and sole maize.

Gholve *et al.* (2005) reported maximum productivity, net returns in addition to improvement in soil fertility status and chemical properties from pigeonpea + pearlmillet intercropping system (2:2) under dry land condition with application of 50 per cent RDF of the respective crops on the basis of area proportion + vermicompost @ 3 t ha^{-1} or FYM @ 5 t ha^{-1}.

Premsing *et al*. (2007) reported that 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}). Similarly the highest net monetary returns (Rs.14617 ha^{-1}) as well as benefit-cost ratio (2.98) and the LER (1.47) were recorded in pearl millet + moth bean intercropping system. On the basis of pearl millet equivalent yield, net monetary

returns and LER showed that pearl millet + moth bean (2:1) or pearl millet + cowpea (2:1) appears the most productive, efficient and profitable for rainfed conditions.

Arjun Sharma and Guled (2011) revealed that pigeonpea + sesame (1:2) intercropping system under set-furrow with application of vermicompost @ 2.5 t ha^{-1} recorded significantly higher water use efficiency (2.76 kg ha^{-1} mm^{-1}), pigeonpea equivalent yield (23.84 q ha^{-1}), LER (1.94) and ATER (1.72) over other intercropping systems. The intercropping system of pigeonpea + sesame (1:2) under set-furrow recorded significantly higher net returns (Rs. 34,467 ha^{-1}) and benefit cost ratio (2.91) over sole crop of pigeonpea (Rs. 17,407 ha^{-1} and 1.85, respectively).

Pawar *et al*. (2013) revealed that pigeonpea based intercropping systems gave significantly higher pigeonpea equivalent yield as compared with sole cropping. The gross monetary returns was maximum with pigeonpea + mungbean (1:2) intercropping system. Application of vermicompost @ 2.5 t ha^{-1} was found less remunerative than FYM @ 5.0 t ha^{-1}. Higher net monetary returns (NMR) was recorded with the application of 100 percent RDF.

Ramachandrappa *et al***.** (2015) reported that results of 4 years data indicated that the site specific nutrient management (155: 45: 203 N, P_2O_5 and K_2O kg ha^{-1}) along with conservation furrow in between the rows of pigeonpea recorded higher mean finger millet grain equivalent yield (3,794 kg ha) with higher net returns (Rs. 29,707 ha^{-1}) and BC ratio (2.73), whereas, application of recommended NPK (50: 40: 25 kg ha^{-1}) recorded finger millet grain equivalent yield of 2,367 kg ha with net returns of Rs. 15,067 ha^{-1} and B:C ratio of 2.04.

Mittoliya *et al*. (2015) revealed that among the treatments, performance of pigeonpea was better with combined application of inorganics, FYM and biofertilizers. Application of 50 percent RDF through inorganic fertilizer + FYM @ 5 tonnes ha^{-1} + (*Rhizobium* + PSB + PGPR @ 5g each/kg seed) at the time of sowing recorded higher grain yield of 361.8 kg/ha followed by 50 percent RDF + FYM + *Rhizobium* + PSB (309.6 kg ha^{-1}) and RDF + *Rhizobium* + PSB + PGPR (264.0 kg ha^{-1}). Thus, it could be concluded that 50 percent RDF + FYM @ 5 t ha^{-1} + *Rhizobium* + PSB + PGPR was the best combination for getting higher productivity with maximum net returns.

Tiwari *et al*. (2016) reported that sole kodo millet and pigeonpea gave highest yield. Association of short duration kodo millet (DPS-19) and medium duration spreading

type pigeonpea (No. 148) in 2:1 rows proved to be best intercropping system with regard to total productivity of 4151 kg ha^{-1} in terms of kodo millet equivalent yield and land equivalent ratio of 1.60. Economics of the treatment significantly fetched maximum gross monetary returns (Rs. 33316 ha^{-1}), net monetary returns (Rs. 18124 ha^{-1}) and benefit-cost ratio (2.19) among all intercropping systems as well as sole cropping of either crops.

Jagadeesha *et al*. (2016) reported that application of sewage sludge (2498 kg ha^{-1}) or PMC (2475 kg ha^{-1}) produced significantly higher fingermillet grain yield and intercrop pigeonpea yield. However, higher benefit cost ratio was recorded with the application of sewage sludge (2.27) and poultry manure compost (2.19) over rest of the organic sources. The results inferred that application of cheaper source organic manure like sewage sludge or poultry manure are substitutes for huge quantity of fertilizers applied for the fingermillet production system.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

Field experiments on "Production and nutritional quality enhancement of nutri-cereals through agronomic manipulations" were conducted during *kharif* season of 2015 and 2016 at Agricultural College Farm, Raichur. The details of experimental techniques adopted, material used for treatment evaluation and methods followed during entire course of investigation are presented in this chapter.

3.1 Experimental site

The experiments were conducted at Agricultural College Farm, Raichur in Plot No. 180 in new area during *kharif* seasons of 2015 and 2016. Raichur is situated in the North Eastern Dry Zone (Zone-2) of Karnataka between 16º15' N latitude and 77º 20' E longitude with an altitude of 389 m above the mean sea level.

3.2 Soil properties of experimental site

The soil of the experimental site was medium black. Composite soil samples were drawn from 0 to 30 cm soil depth before sowing and was analysed for physical and chemical properties. The values obtained along with method employed are presented in Table 1.

3.3 Climatic conditions

The monthly meteorological data for the period from April, 2015 to March, 2016 and April, 2016 to March, 2017 and the average for the last 85 years recorded at the meteorological observatory of the Main Agricultural Research Station, Raichur are presented in Table 2 and depicted in Fig.1.

3.4 Previous crop in the experimental site

Maize was grown during 2014 in the experimental site with uniform cultural practices.

3.5 Experimental details

The details of the experiment are given below.

Table 1. Physical and chemical properties of the soil in experimental site before sowing of crops

Properties	Values	Method
I. Physical properties		
1. Particle size analysis		
Sand (%)	23.91	International pipette method (Piper, 1966)
Silt (%)	26.28	
Clay (%)	48.49	
2. Bulk density (Mg m^{-3})	1.32	Core sampler method (Dastane, 1967)
II. Chemical properties		
Soil pH	8.18	pH meter (Piper, 1966)
Electrical Conductivity (dS m^{-1})	0.15	Conductivity bridge (Piper, 1966)
Organic carbon (%)	0.56	Walkely and Black's wet oxidation method (Jackson, 1967)
Available nitrogen (kg ha^{-1})	239.29	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	34.23	Olsen's method (Jackson, 1967)
Available potassium (kg ha^{-1})	267.12	Flame Photometry method (Jackson, 1967)

Table 2. Mean monthly meteorological data for the year 2015-16, 2016-17 and mean of the last 85 years at Main Agricultural Research Station, Raichur

Month	Average (1932-2016)	Rainfall (mm)		Temperature (^{o}C)						Relative Humidity (%)		
				Average (1932-2016)	Maximum		Average (1932-2016)	Minimum				
		Mean 2015-16	Mean 2016-17		Mean 2015-16	Mean 2016-17		Mean 2015-16	Mean 2016-17	Average (1932-2016)	Mean 2015-16	Mean 2016-17
April	70.7	114.2	0.0	39.9	37.3	41.8	22.6	22.6	28.3	77.0	68.0	32.7
May	71.5	18.7	87.2	39.7	39.9	39.6	22.5	22.5	26.6	80.0	66.0	47.8
June	182.7	38.7	194.1	35.3	36.3	33.8	22.3	22.3	24.2	82.0	77.0	68.6
July	62.5	42.0	143.2	33.4	36.3	31.8	20.5	20.5	23.5	79.0	77.0	73.2
August	21.2	51.4	78.0	32.9	34.6	32.4	19.1	19.1	23.1	79.0	80.0	70.1
September	4.0	316.6	292.5	32.2	39.1	29.2	16.2	16.2	22.6	76.0	88.0	81.6
October	1.2	65.4	39.2	31.5	33.4	31.2	16.8	16.8	19.7	77.0	80.0	66.7
November	1.1	2.0	0.0	31.3	31.9	31.1	18.5	18.5	16.1	62.0	79.0	59.2
December	44.3	2.2	0.3	30.5	32.0	30.2	22.6	22.6	15.2	56.0	83.0	58.1
January	13.0	1.4	1.4	31.2	31.2	31.2	24.4	24.4	17.7	53.0	75.0	53.1
February	42.9	0.0	0.0	32.5	35.5	35.5	25.3	25.3	21.6	60.0	62.0	43.6
March	113.8	24.9	0.0	36.5	37.9	38.4	23.3	23.3	24.6	79.0	66.0	37.5
Total	**628.9**	**677.5**	**835.9**									

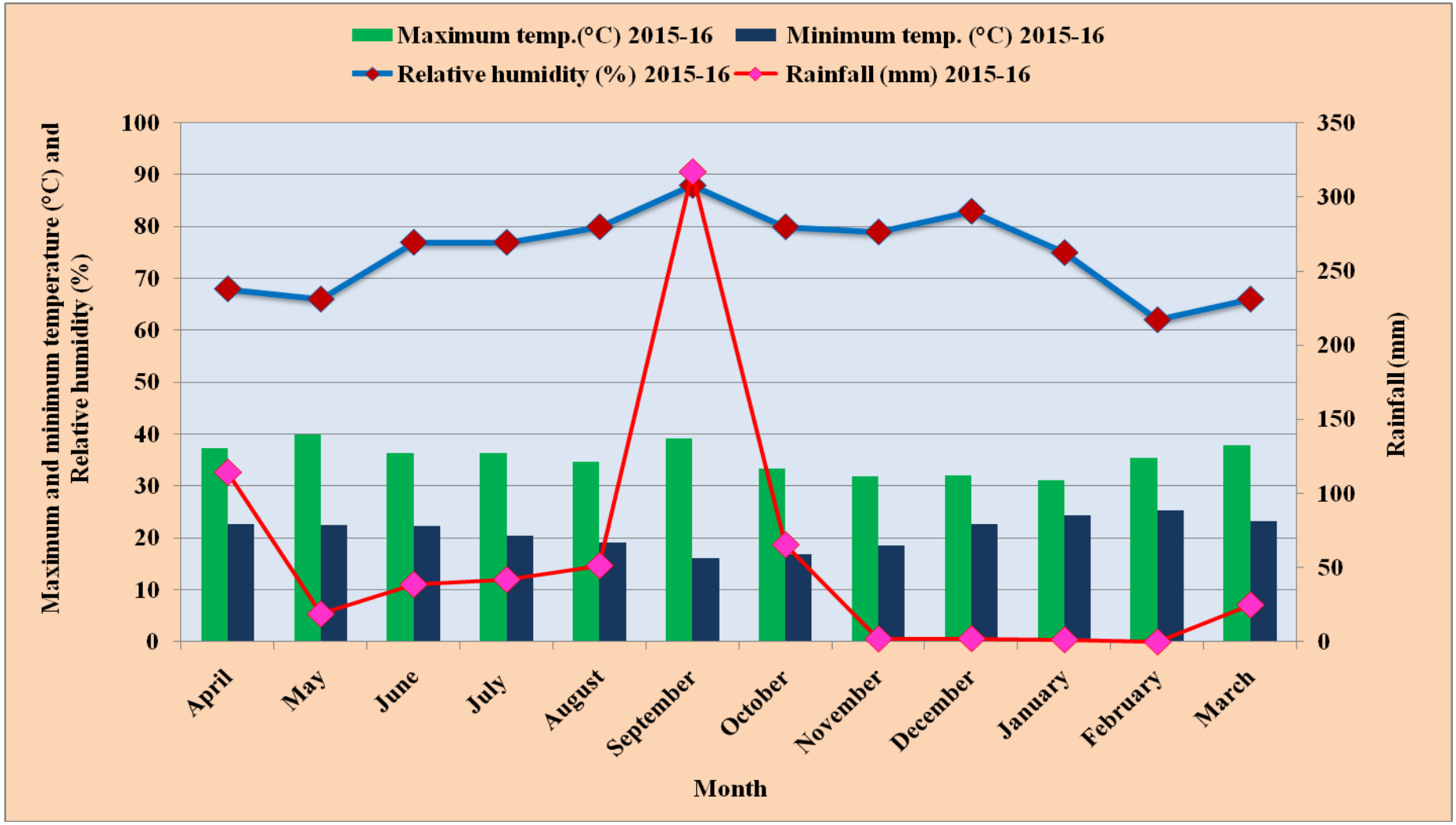

Fig. 1. Mean monthly meteorological data for the year 2015-16 at Main Agricultural Research Station, Raichur

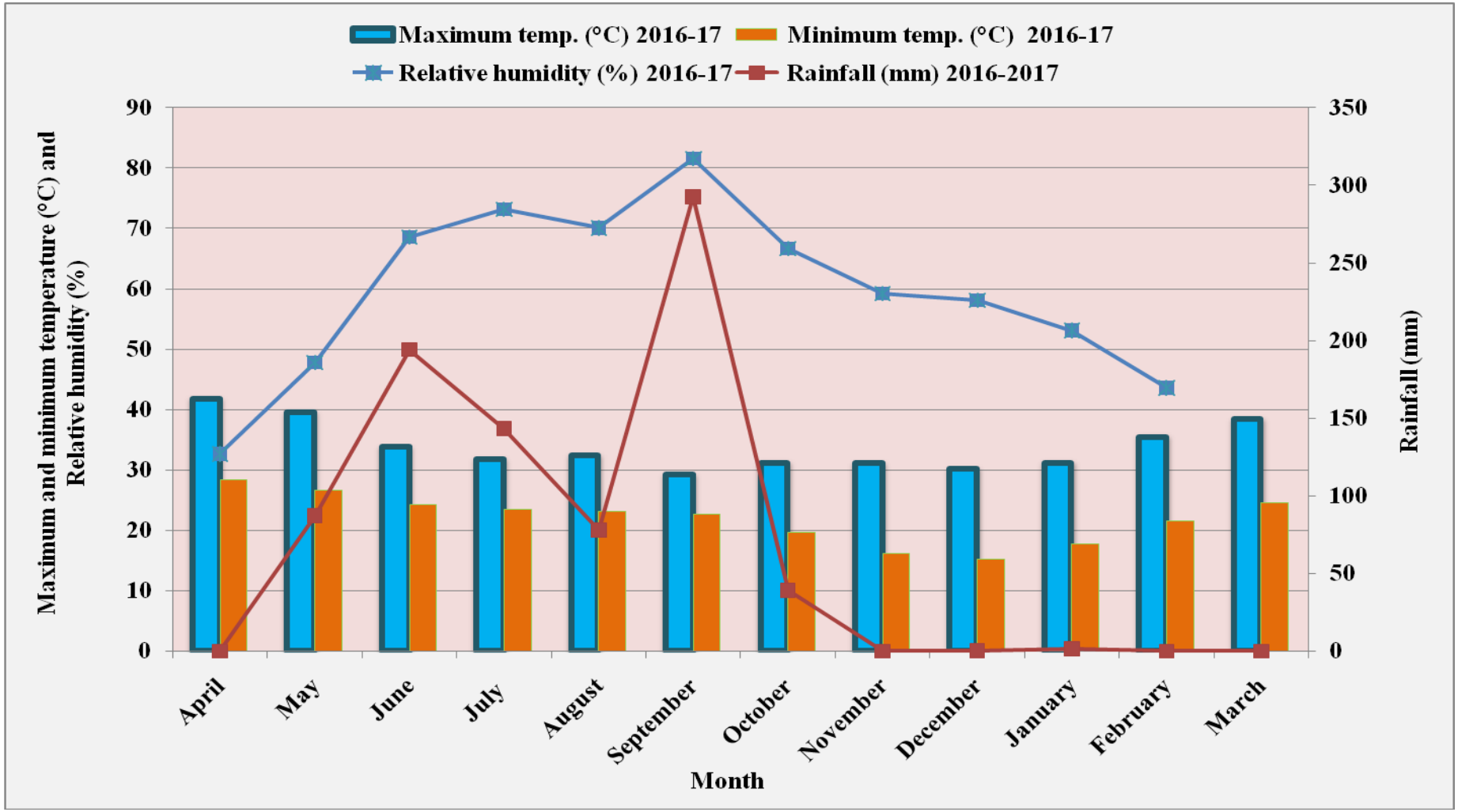

Fig. 2. Mean monthly meteorological data for the year 2016-17 at Main Agricultural Research Station, Raichur

3.5.1 Experiment-I: Performance of pigeonpea and nutri-cereals in traditional intercropping systems under rainfed condition

Treatment details

T_1 :Pigeonpea + Sorghum (1:1)

T_2 :Pigeonpea + Pearl millet (1:1)

T_3 :Pigeonpea + Foxtail millet (1:1)

T_4 :Pigeonpea + Sorghum (1:2)

T_5 :Pigeonpea + Pearl millet (1:2)

T_6 :Pigeonpea + Foxtail millet (1:2)

T_7 :Sole Pigeonpea (90 cm × 30 cm)

T_8 :Sole Sorghum (45 cm × 15 cm)

T_9 :Sole Pearl millet (45cm × 15 cm)

T_{10} :Sole Foxtail millet (30 cm × 10 cm)

Design : Randomized Block Design,

Replications :Three

Plot Size :The gross and net plot size for pigeonpea and intercrops are furnished in Table 3

3.5.2 Experiment-II: Performance of different nutri-cereals in strip cropping with pigeonpea under varied fertility levels

Treatments details

Main plot :Strip cropping systems

M_1: Pigeonpea + Sorghum (2:4)

M_2: Pigeonpea + Pearl millet (2:4)

M_3: Pigeonpea + Foxtail millet (2:4)

Table 3. Details of the treatments, gross and net plot size for the component crops in Experiment-1

Tr. No.	Treatments	Inter row spacing (cm)	Intra row spacing (cm)		Gross plot size = W×L (m^2)	Net plot size = W×L (m^2)	
			Pigeonpea	Intercrop		Pigeonpea	intercrop
T_1	Pigeonpea + Sorghum (1:1)	45	30	15	7.2 × 4.8	5.4 × 3.6	5.4 × 3.6
T_2	Pigeonpea + Pearl millet (1:1)	45	30	15	7.2 × 4.8	5.4 × 3.6	5.4 × 3.6
T_3	Pigeonpea + Foxtail millet (1:1)	45	30	10	7.2 × 4.8	5.4 × 3.6	5.4 × 4.0
T_4	Pigeonpea + Sorghum (1:2)	45	20	15	7.2 × 4.8	4.5 × 4.0	4.5 × 3.6
T_5	Pigeonpea + Pearl millet (1:2)	45	20	15	7.2 × 4.8	4.5 × 4.0	4.5 × 3.6
T_6	Pigeonpea + Foxtail millet (1:2)	45	20	10	7.2 × 4.8	4.5 × 4.0	4.5 × 4.0
T_7	Sole Pigeonpea	90	30	-	7.2 × 4.8	5.4 × 3.6	-
T_8	Sole Sorghum	45	-	15	7.2 × 4.8	-	5.4 × 3.6
T_9	Sole Pearl millet	45	-	15	7.2 × 4.8	-	5.4 × 3.6
T_{10}	Sole Foxtail millet	30	-	10	7.2 × 4.8	-	6.0 × 4.0

Subplot : Fertility Levels

S_1: 50 % RDF to both crops

S_2: 50 % RDF through organic + 50 % RDF through inorganic to both crops

S_3: 100 % RDF to both crops

RDF of pigeonpea :25:50:0 kg N, P_2O_5, K_2O ha^{-1}

RDF sorghum :50:25:0 kg N, P_2O_5, K_2O/ha^{-1}

RDF of pearl millet :50:25:0 kg N, P_2O_5, K_2O $/ha^{-1}$

RDF of foxtail millet :30:15:15 kg N, P_2O_5, K_2O/ha^{-1}

Design : Split plot design.

Replications : Three

Plot size :The gross and net plot size for pigeonpea and intercrops are furnished in Table 4

Location : Agriculture College Farm, Raichur

Table 4. Details of the treatments, gross and net plot size for the component crops in Experiment-II

Treatment No.	Treatment	Gross plot size = W×L (m^2)	Net plot size = W×L (m^2)	
			Pigeonpea	intercrops
M_1	Pigeonpea + Sorghum (2:4)	7.2 × 4.8 m	3.60 ×3.76 m	3.60 × 3.60 m
M_2	Pigeonpea + Pearl millet (2:4)	7.2 × 4.8 m	3.60×3.76 m	3.60 × 3.60 m
M_3	Pigeonpea + Foxtail millet (2:4)	7.2 × 4.8 m	3.60 ×3.76 m	3.60 × 4.00 m

Note 1. Common row spacing of 45 cm is provided in all intercropping treatments.

2. Common intra row spacing of 15 cm is maintained for sorghum and pearl millet and 10 cm for foxtail millet.

3. For pigeonpea, intra row spacing was adjusted to maintain its population at its sole optimum.

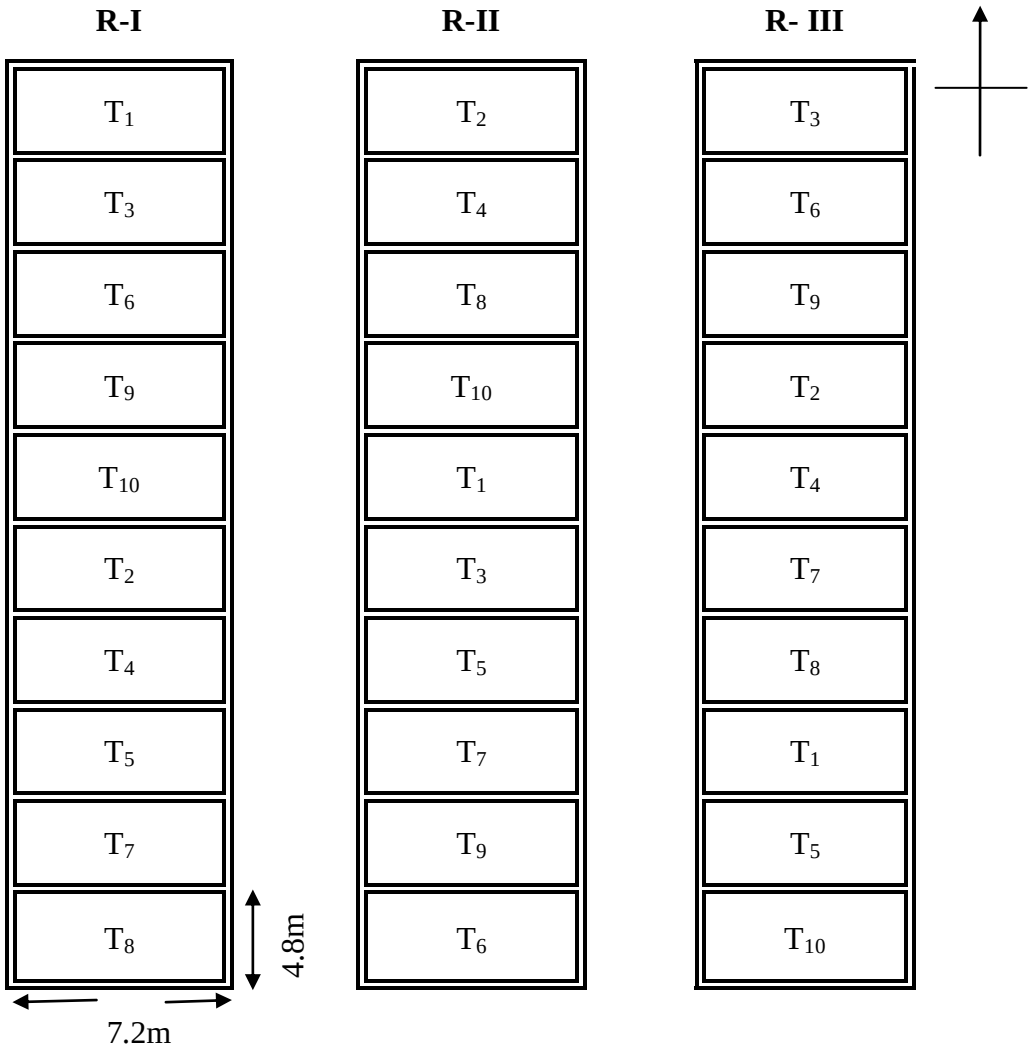

Fig. 3. Plan of layout of Experiment-I

Plate 1. General view of Experiment-I

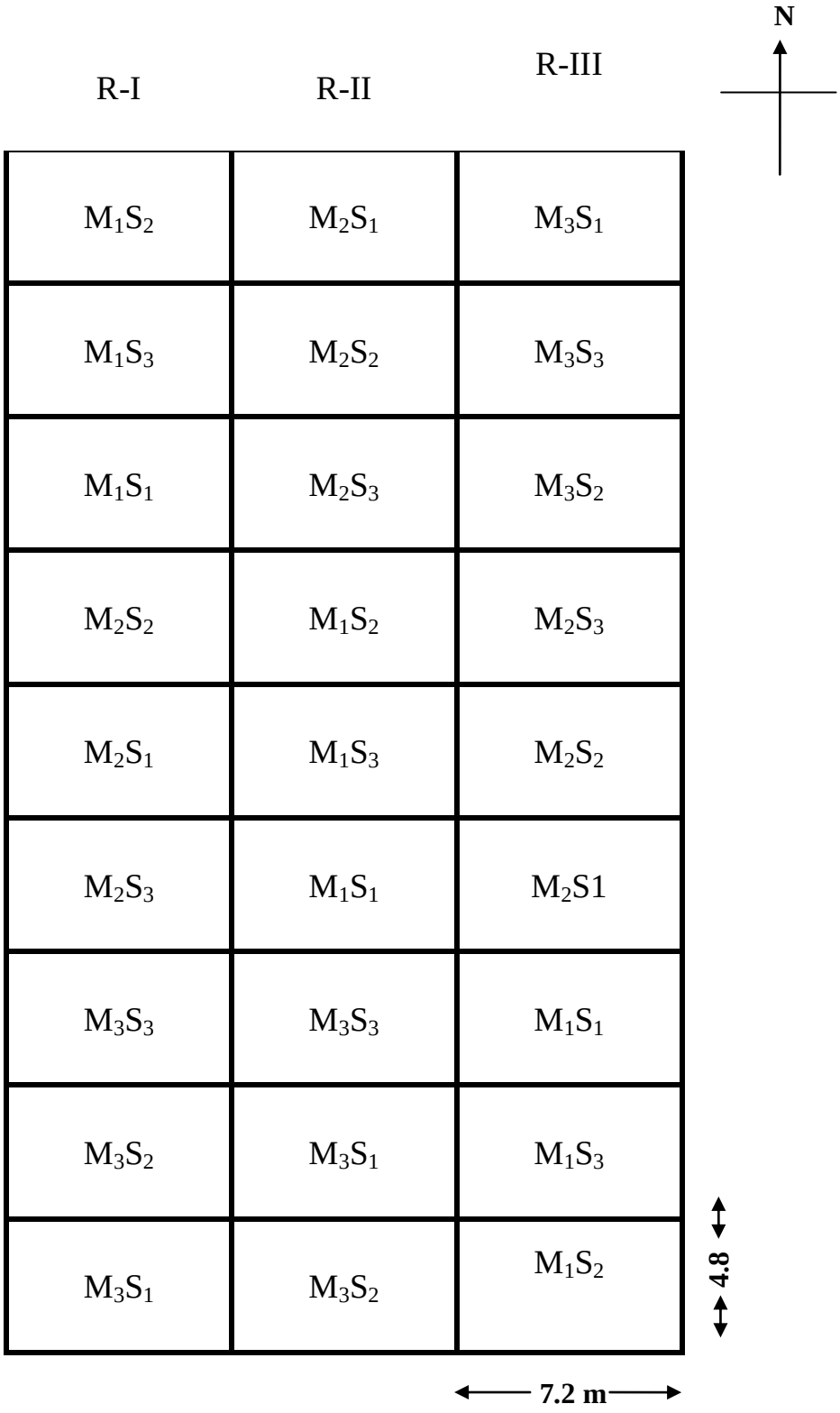

Fig. 4. Plan of layout of Experiment-II

Plate 2. General view of Experiment-II

Table 5. Salient features of cultivars of pigeonpea and intercrops

Sl. No.	Crop	Variety/ Hybrid	Duration (Days)	Yield potential (q/ ha)	Special features
1	Pigeonpea	TS-3R	145-150	10-12	It is resistant to both wilt and sterility mosaic diseases
2	Sorghum	CSH-16	110-115	12-16	Early maturing, resistant to smut disease
3	Pearl millet	ICTP-8203	70-80	12-15	Lodging resistant, more number of tillers and uniform ear head emergence
4	Foxtail millet	SiA-2644	90-95	12-15	Bold seeded and medium resistant to rust

3.6 Cultural operations

3.6.1 Land preparation

The land was ploughed with tractor after harvest of the previous crop and harrowed twice to crush the clods. Stubbles and weeds were removed from the experimental area and the soil was brought to fine tilth. Before sowing, the plots were laid out as per the plan (Fig. 2 and 3) and small bunds were formed around each plot. Each plot was levelled in order to avoid stagnation of water within the plot.

3.6.2 Fertilizer application

In the experiment, the fertilizer application was followed on the basis of plant population occupied by each crop. The nutrients *viz.*, nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Recommended dose of fertilizers were applied for the sole crops of pigeonpea (25:50:00 kg N, P_2O_5 and K_2O ha^{-1}, respectively), sorghum (50:25:0 kg N, P_2O_5 and K_2O ha^{-1}, respectively), Bajra (50:25:0 kg N, P_2O_5 and K_2O ha^{-1}, respectively) and foxtail millet (30:15:15nkg N, P_2O_5 and K_2O ha^{-1}, respectively). In the intercropping system the fertilizers were applied to the component crops according to the treatment details in both years. The entire quantities of fertilizers were applied to all the crops at the time of sowing as basal. The fertilizers were placed in furrows opened at 5 cm away from the seed line (crop row) and covered with soil.

3.6.3 Seeds and Sowing

Bold and healthy seeds of pigeonpea and millets were selected and were treated with captan 2.0 g per kg of seed. Later, the seeds were inoculated with suitable *Rhizobium* and *Azospirillium* strains respectively, and dried in shade before sowing. The crops were sown on different dates as given below.

Experiments	Date of sowing	
	2015-16	2016-17
Experiment-I	06-08-2015	20-07-2016
Experiment-II	06-08-2015	23-07-2016

Two seeds were dibbled in each spot and the seedlings were thinned at 15 DAS to maintain the required plant population.

3.6.4 After care

3.6.4.1 Thinning and gap filling

Gap filling was done one week after sowing and thinning was done two weeks after sowing to maintain one seedling per hill.

3.6.4.2 Weeding

Hand weeding was done at 20 and 40 days after sowing to avoid crop weed competition.

3.6.4.3 Plant protection

Sorghum was applied with carbofuran (10G) in whorl for control of early shoot fly immediately after germination of crop. Pearl millet and foxtail millet were sprayed with coragen @ 0.2 ml/litre of water for control of *spodoptera litura* during flowering and grain filling stages.

Pigeonpea crop was protected against sclerotium wilt with the sprays of bavistin and vitavax powder each @ 2.0 g/ litre of water. *Helicoverpa armigera* (pod borer) was controlled with the sprays of coragen @ 0.2 ml/ litre of water during flowering and pod filling stages and protected against leaf webber with spray of DDVP and chloropyriphos @ 1.5 ml and 2 ml/ litre of water, respectively during flowering stage.

3.6.4.4 Protective irrigation

Crop was given protective irrigation to avoid moisture stress based on needs of the crop.

3.6.4.5 Harvesting and threshing

The net plot area as per treatment was harvested by cutting the plants close to the ground. Harvesting was done at physiological maturity of the crop. After harvesting, the plants were bundled and allowed for sun drying. The seeds were separated from the dried plants by threshing and winnowing. Later the seeds were cleaned and weighed.

3.7 Observations recorded

3.7.1 Growth parameters of pigeonpea

Five randomly selected pigeonpea plants in the net plot area were tagged and used for making observations on various growth parameters at 30, 60, 90,120 days after sowing (DAS) and at harvest.

3.7.1.1 Plant height (cm)

Height from the ground level to the highest growing tip of the plant was recorded from five plants and the mean plant height was worked out.

3.7.1.2 Number of primary branches

The number of branches arising from the main stem were counted from five plants and the mean was taken as the number of primary branches per plant.

3.7.1.3 Number of secondary branches

The total number of branches arising from the primary branches were counted from five plants and the mean was taken as the number of secondary branches per plant.

3.7.1.4 Number of leaves

Total number of fully opened trifoliate leaves was counted in the five plants and their average was taken as number of leaves per plant.

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

The leaf area was worked out by disc method on dry weight basis at 30, 60, 90,120 DAS and harvest as per the procedure suggested by Vivekanandan *et al*. (1972).

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

Where,

LA = Leaf area (dm^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 (dm^2)

3.7.1.6 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).

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

Where,

A= Leaf area per plant (dm^2)

P= Land area occupied by the plant (dm^2)

3.7.1.7 Dry matter production and accumulation in different plant parts

Plant samples for dry matter studies were collected at 30, 60, 90,120 days after sowing and at harvest. At each sampling, five plants were uprooted at random in each treatment and partitioned into leaf, stem and reproductive parts. These samples were oven dried at 70º C in hot air oven for 72 hours till a constant weight. The completely dried samples were weighed and the dry weight of different plant parts was expressed in grams on per plant basis.

3.7.2 Pigeonpea yield and yield components

Five tagged plants from the net plot area which were used for recording growth parameters were harvested separately at physiological maturity and were used for recording various yield components and seed yield as listed below.

3.7.2.1 Number of pods per plant

The pods were counted from five plants and the mean was computed and expressed as number of pods per plant.

3.7.2.2 Number of seeds per pod

The seeds from 10 representative pods were separated, counted and the mean number of seeds per pod was calculated by dividing the number of seeds by the number of pods.

3.7.2.3 Seed weight per plant (g)

The seeds from the pods of five plants were separated by threshing and their mean weight was taken as seed weight per plant.

3.7.2.4 Hundred seed weight (g)

Seed samples from the produce of each net plot were taken and 100-seeds from these samples were counted and weighed.

3.7.2.5 Seed yield (kg ha^{-1})

Pods from each net plot were threshed, cleaned and the seed weight was recorded. From this, seed yield per hectare was computed.

3.7.2.6 Stalk yield (kg ha^{-1})

Plants from the net plot after threshing, were dried and their weight was recorded. From this, the stalk yield per hectare was calculated.

3.7.2.7 Husk yield (kg ha^{-1})

The plants from the net plot area were threshed and partitioned into seed, stalk and husk. The husk weight per plot was weighed and yield per hectare was computed.

3.7.2.8 Harvest index (HI)

Harvest index was calculated by using the formula suggested by Donald (1962).

$$HI = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

3.7.3 Growth components of intercrops

Five randomly selected plants of intercrops *viz.*, sorghum, pearl millet and foxtail millet in the net plot area were tagged and used for making observations on various growth parameters at 30, 60, 90 days after sowing (DAS) and at harvest for sorghum and 30, 60 days after sowing (DAS) and at harvest for pearl millet and foxtail millet.

3.7.3.1 Sorghum, pearl millet and foxtail millet

3.7.3.1.1 Plant height (cm)

The plant height was measured from the base of the plant to the base of the terminal fully opened leaf prior to ear head emergence. After the ear head emergence, it was measured up to the tip of the ear head. The average plant height was calculated and expressed in centimeters.

3.7.3.1.2 Number of green leaves per plant

The total number of fully opened green leaves per plant were counted from five plants and the mean was taken as the number of leaves per plant.

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

Length of the fully opened leaf lamina was measured from the leaf base to the tip. Leaf breadth was taken at the widest point of lamina. The product of leaf length and breadth was multiplied by the factor 0.7554 and was expressed as leaf area in dm^2 per plant.

3.7.3.1.4 Leaf area index (LAI)

Leaf are index (LAI) was worked out by dividing the leaf area per plant by the land area occupied by that plant as suggested by Sestak *et al.* (1971).

$$\text{LAI} = \frac{\text{Leaf area per plant } (dm^2)}{\text{Ground area covered by the plant } (dm^2)}$$

3.7.3.1.5 Dry matter production and its accumulation in different plant parts

Five plants selected randomly were uprooted from each plot and were partitioned into leaf, stem and reproductive parts at harvest. The samples were oven dried to constant weight at 70 ^{0}C and dry weight was expressed in grams per plant.

3.7.4 Yield components and yield of intercrops

3.7.4.1 Yield components and yield of sorghum and pearl millet

Tagged plants used for recording growth parameters were harvested at physiological maturity and were used for recording various yield components and seed yield as listed below.

3.7.4.1.1 Ear head length (cm)

The length of the ear was measured from base to the tip of the ear and expressed in cm.

3.7.4.1.2 Ear head weight (g)

The weight of ear was recorded and expressed in grams

3.7.4.1.3 Grain weight per earhead^{-1} (g)

The total weight of grains obtained from the 10 ears selected at random from the net plot was recorded and the mean was expressed in grams.

3.7.4.1.4 Thousand- grain weight (g)

One thousand seeds were counted from the net plot seed yield and their weight was recorded as 1000-grain weight in grams.

3.7.4.1.5 Seed yield (kg ha^{-1})

The seeds from the net plot area were cleaned, dried and weighed. The seed weight of plants used for sampling was added. On the basis of net plot yield, the seed yield per hectare was calculated.

3.7.4.1.6 Stover yield (kg ha^{-1})

The stover from each net plot was kept for sun drying and the straw weight was recorded after complete drying. From this, the stover yield per hectare was calculated.

3.7.4.1.7 Harvest index (HI)

Harvest index was calculated by using the formula suggested by Donald (1962).

$$HI = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

3.7.4.2 Yield components and yield of foxtail millet

3.7.4.2.1 Number of effective tillers per plant

Number of effective tillers were counted from randomly selected five plants and mean was calculated.

3.7.4.2.2 Length of earhead (cm)

The earhead length was measured from tip to the base of the earhead and expressed in centimeter.

3.7.4.2.3 Grain weight earhead^{-1} (g)

Five randomly selected earheads were threshed, cleaned, weighed and mean weight was expressed in grams ear head^{-1}.

3.7.4.2.4 Thousand-seed weight (g)

One thousand seeds were counted from the net plot seed yield and their weight was recorded as 1000-grain weight in grams.

3.7.4.2.5 Grain yield (kg ha^{-1})

Earheads from net plot were harvested at maturity, air dried, threshed, cleaned, weighed and grain yield ha^{-1} was worked out and expressed in kg ha^{-1}.

3.7.4.2.6 Stover yield (kg ha^{-1})

The stover from each net plot was kept for sun drying and the straw weight was recorded after complete drying. From this, the stover yield per hectare was calculated.

3.7.4.2.7 Harvest index

Harvest index was calculated by using the formula suggested by Donald (1962).

$$HI = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

3.8 Estimation of nutritional quality of nutri-cereals

3.8.1 Nutritional status of seeds prior to sowing

Nutrient content in seeds of pigeonpea, sorghum, pearl millet and foxtail millet were analyzed especially for Zn and Fe before sowing by taking individual 100 g seeds of each by Inductively coupled plasma mass spectrometry (ICP-MS).

3.8.2 Nutritional status of the seeds after harvesting

Nutrient content of seeds analysed such as Zn and Fe after harvesting of crops by taking 100 g sample of individual crops by inductively coupled plasma mass spectrometry (ICP-MS).

3.8.3 Nutritional status of processed products

The nutrient content (zinc and iron) for processed products was analysed after dehusking the seeds of pigeonpea, sorghum, pearl millet and foxtail millet separately by collecting 100 g seeds of individual crops and estimation was done with Inductively coupled plasma mass spectrometry (ICP-MS).

3.9 Chemical analysis of soil and plant sample

3.9.1 Chemical analysis of soil

Soil samples were collected before and after harvest of the crop during 2015-16 and 2016-17 respectively, from 0-15 and 15-30 cm soil depths in all the replications. These soil samples were analyzed for different chemical properties as follows.

3.9.1.1 Soil pH

The soil pH was determined by pH meter (Piper, 1966).

3.9.1.2 Electrical conductivity of soil

The Electrical conductivity of soil was determined by conductivity bridge (Piper, 1966) and expressed as deci siemen metre^{-1} (dS m^{-1}).

3.9.1.3 Available nitrogen

Available nitrogen content was determined by alkaline permanganate method as described by Subbaiah and Asija (1956) and expressed as kg ha^{-1}.

3.9.1.4 Available phosphorus

Available phosphorus content was determined by Olsen's method as outlined by Jackson (1967) and expressed as kg ha^{-1}.

3.9.1.5 Available potassium

Available potassium content was determined by extracting with neutral normal ammonium acetate solution and using flame photometer (ELICO Model) as outlined by Jackson (1967) and expressed as kg ha^{-1}.

3.9.2 Uptake of nutrients

Nitrogen content in both pigeonpea and intercrops was estimated by modified kjeldhal's method as outlined by Jackson (1967). Total phosphorus and potassium were extracted by wet ashing method. Phosphorus was estimated by vanadomolybdo phosphoric yellow colour method (Jackson, 1967) and potassium was determined by Flame photometer method (Jackson, 1967).

3.9.2.1 Uptake of nitrogen

Nitrogen content estimated earlier was multiplied with grain yield/stover yield to obtain uptake of nitrogen. Sum of nitrogen uptake in grain and haulm/stover was used to represent total nitrogen uptake in kg ha^{-1}.

N uptake was calculated by using following formula.

$$\text{N uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration in sample (\%)}}{100} \times \text{Biomass yield (kg ha}^{-1}\text{)}$$

3.9.2.2 Uptake of phosphorus and potassium

The uptake of phosphorus and potassium were computed as in case of nitrogen.

3.10 Assessment of yield advantage in intercropping system

3.10.1 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. Finally pigeonpea equivalent yield was calculated as,

$$\text{PEY} = \frac{\text{Yield of intercrop x Price of intercrop}}{\text{Price of pigeonpea}} + \text{Yield of pigeonpea}$$

3.10.2 Land Equivalent Ratio (LER)

It is defined as the relative land area under sole crops that is required to produce the yields obtained in intercropping at the same level of management (Willey, 1979). It is calculated as follows.

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

3.10.3 Area Time Equivalent Ratio (ATER)

The limitation in the use of LER is the emphasis on the land area without consideration of time the field is dedicated to production. To correct this deficiency, the LER was modified by Hiebsch (1980) to include the duration of time of crop present on

the land from planting to harvest. This is known as the area time equivalent ratio (ATER). ATER was calculated according to formula given by Hiebsch (1980).

$$ATER = \frac{(RYs \times ts) + (RYp \times tp)}{T}$$

Where,

RY = Relative yield of species s and p

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

t = Duration (days) for species s and p

T = Total duration (days) of the intercropping system

3.11 Light Transmission Ratio (LTR)

Both incoming and outgoing photosyntheticaly active radiation (PAR) values were measured periodically at the top and bottom of the crop canopy and leaf area index throughout the season by using sunscan canopy analyzer (Delta-T Device, Cambridge, UK) probe. The above measurements were taken at regular intervals on clear sunny days between 11:00 and 14:00 h IST when solar zenith angle were minimum. The transmitted photosyntheticaly active radiation (IPAR) for a particular day was computed as difference between PAR at the top and bottom of canopy. The fraction of IPAR (fIPAR) for a particular day is the ratio between transmitted PAR and total incident PAR on that day (Jha *et al.*, 2012). Values for fIPAR for each day after sowing were interpolated between actual measurements by linear interpolation throughout the crop season. Daily incoming solar radiation was calculated by the procedure described in Allen *et al.* (1998) using daily bright sunshine hours observation. The daily incoming solar radiation was multiplied by a factor, 0.48 to get incoming incident PAR. Then the daily incident PAR values were multiplied by corresponding daily fIPAR values to compute daily intercepted PAR (IPAR). Radiation interception of photosynthetically active radiation was measured by using a Sunscan canopy analyzer (Delta-T Device, Cambridge, UK) probe. It has two parts, single quantum sensor probe placed at 1.8 m height above the ground to record incident PAR without any shade on the globe. Another one meter long probe has 64 diodes kept at bottom of the canopy to record intercepted light by the crop canopy. Inside

shade cloths light intensity was measured on top of the canopy and at ground levels. The measurements were taken between 11.00 am and 03:00 pm (IST) during clear sunny days at an interval of fifteen days. The light transmission ratio was calculated by the following formula.

$$F = 1 - \left(\frac{I_o}{I_t} \right)$$

Where,

F = Light Transmission Ratio

I_o = Measured incident PAR below a canopy layer

I_t = Radiant flux density on the top of the canopy

3.12 Economics of intercropping system

The cost of the following items was considered for working out the cost of cultivation of pigeonpea and sesame.

1. Labour charges
2. Seeds
3. Fertilizers
4. Plant protection chemicals
5. Miscellaneous (marketing charges, *etc*.)

The prices of the inputs that were prevailing at the time of their use were taken into account to work out the cost of cultivation. Gross returns were calculated using the yield of crops and market prices of the produce at the time of marketing.

3.12.1 Net returns

The net return per hectare was calculated by deducting the cost of cultivation from gross returns per hectare.

3.12.2 Benefit cost ratio

The benefit cost ratio was calculated as follows.

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs.ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs.ha}^{-1}\text{)}}$$

3.13 Statistical analysis and the interpretation of data

Fisher's method of analysis of variance was used for analysis and interpretation of the data as outlined by Panse and Sukhatme (1967). The level of significance used in 'F' and't' test was P = 0.05. Critical differences were calculated wherever 'F' test was significant.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the field experiments conducted during *Kharif* season of 2015 and 2016 on production and nutritional quality enhancement of nutri-cereals through agronomic manipulations at Agricultural College Farm, Raichur are presented in this chapter.

4.1 Experiment I: Performance of pigeonpea and nutri-cereals in traditional intercropping systems under rainfed condition

4.1.1 Growth parameters of pigeonpea

4.1.1.1 Plant height (cm)

The results revealed that the plant height of pigeonpea was significantly influenced due to intercropping with nutri-cereal crops with row ratios at all the stages of crop growth as presented in Table 6.

During both the years, 2015 and 2016 at 30 DAS, significantly higher plant height was recorded with sole pigeonpea (43.26 and 44.47 cm, respectively) over the intercropped treatments. The intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (38.46 and 39.79 cm, respectively), pigeonpea + sorghum (1:1) (37.70 and 38.87 cm, respectively), pigeonpea + foxtail millet (1:2) (36.62 and 37.69 cm, respectively) and pigeonpea + pearl millet (1:1) (34.85 and 35.32 cm, respectively) recorded on par plant height among one another. However, during both the years, significantly lower plant height was recorded with pigeonpea + pearlmillet (1:2) (33.52 and 34.59 cm, respectively) and was found on par with pigeonpea + sorghum (1:2) (34.36 and 35.20 cm, respectively). Pooled data also followed the similar trend.

With advancement in growth of pigeonpea and the intercrops, plant height of pigeonpea was significantly influenced. At 60 DAS, significantly lower plant height was recorded with pigeonpea + pearlmillet (1:2) (52.07 and 53.16 cm, respectively) during both the years when compared to other intercropped treatments and was found on par with the pigeonpea + sorghum (1:2) (53.66 and 54.37 cm, respectively). During both the years, sole pigeonpea (64.48 and 66.63 cm, respectively) recorded significantly higher plant height over the intercropped treatments.

Table 6. Plant height of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Plant height (cm)														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	37.70	38.87	38.29	57.46	58.64	58.05	115.38	115.96	115.59	137.96	139.05	138.51	147.32	151.15	149.24
T_2	34.85	35.32	35.09	55.85	56.67	56.26	112.77	113.61	113.19	135.56	137.17	136.37	143.48	145.30	144.39
T_3	38.46	39.79	39.13	60.13	61.10	60.61	116.48	117.63	117.06	139.59	141.59	140.59	149.70	152.49	151.10
T_4	34.36	35.20	34.78	53.66	54.37	54.01	109.32	110.46	111.28	134.27	134.01	134.14	141.15	143.22	142.19
T_5	33.52	34.59	34.06	52.07	53.16	52.61	106.71	110.91	108.81	132.09	133.08	132.58	139.80	142.40	141.10
T_6	36.62	37.69	37.16	57.21	58.10	57.66	114.96	115.81	116.17	137.12	138.78	137.95	145.70	148.81	147.26
T_7	43.26	44.47	43.87	64.48	66.63	65.55	123.61	125.41	124.51	146.72	149.30	148.01	157.18	161.06	159.12
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	1.43	1.51	1.29	1.35	1.68	1.30	2.21	1.86	1.77	1.55	2.32	1.36	2.14	2.70	1.97
C.D. (P=0.05)	4.59	4.67	4.13	4.34	5.37	4.17	7.07	5.96	5.67	4.95	7.41	4.35	6.85	8.54	6.27

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

At 90 DAS, during both the years (2015 and 2016) on par plant height was recorded among intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (116.48 and 117.63 cm, respectively), pigeonpea + sorghum (1:1) (115.38 and 115.96 cm, respectively), pigeonpea + foxtail millet (1:2) (114.96 and 115.81 cm, respectively) and pigeonpea + pearl millet (1:1) (112.77 and 113.61 cm, respectively) and were significantly lower when compared to sole pigeonpea. Similar trend was followed at 120 DAS and at harvest. The pooled mean also revealed the similar trend at all the stages of crop growth.

4.1.1.2 Number of leaves per plant

The results indicated that number of leaves per plant of pigeonpea was significantly influenced due to intercropping with nutri-cereal crops at different row proportion at all the crop growth stages (30, 60, 90, 120 DAS and at harvest) as presented in Table 7.

At 30 DAS, during both the years (2015 and 2016), sole pigeonpea (27.19 and 28.97, respectively) recorded significantly higher number of leaves when compared to intercropped treatments. Among intercropped treatments, pigeonpea with foxtail millet (1:1) (23.76 and 24.84, respectively), pigeonpea with sorghum (1:1) (22.25 and 23.70, respectively), pigeonpea with foxtail millet (1:2) (21.82 and 23.02, respectively) and pigeonpea with pearl millet (1:1) (21.29 and 22.36, respectively) recorded on par number of leaves per plant. However during both the years (2015 and 2016) significantly lower number of leaves per plant was recorded with pigeonpea + pearl millet (1:2) (19.17 and 20.40, respectively) over other intercropped treatments which was found on par with pigeonpea + sorghum (1:2) (19.86 and 21.32, respectively).

At 60 DAS, among the different intercropped treatments, pigeonpea + foxtail millet (1:1) (89.03 and 94.20, respectively) recorded significantly higher number of leaves per plant and it was found on par with pigeonpea + sorghum (1:1) (86.71 and 93.53, respectively), pigeonpea + foxtail millet (1:2) (85.67 and 91.97, respectively) and pigeonpea + pearl millet (1:1) (84.78 and 89.12, respectively) during both the years.

At 90 DAS, pooled data revealed that sole pigeonpea (143.04) recorded significantly higher number of leaves per plant over the intercropped treatments. However, among the intercropped treatments, pigeonpea + foxtail millet (1:1) recorded

Table 7. Number of leaves per plant of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Number of leaves per plant														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	22.25	23.70	23.13	86.71	93.53	90.12	124.14	129.27	126.71	142.37	145.66	144.01	77.74	80.57	79.16
T_2	21.29	22.36	21.83	84.78	89.12	86.95	121.42	126.26	123.84	140.33	143.16	141.74	75.88	79.01	77.45
T_3	23.76	24.84	24.30	89.03	94.20	91.62	127.61	132.68	130.15	144.58	147.17	145.87	80.15	82.35	81.25
T_4	19.86	21.32	20.59	81.28	86.10	83.69	118.03	123.01	120.52	136.80	138.46	137.63	73.36	75.84	74.60
T_5	19.17	20.40	19.78	79.36	84.62	81.99	114.61	119.56	117.09	134.88	136.87	135.88	71.47	73.65	72.56
T_6	21.82	23.02	22.42	85.67	91.97	88.82	122.67	127.73	125.20	141.04	144.34	142.69	76.41	79.63	78.02
T_7	27.19	28.97	28.08	95.55	102.55	101.71	140.61	145.46	143.04	160.79	164.25	162.52	96.27	98.57	97.42
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.92	0.90	0.86	1.68	2.08	2.06	1.99	4.27	1.86	2.23	2.37	2.18	2.22	1.88	1.86
C. D. P=0.05)	2.93	2.86	2.76	5.36	6.66	6.60	6.37	7.13	5.94	7.15	7.58	6.97	7.12	6.02	5.91

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

significantly higher number of leaves per plant (130.15) and it was found on par with pigeonpea + sorghum (1:1) (126.71), pigeonpea + foxtail (1:2) (125.20) and pigeonpea + pearl millet (1:1) (123.84). Whereas significantly lower number of leaves per plant were observed in pigeonpea with pearl millet (1:2) (117.09) and pigeonpea with sorghum (1:2) (120.52) intercropping over other intercropped treatments.

At 120 DAS and at harvest, pooled data revealed that sole pigeopea recorded significantly higher number of leaves per plant (162.52 and 97.42, respectively) over the intercropped treatments. However, significantly lower number of leaves per plant was recorded under pigeonpea + pearl millet (1:2) (135.88 and 72.56, respectively) and pigeonpea + sorghum (1:2) (137.63 and 74.60, respectively) over the other intercropped treatments.

4.1.1.3 Number of primary branches per plant

The data regarding number of primary branches per plant of pigeonpea at different stages of crop growth (30, 60, 90,120 DAS and at harvest) are presented in Table 8**.** The results revealed that the number of primary branches per plant of pigeonpea was significantly influenced due to different intercrops, irrespective of row proportion or intercropping system at all the stages of crop.

During both the years (2015 and 2016) at 30 DAS, sole pigeonpea (4.27 and 4.69, respectively) recorded significantly higher number of primary branches per plant when compared to intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (3.46 and 3.58, respectively), pigeonpea + sorghum (1:1) (3.23 and 3.40, respectively), pigeonpea + foxtail millet (1:2) (3.18 and 3.34, respectively) and pearl millet (1:1) (3.02 and 3.09, respectively) recorded significantly higher number of primary branches per plant when compared to other intercropped treatments *viz*., pigeonpea + pearl millet (1:2) (2.49 and 2.55, respectively) and pigeonpea + sorghum (1:2) (2.70 and 2.71, respectively) and were on par with one another during both the years.

Similar trend prevailed at 60 and 90 DAS in pooled mean which revealed that the intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (6.52 and 8.25, respectively), pigeonpea + sorghum (1:1) (6.23 and 7.71, respectively), pigeonpea + foxtail millet (1:2) (6.04 and 7.53, respectively) and pigeonpea + pearl millet (1:1) (5.94 and 7.37, respectively) recorded significantly higher number of primary branches per plant when

Table 8. Number of primary branches per plant of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Number of primary branches per plant														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	3.23	3.40	3.32	6.17	6.28	6.23	7.58	7.84	7.71	9.21	9.88	9.55	10.39	11.04	10.72
T_2	3.02	3.09	3.06	5.51	5.73	5.94	7.19	7.54	7.37	8.67	9.44	9.06	9.84	10.31	10.08
T_3	3.46	3.58	3.52	6.41	6.64	6.52	8.03	8.46	8.25	9.63	10.29	9.96	11.18	11.64	11.41
T_4	2.70	2.71	2.71	5.02	5.37	5.19	6.81	6.98	6.89	8.02	8.57	8.29	9.27	9.63	9.45
T_5	2.49	2.55	2.52	4.84	5.02	4.93	6.38	6.67	6.53	7.74	8.26	8.00	9.08	9.38	9.23
T_6	3.18	3.34	3.26	5.89	6.19	6.04	7.31	7.75	7.53	8.72	9.70	9.21	9.94	10.47	10.21
T_7	4.27	4.69	4.48	7.74	8.08	7.91	10.22	11.15	10.69	12.10	13.17	12.64	14.56	15.49	15.03
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.23	0.28	0.18	0.36	0.29	0.20	0.38	0.45	0.38	0.47	0.52	0.46	0.59	0.60	0.58
C. D. P=0.05)	0.75	0.88	0.56	1.15	0.92	0.63	1.20	1.45	1.23	1.50	1.66	1.47	1.88	1.92	1.85

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

compared to other intercropped treatments *viz*., pigeonpea + pearl millet (1:2) (4.93 and 5.19, respectively) and pigeonpea + sorghum (1:2) (6.53 and 6.89, respectively) which were on par with each other.

The pooled mean at 120 DAS and harvest indicated that significantly lower number of primary branches per plant of pigeonpea was recorded with pigeonpea + pearl millet (1:2) (8.00 and 9.23, respectively) which was found on par with pigeonpea + sorghum (1:2) (8.29 and 9.45, respectively). However, significantly higher number of primary branches per plant was recorded with sole pigeonpea (12.64 and 15.03, respectively) over the intercropped treatments.

4.1.1.4 Number of secondary branches per plant

The data concerned to number of secondary branches per plant of pigeonpea at different stages of crop growth (90, 120 DAS and at harvest) are presented in Table 9. The results indicated that the number of secondary branches per plant of pigeonpea was significantly influenced due to different component crops, irrespective of row proportion under intercropping.

At 90 DAS, during both the years (2015 and 2016), sole pigeonpea (6.47 and 7.14, respectively) recorded significantly higher number of secondary branches per plant over intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (5.24 and 6.03, respectively), pigeonpea + sorghum (1:1) (4.46 and 5.68, respectively) pigeonpea + foxtail millet (1:2), (4.40 and 5.52, respectively) and pigeonpea + pearl millet (1:1) (4.28 and 5.39, respectively) recorded significantly higher number of secondary branches per plant over other intercropped treatments and were on par with one another. However, during both the years, among the intercropped treatments, significantly lower number of secondary branches per plant was recorded with pigeonpea + pearl millet (1:2) (3.69 and 4.38, respectively) over other treatments and it was on par with pigeonpea + sorghum (1:2) (3.95 and 4.71, respectively). Similar trend was followed at 120 DAS and harvest during both the years.

During all the stages (90, 120 DAS and harvest) pooled data revealed that significantly higher number of secondary branches per plant was recorded under sole pigeonpea (7.02, 8.62 and 11.17) over intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (5.64, 7.07 and 8.55), pigeonpea + sorghum (1:1) (5.07, 6.52 and 7.88),

Table 9. Number of secondary branches per plant of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Number of secondary branches per plant								
	90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	4.46	5.68	5.07	6.36	6.68	6.52	7.40	8.35	7.88
T_2	4.28	5.39	4.84	5.91	6.25	6.08	6.96	7.97	7.47
T_3	5.24	6.03	5.64	6.61	7.07	6.84	8.01	9.08	8.55
T_4	3.95	4.71	4.33	5.35	5.70	5.52	6.39	7.22	6.80
T_5	3.69	4.38	4.03	4.89	5.25	5.07	6.15	7.04	6.59
T_6	4.40	5.52	4.96	6.14	6.44	6.29	7.14	8.19	7.66
T_7	6.47	7.14	7.02	8.27	8.96	8.62	10.71	11.64	11.17
T_8	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-
S. Em.±	0.32	0.41	0.35	0.34	0.41	0.36	0.42	0.44	0.39
C.D. (P=0.05)	1.01	1.08	1.11	1.08	1.31	1.15	1.36	1.41	1.25

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

pigeonpea + foxtail millet (1:2) (4.96, 6.29 and 7.66), pigeonpea + pearl millet (1:1) (4.84 6.08 and 7.47), pigeonpea + sorghum (1:2) (4.33, 5.52 and 6.80) and pigeonpea + pearl millet (1:2) (4.03, 5.07 and 6.59), respectively. Among the intercropped treatments, significantly lower number of secondary branches per plant was recorded with pigeonpea with pearl millet (1:2) and pigeonpea with sorghum (1:2) when compared to other treatments and were on par with each other.

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

The data pertaining to leaf area (dm^2 $plant^{-1}$) of pigeonpea as influenced by different intercrops and their row numbers at different growth stages (30, 60, 90, 120 DAS and at harvest) are presented in Table 10 and depicted in Fig 5.

At 30 DAS, during both the years (2015 and 2016), sole pigeonpea (7.20 and 7.71 dm^2 $plant^{-1}$, respectively) recorded significantly higher leaf area per plant over intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (6.32 and 6.53 dm^2 $plant^{-1}$), pigeonpea + sorghum (1:1) (6.19 and 6.29 dm^2 $plant^{-1}$), pigeonpea + foxtail millet (1:2) (5.95 and 6.08 dm^2 $plant^{-1}$) and pigeonpea + pearl millet (1:1) (5.91 and 5.82 dm^2 $plant^{-1}$) respectively, recorded significantly higher leaf area per plant over other intercropped treatments and at par with one another. The significantly lower leaf area per plant was recorded with pigeonpea + pearl millet (1:2) (4.97 and 5.12 dm^2 $plant^{-1}$, respectively) over other intercropped treatments, but it was on par with pigeonpea + sorghum (1:2) (5.05 and 5.28 dm^2 $plant^{-1}$, respectively).

At 60 DAS, significantly lower leaf area was recorded in pigeonpea + pearlmillet (1:2) (12.66 and 13.03 dm^2 $plant^{-1}$, respectively) during both the years when compared to remaining intercropped treatments but was found on par with the pigeonpea + sorghum (1:2) (13.04 and 13.36 dm^2 $plant^{-1}$, respectively). During both years, sole pigeonpea (18.63 and 19.49 dm^2 $plant^{-1}$, respectively) recorded significantly higher leaf area per plant over intercropped treatments.

At 90 DAS, pooled data showed that pigeonpea + foxtail millet (1:1) (29.11 dm^2 $plant^{-1}$) recorded significantly higher leaf area per plant when compared to pigeonpea + pearl millet (1:2) (24.36 dm^2 $plant^{-1}$) and pigeonpea + sorghum (1:2) (25.18 dm^2 $plant^{-1}$) and was statistically comparable with pigeonpea + sorghum (1:1) (27.38 dm^2 $plant^{-1}$), pigeonpea + foxtail millet (1:2) (26.88 dm^2 $plant^{-1}$) and pigeonpea + pearl millet (1:1)

Table 10. Leaf area of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Leaf area (dm^2 $plant^{-1}$)														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	6.19	6.29	6.24	14.27	15.02	14.65	26.83	27.92	27.38	21.89	22.71	22.30	11.76	12.59	12.17
T_2	5.91	5.82	5.87	13.88	14.45	14.17	26.01	27.09	26.55	20.64	21.55	21.09	10.58	11.23	10.91
T_3	6.32	6.53	6.43	15.11	15.91	15.51	28.53	29.69	29.11	22.75	23.49	23.12	12.02	13.19	12.60
T_4	5.05	5.28	5.17	13.04	13.36	13.20	24.41	25.95	25.18	18.64	19.57	19.10	8.37	9.05	8.71
T_5	4.97	5.12	5.05	12.66	13.03	12.85	23.79	24.93	24.36	17.58	18.68	18.13	7.84	8.44	8.14
T_6	5.95	6.08	6.02	14.07	14.77	14.42	26.23	27.52	26.88	21.16	22.41	21.79	10.93	11.94	11.44
T_7	7.20	7.71	7.46	18.63	19.49	19.06	36.52	38.23	37.38	33.11	34.65	33.88	17.84	19.10	18.47
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.33	0.36	0.32	0.64	0.75	0.67	1.17	1.07	1.05	0.95	0.89	0.89	0.69	0.68	0.66
C.D. (P=0.05)	1.05	1.14	1.04	2.04	2.40	2.14	3.74	3.43	3.36	3.04	2.85	2.86	2.20	2.17	2.10

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

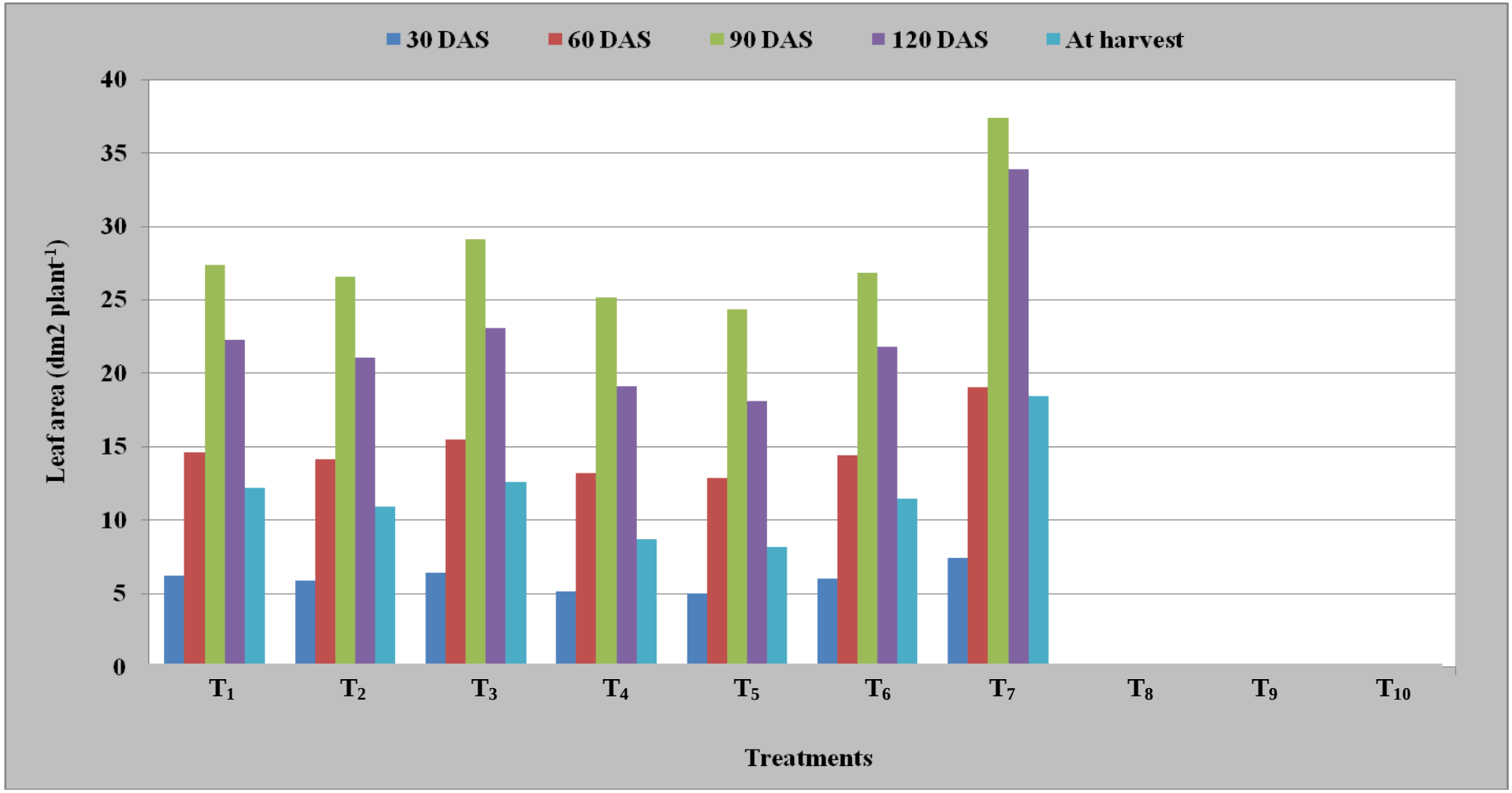

Fig. 5. Leaf area of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

(26.55 dm^2 $plant^{-1}$). The treatments *viz.*, pigeonpea + pearl millet (1:2) and pigeonpea + sorghum (1:2) were on par with each other.

At 120 DAS and harvest, pooled data revealed that sole pigeopea recorded significantly higher leaf area per plant (33.88 and 18.47 dm^2 $plant^{-1}$, respectively) over intercropped treatments. Among intercropped treatments, significantly lower leaf area per plant was recorded with pigeonpea + pearl millet (1:2) (18.13 and 8.14 dm^2 $plant^{-1}$, respectively) and pigeonpea + sorghum (1:2) (19.10 and 8.71 dm^2 $plant^{-1}$, respectively) over other intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1), pigeonpea + sorghum (1:1), pigeonpea + foxtail millet (1:2) and pigeonpea + pearl millet (1:1) and were on par with one another.

4.1.1.6 Leaf area index

The results revealed that the leaf area index of pigeonpea was significantly influenced due to intercropping with nutri-cereal crops under different row ratios at all the stages of crop growth as presented in Table 11 and fig 6.

During both the years, 2015 and 2016, at 30 DAS significantly higher leaf area index was recorded with sole pigeonpea (0.267 and 0.286) over the intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (0.234 and 0.242), pigeonpea + sorghum (1:1) (0.229 and 0.233), pigeonpea + foxtail millet (1:2) (0.220 and 0.225), pigeonpea + pearl millet (1:1) (0.219 and 0.216), pigeonpea + sorghum (1:2) (0.187 and 0.196) and pigeonpea + pearl millet (1:2) (0.184 and 0.190), respectively. Among the intercropped treatments, significantly lower leaf area index was recorded with pigeonpea + pearlmillet (1:2) when compared to pigeonpea + foxtail millet (1:1), pigeonpea + sorghum (1:1), (pigeonpea + foxtail millet (1:2) and pigeonpea + pearl millet (1:1) but was found on par with pigeonpea + sorghum (1:2). Pooled data also followed the similar trend.

With advancement in growth of pigeonpea and the intercrops, pigeonpea leaf area index was significantly influenced. At 60 DAS, significantly lower leaf area index was recorded with pigeonpea + pearlmillet (1:2) (0.469 and 0.483, respectively) during both the years when compared to other intercropped treatments but was found on par with the pigeonpea + sorghum (1:2) (0.483 and 0.495, respectively). During both the years sole pigeonpea (0.690 and 0.722, respectively) recorded significantly higher leaf index over the intercropped treatments.

Table 11. Leaf area index of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Leaf area index														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	0.229	0.233	0.231	0.529	0.556	0.543	0.994	1.034	1.014	0.811	0.841	0.826	0.436	0.466	0.451
T_2	0.219	0.216	0.218	0.514	0.535	0.525	0.963	1.003	0.983	0.764	0.798	0.781	0.392	0.416	0.404
T_3	0.234	0.242	0.238	0.560	0.589	0.575	1.057	1.100	1.079	0.843	0.870	0.857	0.445	0.489	0.467
T_4	0.187	0.196	0.192	0.483	0.495	0.489	0.904	0.961	0.933	0.690	0.725	0.707	0.310	0.335	0.323
T_5	0.184	0.190	0.187	0.469	0.483	0.476	0.881	0.923	0.902	0.651	0.692	0.672	0.290	0.313	0.302
T_6	0.220	0.225	0.223	0.521	0.547	0.534	0.971	1.019	0.995	0.784	0.830	0.807	0.405	0.442	0.424
T_7	0.267	0.286	0.277	0.690	0.722	0.706	1.353	1.416	1.385	1.226	1.283	1.255	0.661	0.707	0.684
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.011	0.009	0.011	0.015	0.017	0.016	0.028	0.026	0.026	0.037	0.046	0.039	0.026	0.030	0.024
C.D. (P=0.05)	0.031	0.025	0.030	0.042	0.048	0.045	0.081	0.078	0.080	0.109	0.134	0.118	0.074	0.089	0.070

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

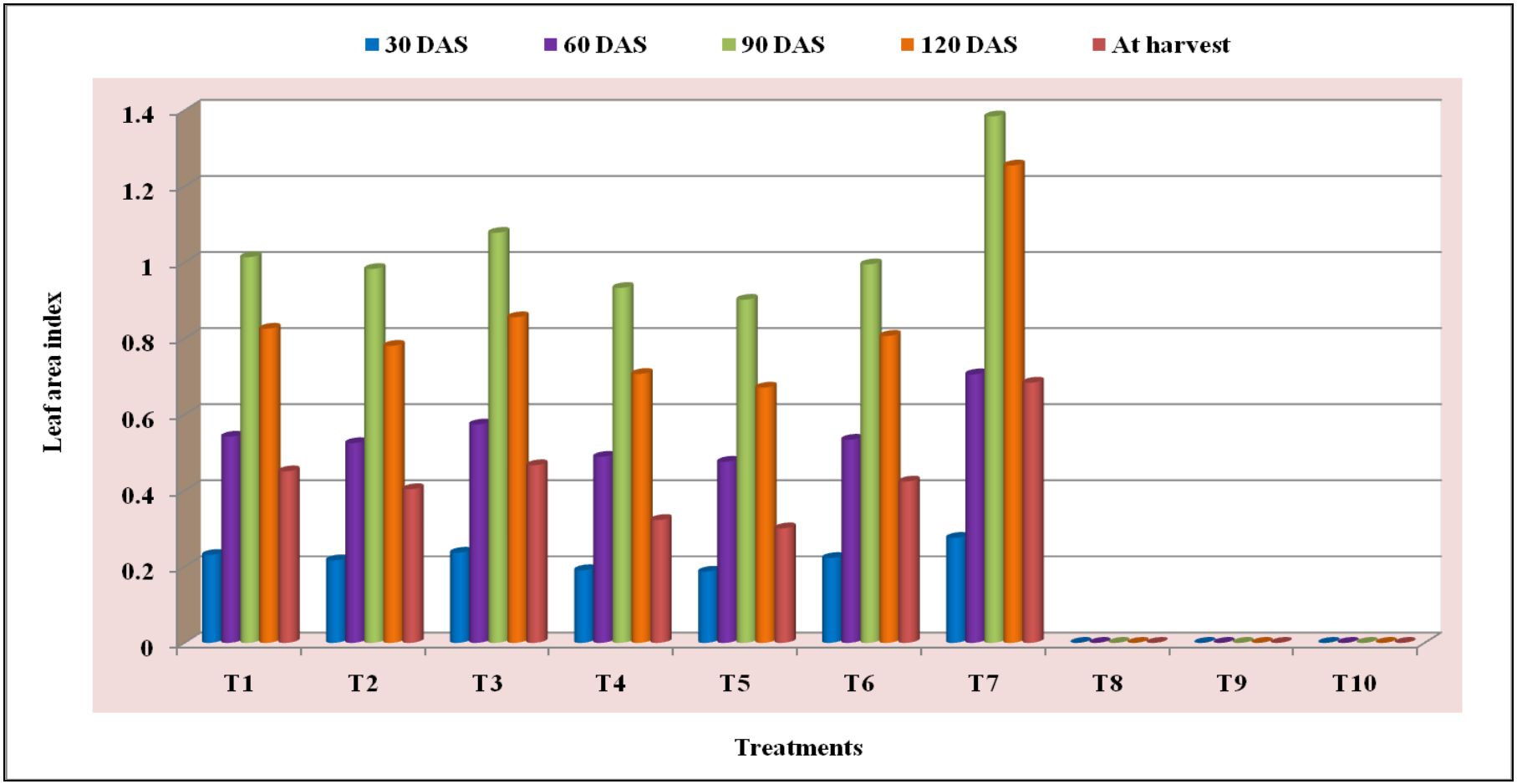

Fig. 6. Leaf area index of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

At 90 DAS, during both the years on par leaf area index was recorded among intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (1.057 and 1.100), pigeonpea + sorghum (1:1) (0.994 and 1.034), pigeonpea + foxtail millet (1:2) (0.971 and 1.019) and pigeonpea + pearl millet (1:1) (0.963 and 1.003), respectively and were significantly lower when compared to sole pigeonpea. Similar trend was followed at 120 DAS and at harvest. The pooled mean also revealed the similar trend at all the stages of crop growth.

4.1.1.7 Dry matter accumulation in leaves (g plant^{-1})

The results indicated that dry matter accumulation in leaves of pigeonpea per plant was significantly influenced due to intercropping with nutri-cereal crops at different row proportion at all the crop growth stages (30, 60, 90, 120 DAS and at harvest) as presented in Table 12.

At 30 DAS, during both the years (2015 and 2016), sole pigeonpea (3.94 and 4.52 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in leaves per plant when compared to intercropped treatments. Among the intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (3.22 and 3.42, g plant^{-1} respectively), pigeonpea + sorghum (1:1) (3.12 and 3.24, g plant^{-1} respectively), pigeonpea + foxtail millet (1:2) (2.93 and 3.10 g plant^{-1}, respectively) and pigeonpea + pearl millet (1:1) (2.77 and 2.91, g plant^{-1} respectively) recorded on par dry matter accumulation in leaves and were significantly higher when compared to pigeonpea + pearl millet (1:2) (2.24 and 2.37 g plant^{-1}, respectively) and pigeonpea + sorghum (1:2) (2.24 and 2.37 g plant^{-1}, respectively) which were on par with each other.

With advancement in growth of pigeonpea with intercrops, dry matter accumulation in leaves per plant were varied and significantly influenced. At 60 DAS, among the different intercropped treatments, pigeonpea + foxtail millet (1:1) (5.67 and 6.01 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in leaves per plant and it was found on par with pigeonpea + sorghum (1:1) (5.36 and 5.78 g plant^{-1}, respectively), pigeonpea + foxtail millet (1:2) (5.12 and 5.50 g plant^{-1}, respectively) and pigeonpea + pearl millet (1:1) (4.87 and 5.31 g plant^{-1}, respectively) during both the years.

At 90 DAS, pooled data revealed that sole pigeonpea (18.02 g plant^{-1}) recorded significantly higher dry matter accumulation in leaves per plant over the intercropped

Table 12. Dry matter accumulation in leaves of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter accumulation in leaves (g plant^{-1})														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	3.12	3.24	3.18	5.36	5.78	5.57	13.83	14.35	14.09	10.86	11.17	11.01	5.86	6.19	6.02
T_2	2.77	2.91	2.84	4.87	5.31	5.09	12.62	13.25	12.94	10.24	10.51	10.38	5.27	5.60	5.44
T_3	3.22	3.42	3.32	5.67	6.01	5.84	14.19	14.57	14.38	11.24	11.63	11.44	6.20	6.55	6.38
T_4	2.49	2.62	2.56	4.22	4.69	4.46	11.34	12.02	11.68	8.64	8.92	8.78	4.26	4.66	4.46
T_5	2.24	2.37	2.30	3.91	4.30	4.10	10.81	11.52	11.17	8.15	8.48	8.32	3.76	4.13	3.94
T_6	2.93	3.10	3.02	5.12	5.50	5.31	13.12	13.71	13.41	10.48	10.91	10.70	5.51	5.93	5.72
T_7	3.94	4.52	4.23	7.15	7.55	7.35	17.62	18.43	18.02	14.46	14.81	14.64	8.11	8.62	8.37
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.22	0.24	0.22	0.33	0.37	0.33	0.52	0.47	0.48	0.35	0.42	0.36	0.32	0.38	0.33
C.D. (P=0.05)	0.71	0.77	0.70	1.06	1.19	1.06	1.66	1.52	1.55	1.11	1.36	1.16	1.04	1.22	1.06

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

treatments. However, among intercropped treatments, pigeonpea + foxtail millet (1:1) recorded significantly higher dry matter accumulation in leaves per plant (14.38 g plant^{-1}) and it was found on par with pigeonpea + sorghum (1:1) (14.09 g plant^{-1}), pigeonpea + foxtail (1:2) (13.41 g plant^{-1}) and pigeonpea + pearl millet (1:1) (12.94 g plant^{-1}). Whereas significantly lower dry matter accumulation in leaves per plant were observed in pigeonpea with pearl millet (1:2) (11.17 g plant^{-1}) and pigeonpea with sorghum (1:2) (11.68 g plant^{-1}) over the other intercropped treatments and were on par with each other.

At 120 DAS and harvest, the pooled data revealed that sole pigeopea recorded significantly higher dry matter accumulation in leaves per plant (14.64 and 8.37 g plant^{-1}, respectively) over the intercropped treatments. However, significantly lower dry matter accumulation in leaves per plant was recorded under pigeonpea + pearl millet (1:2) (8.32 and 3.94 g plant^{-1}) and pigeonpea + sorghum (1:2) (8.78 and 4.46 g plant^{-1}), respectively over other intercropped treatments and were at par with each other.

4.1.1.8 Dry matter accumulation in stem (g plant^{-1})

The data pertaining to dry matter accumulation in stem (g plant^{-1}) of pigeonpea as influenced by different intercrops and their row numbers at different growth stages (30, 60, 90, 120 DAS and at harvest) are presented in Table 13 and depicted in Fig.

At 30 DAS, during both the years (2015 and 2016), sole pigeonpea (4.17 and 4.37, g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem over intercropped treatments. Among intercropped treatments, pigeonpea + foxtail millet (1:1) (3.07 and 3.35 g plant^{-1}), pigeonpea + sorghum (1:1) (2.92 and 3.11 g plant^{-1}), pigeonpea + foxtail millet (1:2) (2.84 and 3.02 g plant^{-1}) and pigeonpea + pearl millet (1:1) (2.70 and 2.85 g plant^{-1}), respectively recorded significantly higher dry matter accumulation in stem over other intercropped treatments and were at par with one another. However during both the years (2015 and 2016), significantly lower dry matter accumulation in stem was recorded with pigeonpea + pearl millet (1:2) (2.32 and 2.45 g plant^{-1}, respectively) over other intercropped treatments but it was on par with pigeonpea + sorghum (1:2) (2.47 and 2.61 g plant^{-1}, respectively).

At 60 DAS, significantly lower dry matter accumulation in stem was recorded under pigeonpea + pearlmillet (1:2) (12.24 and 12.69 g plant^{-1}, respectively) during both the years when compared to remaining intercropped treatments but was found on par with

Table 13. Dry matter accumulation in stem of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter accumulation in stem (g plant^{-1})														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	2.92	3.11	3.02	14.92	15.37	15.14	37.92	38.76	38.34	47.81	49.37	48.59	83.85	85.64	84.75
T_2	2.70	2.85	2.78	13.94	14.38	14.16	35.97	37.21	36.59	46.23	47.63	46.93	81.28	83.55	82.42
T_3	3.07	3.35	3.21	15.35	15.73	15.54	38.43	39.24	38.83	49.21	51.35	50.28	85.23	87.05	86.14
T_4	2.47	2.61	2.54	12.79	13.35	13.07	34.04	35.31	34.68	43.24	44.95	44.10	77.62	79.26	78.44
T_5	2.32	2.45	2.38	12.24	12.69	12.47	33.98	34.81	34.40	42.17	43.63	42.90	75.04	77.59	76.32
T_6	2.84	3.02	2.93	14.48	14.88	14.68	37.17	38.05	37.61	47.23	48.49	47.86	82.81	84.71	83.76
T_7	4.17	4.37	4.27	18.71	19.45	19.08	46.62	48.05	47.34	66.91	68.36	67.63	108.09	110.48	109.29
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.18	0.18	0.17	0.65	0.72	0.67	1.15	1.06	1.07	1.54	1.65	1.54	2.08	1.81	1.79
C.D. (P=0.05)	0.57	0.59	0.55	2.07	2.30	2.15	3.69	3.38	3.42	4.93	5.29	4.93	6.65	5.79	5.74

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

the pigeonpea + sorghum (1:2) (12.79 and 13.35 g plant^{-1}, respectively). During both years, sole pigeonpea (18.71 and 19.45 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem over intercropped treatments.

At 90 DAS, pooled data showed that pigeonpea + foxtail millet (1:1) (38.83 g plant^{-1}) recorded significantly higher dry matter accumulation in stem when compared to pigeonpea + sorghum (1:1) (38.34 g plant^{-1}), pigeonpea + foxtail millet (1:2) (37.61 g plant^{-1}) and pigeonpea + pearl millet (1:1) (36.59 g plant^{-1}) over other intercropped treatments, and were on par with one another. However, significantly lower dry matter accumulation in stem was recorded with pigeonpea + pearl millet (1:2) (34.40 g plant^{-1}) which was on par with pigeonpea + sorghum (1:2) (34.68 g plant^{-1}).

At 120 DAS and harvest, the pooled data revealed that sole pigeopea recorded significantly higher dry matter accumulation in stem per plant (67.63 and 109.29 g plant^{-1}, respectively) over intercropped treatments. Among intercropped treatments, significantly lower dry matter accumulation in stem was recorded with pigeonpea + pearl millet (1:2) (42.90 and 76.32 g plant^{-1}) and pigeonpea + sorghum (1:2) (44.10 and 78.44 g plant^{-1}), respectively over other intercropped treatments and were on par with each other.

4.1.1.9 Dry matter accumulation in reproductive parts (g plant^{-1})

The data concerned to dry matter accumulation in reproductive parts per plant of pigeonpea at different stages of crop growth (90, 120 DAS and at harvest) are presented in Table 14. The results indicated that the dry matter accumulation in reproductive parts per plant of pigeonpea was significantly influenced due to different component crops irrespective of row proportion under intercropping.

At 90 DAS, during both the years (2015 and 2016), sole pigeonpea (6.04 and 6.96 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in reproductive parts per plant over intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (4.45 and 4.85 g plant^{-1}), pigeonpea + sorghum (1:1) (4.04 and 4.37 g plant^{-1}), pigeonpea + foxtail millet (1:2) (3.91 and 4.20 g plant^{-1}) and pigeonpea + pearl millet (1:1) (3.61 and 3.94 g plant^{-1}), respectively recorded significantly higher dry matter accumulation in reproductive parts over other intercropped treatments and were on par with one another. However, during both the years, among the intercropped treatments significantly lower dry matter accumulation in reproductive parts

Table 14. Dry matter accumulation in reproductive parts of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter accumulation in reproductive parts (g plant^{-1})								
	90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	4.04	4.37	4.20	15.53	16.41	15.97	24.38	26.02	25.20
T_2	3.61	3.94	3.77	14.72	15.34	15.03	23.24	24.87	24.06
T_3	4.45	4.85	4.65	16.35	17.05	16.70	25.75	27.26	26.50
T_4	3.02	3.35	3.18	13.89	14.60	14.25	22.06	23.57	22.81
T_5	2.69	2.95	2.82	12.87	14.13	13.50	21.21	22.47	21.84
T_6	3.91	4.20	4.05	15.14	16.07	15.61	23.85	25.36	24.61
T_7	6.04	6.96	6.50	19.39	20.59	19.99	30.36	32.01	31.19
T_8	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-
S. Em.±	0.35	0.39	0.33	0.49	0.73	0.58	0.86	0.92	0.84
C.D. (P=0.05)	1.11	1.25	1.07	1.56	2.34	1.84	2.76	2.95	2.70

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

per plant was recorded with pigeonpea + pearl millet (1:2) (2.69 and 2.95 g plant^{-1}, respectively) over other treatments and it was on par with pigeonpea + sorghum (1:2) (3.02 and 3.35 g plant^{-1}, respectively). Similar trend was followed at 120 DAS and harvest during both the years.

At all the stages (90, 120 DAS and harvest), pooled data revealed that significantly higher dry matter accumulation in reproductive parts was recorded under sole pigeonpea (5.50, 19.99 and 31.19 g plant^{-1}, respectively) over intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (4.65, 16.70 and 26.50 g plant^{-1}), pigeonpea + sorghum (1:1) (4.20, 15.97 and 25.20 g plant^{-1}), pigeonpea + foxtail millet (1:2) (4.05, 15.61 and 24.61 g plant^{-1}), pigeonpea + pearl millet (1:1) (3.77, 15.03 and 24.06 g plant^{-1}), pigeonpea with pearl millet (1:2) (2.82, 13.50 and 21.84 g plant^{-1}) and pigeonpea with sorghum (1:2) (3.18, 14.25 and 22.81 g plant^{-1}) , respectively. Among the intercropped treatments, pigeonpea + foxtail millet (1:1), pigeonpea + sorghum (1:1), pigeonpea + foxtail millet (1:2) and pigeonpea + pearl millet (1:1) recorded significantly higher dry matter accumulation in reproductive parts per plant when compared to pigeonpea + pearl millet (1:2) and pigeonpea + sorghum (1:2) and were on par with one another.

4.1.1.10 Dry matter production (g plant^{-1})

The results revealed that the dry matter production of pigeonpea was significantly influenced due to intercropping with nutri-cereal crops with different row ratios at all the stages of crop growth as presented in Table 15 fig 7.

During both the years (2015 and 2016), at 30 DAS, significantly higher dry matter production per plant was recorded with sole pigeonpea (8.11 and 8.89 g plant^{-1}, respectively) over the intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (6.29 and 6.77 g plant^{-1}), pigeonpea + sorghum (1:1) (6.04 and 6.35 g plant^{-1}), (pigeonpea + foxtail millet (1:2) (5.77 and 6.13 g plant^{-1}) and pigeonpea + pearl millet (1:1) (5.48 and 5.76 g plant^{-1}), respectively recorded on par dry matter production per plant among one another and were significantly higher when compared to pigeonpea + pearlmillet (1:2) (4.56 and 4.81 g plant^{-1}) and pigeonpea + sorghum (1:2) (4.95 and 5.23 g plant^{-1}), respectively which were on par with each other.

Table 15. Dry matter production of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter production (g plant^{-1})														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	6.04	6.35	6.20	20.28	21.14	20.71	55.79	57.48	56.63	74.20	77.62	75.91	114.08	117.86	115.97
T_2	5.48	5.76	5.62	18.81	19.69	19.25	52.19	54.52	53.36	71.19	73.47	72.46	109.78	114.36	112.07
T_3	6.29	6.77	6.53	21.02	21.73	21.38	57.07	58.65	57.86	76.80	80.03	78.42	117.19	120.85	119.02
T_4	4.95	5.23	5.09	17.01	18.04	17.53	48.40	50.69	49.54	65.77	68.47	67.12	103.94	107.49	105.71
T_5	4.56	4.81	4.69	16.15	16.99	16.57	47.48	49.29	48.38	63.19	66.24	64.72	100.00	104.19	102.10
T_6	5.77	6.13	5.95	19.60	20.39	19.99	54.19	55.95	55.07	72.85	75.47	74.16	112.17	116.04	114.11
T_7	8.11	8.89	8.50	25.86	27.00	26.43	70.27	72.45	71.36	100.76	103.76	102.26	146.57	151.11	148.84
T_8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	0.28	0.33	0.29	0.76	0.93	0.83	1.63	1.31	1.59	1.83	2.09	1.88	2.33	2.14	2.25
C.D. (P=0.05)	0.88	1.07	0.91	2.43	2.98	2.66	5.23	4.20	5.07	5.84	6.69	6.02	7.45	6.86	7.21

T_1 and T_4- Pigeonpea + sorghum (1:1 and 1:2), T_2 and T_5- Pigeonpea + pearl millet (1:1 and 1:2), T_3 and T_6- Pigeonpea + foxtail millet (1:1 and 1:2) and T_7, T_8, T_9 and T_{10}- Respective sole crops of Pigeonpea (90 ×30cm), Sorghum (45 cm × 15 cm), Pearl millet (45 cm × 15 cm) and Foxtail millet (30 cm × 10 cm).

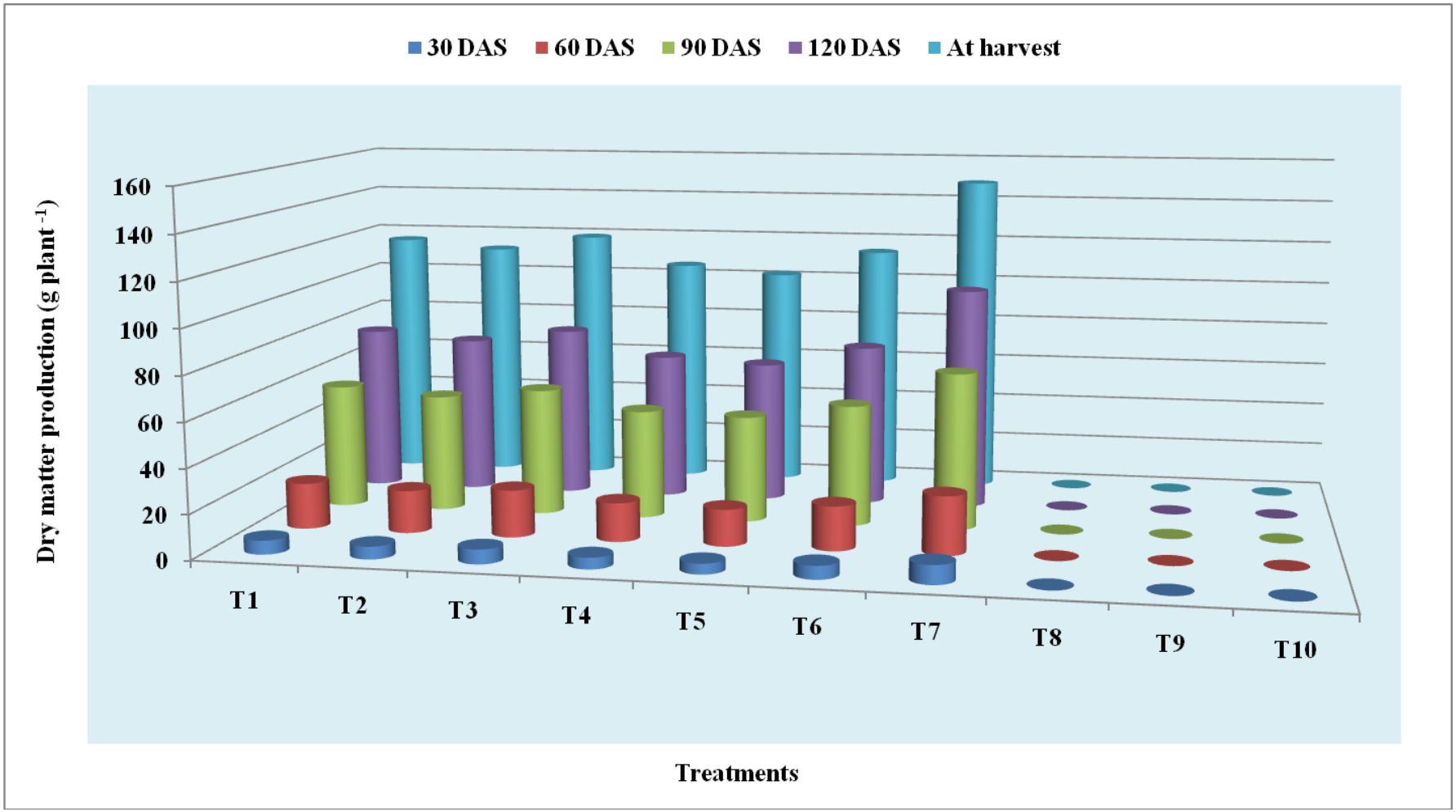

Fig. 7. Dry matter production of pigeonpea at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

At 60 DAS, significantly lower dry matter production per plant was recorded with pigeonpea + pearlmillet (1:2) (16.15 and 16.99 g plant^{-1}, respectively) during both the years when compared to other intercropped treatments but was found on par with the pigeonpea + sorghum (1:2) (17.01 and 18.04 g plant^{-1}, respectively). During both the years sole pigeonpea (25.86 and 27.00 g plant^{-1}, respectively) recorded significantly higher dry matter production per plant over the intercropped treatments.

At 90 DAS, during both the years on par dry matter production was recorded among intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (57.07 and 58.65 g plant^{-1}), pigeonpea + sorghum (1:1) (55.79 and 57.48 g plant^{-1}), pigeonpea + foxtail millet (1:2) (54.19 and 55.95 g plant^{-1}) and pigeonpea + pearl millet (1:1) (52.19 and 54.52 g plant^{-1}), respectively and were significantly lower when compared to sole pigeonpea. Similar trend was followed at 120 DAS and harvest. The pooled mean also revealed the similar trend at all the stages of crop growth.

4.1.2 Yield components and yield of pigeonpea

4.1.2.1 Number of pods per plant

The data concerned to number of pods per plant of pigeonpea are presented in Table 16 and fig 8. The results indicated that the number of pods per plant of pigeonpea was significantly influenced due to different component crops irrespective of row proportion under intercropping.

During both the years (2015 and 2016), sole pigeonpea (101.73 and 105.23, respectively) recorded significantly higher number of pods per plant over the intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (88.70 and 89.66), pigeonpea + sorghum (1:1) (85.50 and 87.32), pigeonpea + foxtail millet (1:2) (83.99 and 84.77) and pigeonpea + pearl millet (1:1) (81.14 and 83.40), respectively recorded significantly higher number of pods per plant over other intercropped treatments and were on par with one another. However, during both the years, among the intercropped treatments, significantly lower number of pods per plant was recorded with pigeonpea + pearl millet (1:2) (76.97 and 79.89, respectively) over other treatments and it was on par with pigeonpea + sorghum (1:2) (78.96 and 82.51, respectively).

Pooled data revealed that significantly higher number of pods per plant was recorded under sole pigeonpea (103.48) over intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (89.18), pigeonpea + sorghum (1:1) (86.41), pigeonpea + foxtail millet (1:2) (84.38), pigeonpea + pearl millet (1:1) (82.27), pigeonpea + sorghum (1:2) (80.74) and pigeonpea + pearl millet (1:2) (78.43). Among intercropped treatments, significantly lower number of pods per plant was recorded under pigeonpea with pearl millet (1:2) and pigeonpea with sorghum (1:2) when compared to other treatments and were on par with each other.

4.1.2.2 Number of seeds per pod

The data on number of seeds per pod of pigeonpea are presented in the Table 16 and Fig. The number of seeds per pod of pigeonpea did not differ significantly due to intercropping of pigeonpea with different crops in varying row proportions.

4.1.2.3 Seed yield per plant (g)

The data concerned to seed weight per plant of pigeonpea are presented in Table 16 and fig 8. The results indicated that the seed yield per plant of pigeonpea was significantly influenced due to different component crops irrespective of row proportion under intercropping.

During both the years (2015 and 2016), sole pigeonpea (34.48 and 37.15, g plant^{-1}, respectively) recorded significantly higher seed yield per plant over intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (26.04 and 27.49 g plant^{-1}), pigeonpea + sorghum (1:1) (23.81 and 25.37 g plant^{-1}), pigeonpea + foxtail millet (1:2) (22.49 and 23.92 g plant^{-1}) and pigeonpea + pearl millet (1:1) (21.44 and 22.51 g plant^{-1}), respectively recorded significantly higher seed yield per plant over other intercropped treatments *viz*., pigeonpea + pearl millet (1:2) (19.59 and 20.52 g plant^{-1}, respectively) and pigeonpea + sorghum (1:2) (20.43 and 22.13 g plant^{-1}, respectively) which were on par with each other.

Pooled data revealed that significantly higher seed yield per plant was recorded under sole pigeonpea (35.82 g plant^{-1}) over intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (26.76 g plant^{-1}), pigeonpea + sorghum (1:1) (24.59 g plant^{-1}), pigeonpea + foxtail millet (1:2) (23.20 g plant^{-1}), pigeonpea + pearl millet (1:1) (21.86 g plant^{-1}), pigeonpea + sorghum (1:2) (21.28 g plant^{-1}) and pigeonpea + pearl millet (1:2)

Table 16. Number of pods plant^{-1}, number of seeds pod^{-1}, seed yield plant^{-1} and hundred seed weight of pigeonpea as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Number of pods plant^{-1}			Number of seeds pod^{-1}			Seed yield plant^{-1} (g)			100 seed weight (g)		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
T_1 -Pigeonpea + sorghum (1:1)	85.50	87.32	86.41	3.29	3.36	3.36	23.81	25.37	24.59	10.92	11.04	10.98
T_2 -Pigeonpea + pearl millet (1:1)	81.14	83.40	82.27	3.22	3.30	3.26	21.44	22.51	21.86	10.49	10.62	10.55
T_3-Pigeonpea + foxtail millet (1:1)	88.70	89.66	89.18	3.32	3.40	3.36	26.03	27.49	26.76	11.08	11.37	11.22
T_4 -Pigeonpea + sorghum (1:2)	78.96	82.51	80.74	3.21	3.26	3.24	20.43	22.13	21.28	10.59	10.80	10.70
T_5-Pigeonpea + pearl millet (1:2)	76.97	79.89	78.43	3.16	3.25	3.21	19.59	20.52	20.05	10.29	10.37	10.33
T_6-Pigeonpea + foxtail millet (1:2)	83.99	84.77	84.38	3.26	3.35	3.31	22.49	23.92	23.20	10.78	10.97	10.87
T_7 -Sole pigeonpea (90 cm × 30 cm)	101.73	105.22	103.48	3.50	3.63	3.57	34.48	37.15	35.82	11.62	11.86	11.74
T_8 -Sole sorghum (45 cm × 15 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_9-Sole pearl millet (45cm × 15 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}-Sole foxtail millet (30 cm × 10 cm)	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	2.99	2.84	2.57	0.19	0.21	0.20	1.72	1.57	1.57	0.54	0.58	0.56
C.D. (P=0.05)	9.57	9.10	8.22	NS	NS	NS	5.50	5.04	5.03	NS	NS	NS

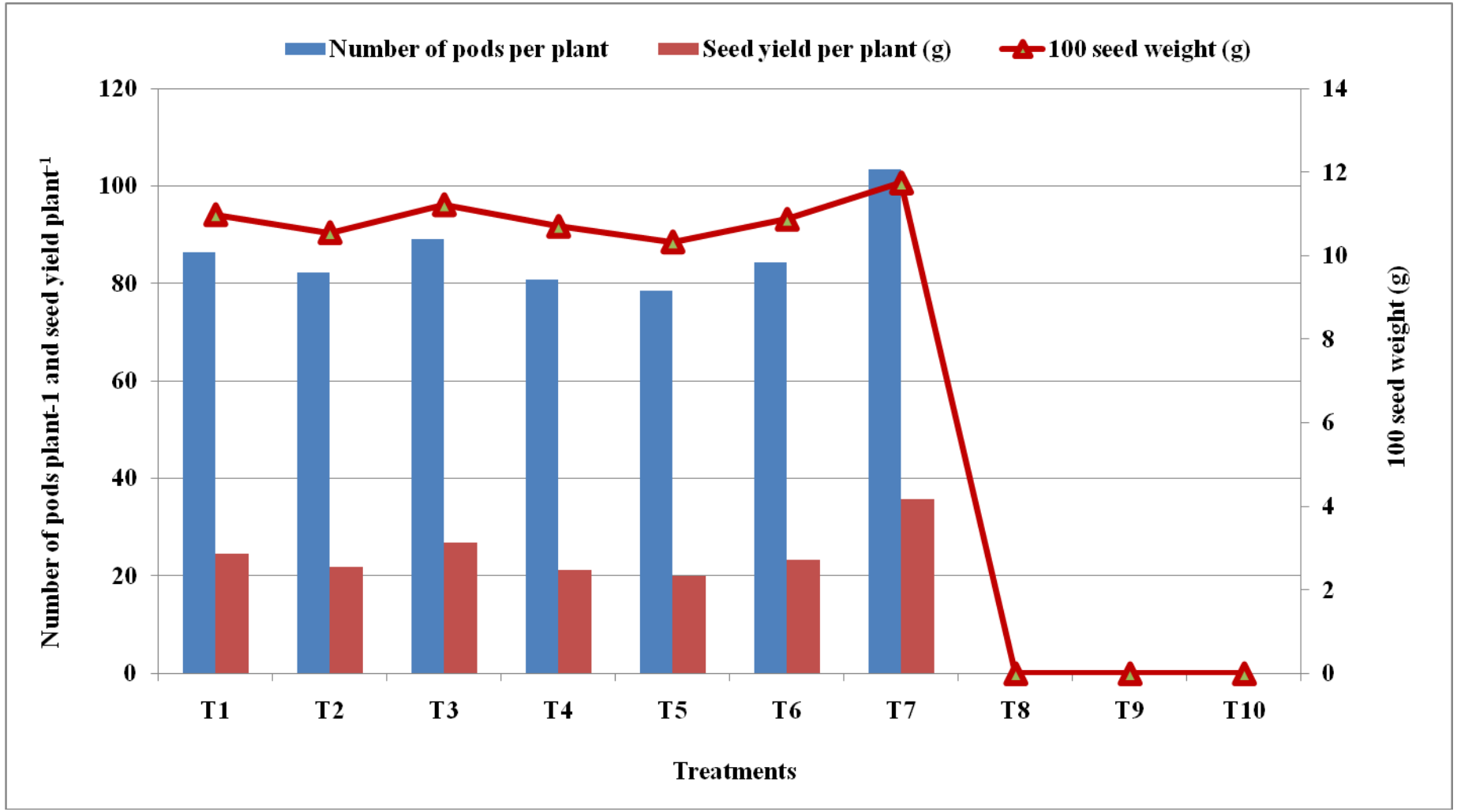

Fig. 8. Number of pods plant^{-1}, seed yield per plant^{-1} and hundred seed weight of pigeonpea as influenced by varying row proportion in intercropping systems under rainfed condition

(20.05 g plant^{-1}). Among the intercropped treatments, pigeonpea + foxtail millet (1:1), pigeonpea + sorghum (1:1), pigeonpea + foxtail millet (1:2) and pigeonpea + pearl millet (1:1) recorded significantly higher seed yield per plant over pigeonpea + sorghum (1:2) and pigeonpea + pearl millet (1:2) which were on par with each other.

4.1.2.4 Hundred seed weight (g)

The data on hundred seed weight of pigeonpea are presented in the Table 16 and and fig 8**.** The hundred seed weight of pigeonpea did not differ significantly due to intercropping of pigeonpea with nutri-cereal crops in varying row proportion.

Pooled data showed that sole pigeonpea (11.74 g) recorded numerically higher hundred seed weight followed by pigeonpea + foxtail millet (1:1) (11.22 g), pigeonpea + sorghum (1:1) (10.98 g), pigeonpea + foxtail millet (1:2), (10.87 g), pigeonpea + pearl millet (1:1) (10.55 g), pigeonpea + sorghum (1:2) (10.70 g) and pigeonpea + pearl millet (1:2) (10.33 g).

4.1.2.5 Seed yield (kg ha^{-1})

The data concerned to seed yield of pigeonpea are presented in Table 17 and fig 9. The results indicated that the seed yield of pigeonpea was significantly influenced due to different component crops irrespective of row proportion under intercropping.

During both the years (2015 and 2016), sole pigeonpea (1302 and 1419 kg ha^{-1}, respectively) recorded significantly higher seed yield over intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (964 and 1017 kg ha^{-1}, respectively), pigeonpea + sorghum (1:1) (889 and 930 kg ha^{-1}, respectively), pigeonpea + foxtail millet (1:2) (834 and 861 kg ha^{-1}, respectively) and pearl millet (1:1) (788 and 836 kg ha^{-1}, respectively) recorded significantly higher seed yield over other treatments *viz*., pigeonpea + pearl millet (1:2) (717 and 751 kg ha^{-1}, respectively) and pigeonpea + sorghum (1:2) (771 and 832 kg ha^{-1}, respectively) and were on par with one another. However, the treatments *viz*., pigeonpea + pearl millet (1:2) and pigeonpea + sorghum (1:2) were on par with each other.

Pooled data indicated that significantly higher seed yield of pigeonpea was recorded under sole pigeonpea (1360 kg ha^{-1}) over intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (991 kg ha^{-1}), pigeonpea + sorghum (1:1) (909 kg ha^{-1}),

pigeonpea + foxtail millet (1:2) (847 kg ha^{-1}) and pigeonpea + pearl millet (1:1) (813 kg ha^{-1}) which were at par with one another and recorded significantly higher seed yield of pigeonpea when compared to pigeonpea with pearl millet (1:2) (734 kg ha^{-1}) and pigeonpea with sorghum (1:2) (810 kg ha^{-1}) which were on par with each other.

4.1.2.6 Stalk yield (kg ha^{-1})

The data on stalk yield (kg ha^{-1}) of pigeonpea are presented in the Table 17 and Fig 9. The stalk yield of pigeonpea differed significantly due to intercropping with different crops under different row proportions.

During both the years (2015 and 2016), at 30 DAS, significantly higher stalk yield of pigeonpea was recorded with sole pigeonpea (2751 and 2925 kg ha^{-1}, respectively) over the intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (2484 and 2610 kg ha^{-1}, respectively) recorded on par stalk yield with pigeonpea + sorghum (1:1) (2351 and 2509 kg ha^{-1}, respectively), pigeonpea + foxtail millet (1:2) (2238 and 2451 kg ha^{-1}, respectively) and pigeonpea + pearl millet (1:1) (2246 and 2359 kg ha^{-1}, respectively) and significantly higher stalk yield over pigeonpea + pearlmillet (1:2) (1924 and 2062 kg ha^{-1}, respectively) which was found on par with pigeonpea + sorghum (1:2) (2115 and 2264 kg ha^{-1}, respectively). Pooled mean revealed that the sole pigeonpea (2838 kg ha^{-1}) recorded significantly higher stalk yield of pigeonpea over the intercropped treatments. However, among intercropping treatments, pigeonpea + foxtail millet (1:1) recorded significantly higher stalk yield of pigeonpea (2541 kg ha^{-1}) and it was found on par with pigeonpea + sorghum (1:1) (2430 kg ha^{-1}), pigeonpea + foxtail (1:2) (2327 kg ha^{-1}) and pigeonpea + pearl millet (1:1) (2285 kg ha^{-1}). Whereas significantly lower stalk yield of pigeonpea was observed in pigeonpea with pearl millet (1:2) (1993 kg ha^{-1}) and it was on par with pigeonpea with sorghum (1:2) (2189 kg ha^{-1}).

4.1.2.7 Husk yield (kg ha^{-1})

The data pertaining to husk yield (kg ha^{-1}) of pigeonpea are presented in the Table 17 and fig 9. The husk yield of pigeonpea differed significantly due to intercropping with different crops in varying row proportion.

During both the years, significantly higher husk yield was recorded with sole pigeonpea (959 and 1021 kg ha^{-1}, respectively) over intercropped treatments. Among the

Table 17. Seed yield, stalk yield, husk yield and harvest index of pigeonpea as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Seed yield (kg ha^{-1})			Stalk yield (kg ha^{-1})			Husk yield (kg ha^{-1})			Harvest index		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	889	930	909	2351	2509	2430	728	790	748	0.223	0.219	0.221
T_2 -Pigeonpea + pearl millet (1:1)	788	836	813	2246	2359	2285	672	706	689	0.214	0.214	0.214
T_3-Pigeonpea + foxtail millet (1:1)	964	1017	991	2484	2610	2541	807	863	835	0.226	0.223	0.225
T_4 -Pigeonpea + sorghum (1:2)	771	832	810	2115	2264	2189	676	703	690	0.220	0.221	0.220
T_5-Pigeonpea + pearl millet (1:2)	717	751	734	1924	2062	1993	597	631	614	0.221	0.217	0.219
T_6-Pigeonpea + foxtail millet (1:2)	834	861	847	2238	2415	2327	716	756	736	0.219	0.213	0.216
T_7 -Sole pigeonpea (90 cm × 30 cm)	1302	1419	1360	2751	2925	2838	959	1021	990	0.260	0.264	0.262
T_8 -Sole sorghum (45 cm × 15 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_9-Sole pearl millet (45cm × 15 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_{10}-Sole foxtail millet (30 cm × 10 cm)	-	-	-	-	-	-	-	-	-	-	-	-
S. Em.±	60	57	56	78	97	92	33	38	46	0.01	0.01	0.01
C.D. (P=0.05)	191	183	179	250	312	295	106	122	140	NS	NS	NS

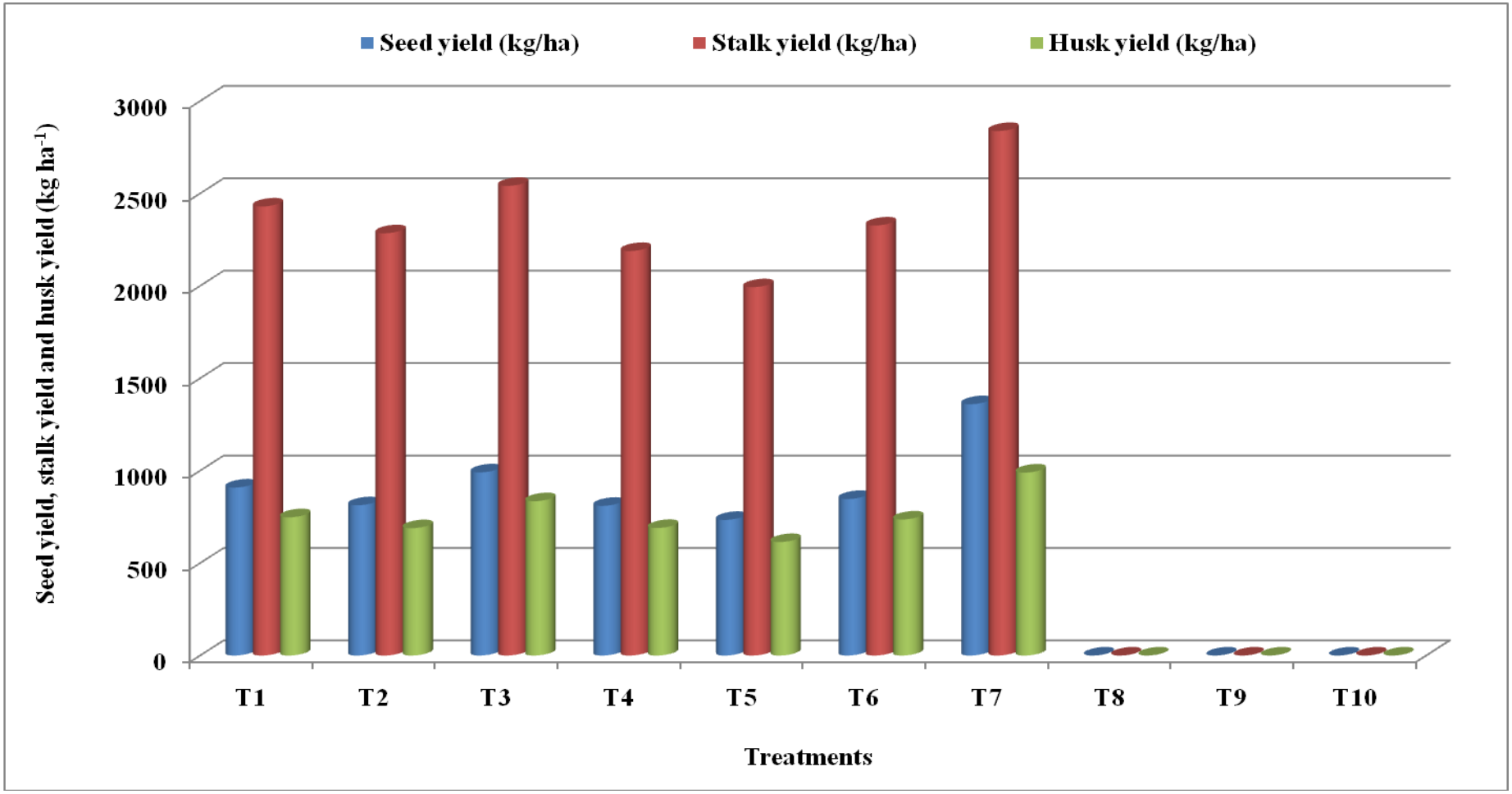

Fig. 9. Seed yield, stalk yield and husk yield of pigeonpea as influenced by varying row proportion in intercropping systems under rainfed condition

intercropped treatments, significantly lower husk yield during both the years (2015 and 2016) was noticed under pigeonpea + pearl millet (1:2) (597 and 631 kg ha^{-1}, respectively) over other intercropping treatments and was found on par with pigeonpea + sorghum (1:2) (676 and 703 kg ha^{-1}, respectively). However, the intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (807 and 863 kg ha^{-1}, respectively), pigeonpea + sorghum (1:1) (728 and 790 kg ha^{-1}, respectively), pigeonpea + foxtail millet (1:2) (716 and 756 kg ha^{-1}, respectively) and pigeonpea + pearl millet (1:1) (672 and 706 kg ha^{-1}, respectively) were on par with one another with respect to husk yield of pigeonpea. The pooled mean over two years revealed that sole pigeonpea (990 kg ha^{-1}) recorded significantly higher husk yield of pigeonpea over the intercropped treatments. However, among intercropping treatments, pigeonpea + foxtail millet (1:1) recorded significantly higher husk yield of pigeonpea (835 kg ha^{-1}) and it was found on par with pigeonpea + sorghum (1:1) (748 kg ha^{-1}), pigeonpea + foxtail (1:2) (736 kg ha^{-1}) and pigeonpea + pearl millet (1:1) (689 kg ha^{-1}). Whereas significantly lower husk yield of pigeonpea was observed in pigeonpea with pearl millet (1:2) (614 kg ha^{-1}) which was on par with pigeonpea with sorghum (1:2) (690 kg ha^{-1}).

4.1.2.8 Harvest index

The data pertaining to harvest index of pigeonpea are presented in the Table 17. The data revealed that harvest index of pigeonpea was non-significant due to intercropping of pigeonpea with various crops in different row proportion during both years and same trend was followed in pooled mean.

4.1.3 Estimation of nutritional quality of nutri-cereals

4.1.3.1 Nutritional status of seeds prior to sowing

Prior to sowing, zinc (Zn) and iron (Fe) content of seeds were analyzed for both main and intercrops and presented in (Appendix XI). Analyzed results revealed that nutrient concentration varied with seeds of both pigeonpea and intercrops *viz.*, sorghum, pearl millet and foxtail millet. Analyzed data indicated that higher Zn content was found with foxtail millet during both the years and in pooled data (38.21, 40.19 and 39.20 ppm) and lower Zn content was observed in sorghum (10.20, 11.45 and10.83 ppm) when compared to pearl millet (20.15, 23.45 and 21.80 ppm) and pigeonpea (16.49, 17.21 and 16.85 ppm), respectively.

Similarly during both the years *viz*., 2015 and 2016 and in pooled data, higher Fe content was recorded with pearl millet (621.05 627.56 and 624.31 ppm, respectively) and lower Fe content was recorded with pigeonpea (64.90 67.71 and 66.21 ppm, respectively) when compared to sorghum (69.51, 72.19 and 70.85, respectively) and foxtail millet (253.97, 256.17 and 255.07 ppm, respectively).

4.1.3.2 Nutritional status of the seeds after harvesting

Nutrient content of seeds was analyzed for pigeonpea and intercrops at harvest after subjected to agronomic manipulations like intercropping under different row proportions. Nutrient content of pigeonpea seeds due to intercropping of pigeonpea with different intercrops irrespective of the row proportion was not influenced significantly (Table 18). However, pooled data indicated numerically higher Zn and Fe content in pigeonpea seeds when grown as sole stand (18.40 ppm and 68.47 ppm, respectively) as compared to intercropped systems. Lowest Zn and Fe content was recorded in pigeonpea seeds when intercropped with pearl millet (1:2) (16.87 and 67.53 ppm, respectively) when compared to other intercropped treatments.

Nutrient content of intercrops after harvesting did not vary significantly due to intercropping with pigeonpea under varying row proportions. During both the years, the sole stand of each of the intercrops, recorded numerically higher Zn content *viz*., sole foxtail millet (39.54 and 41.98 ppm, respectively), sole pearl millet (20.83 and 24.65 ppm, respectively) and sole sorghum (10.89 and 12.13, respectively) when compared to respective intercropped treatments. The lower Zn content was recorded in sorghum under pigeonpea + sorghum intercropping (1:2) (11.73 and 11.17 ppm, respectively) when compared to other treatments.

Similarly sole stand of intercrops recorded significantly higher Fe content over respective intercropped treatments. Pooled results revealed that numerically higher Fe content was observed with sole crops of pearl millet (629.43 ppm), foxtail millet (259.43 ppm) and sorghum (72.14 ppm) compared to their intercropped treatments. Whereas, lower Fe content was recorded with sorghum under pigeonpea + sorghum (1:1) (71.50 ppm) when compared to other treatments.

Table 18. Estimated Zn and Fe content of pigeonpea and intercrops after harvest of seeds as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Pigeonpea						Intercrops					
	Zn (ppm)			Fe(ppm)			Zn (ppm)			Fe(ppm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	17.73	17.90	17.82	67.44	68.19	67.82	10.85	11.98	11.42	69.83	73.16	71.50
T_2 -Pigeonpea + pearl millet (1:1)	17.10	17.24	17.17	66.97	67.91	67.44	20.63	24.14	22.39	625.09	630.35	627.02
T_3-Pigeonpea + foxtail millet (1:1)	18.17	18.25	18.21	68.04	68.27	68.15	39.08	41.86	40.47	254.36	260.17	257.27
T_4 -Pigeonpea + sorghum (1:2)	16.89	16.95	16.92	66.58	67.76	67.17	10.61	11.73	11.17	70.31	72.43	71.37
T_5-Pigeonpea + pearl millet (1:2)	16.84	16.91	16.87	66.45	67.62	67.03	20.81	23.85	22.33	623.12	630.91	627.80
T_6-Pigeonpea + foxtail millet (1:2)	17.25	17.41	17.33	67.11	68.11	67.61	39.04	41.45	40.25	255.61	259.74	257.68
T_7 -Sole pigeonpea (90 cm × 30 cm)	18.34	18.46	18.40	68.30	68.64	68.47	-	-		-	-	
T_8 -Sole sorghum (45 cm × 15 cm)	-	-	-	-	-	-	10.89	12.13	11.51	70.56	73.71	72.14
T_9-Sole pearl millet (45cm × 15 cm)	-	-	-	-	-	-	20.83	24.65	22.74	627.76	631.09	629.43
T_{10}-Sole foxtail millet (30 cm × 10 cm)	-	-	-	-	-	-	39.54	41.98	40.76	257.47	260.89	259.18
S. Em.±	0.78	0.75	0.75	1.02	1.13	1.07	-	-	-	-	-	-
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	-	-	-	-	-	-

Table 19. Estimated Zn and Fe content of pigeonpea and intercrops after processing of seeds as influenced by varying row proportion in pigeonpea and nutricereals (1:1 and 1:2) in intercropping systems under rainfed condition

Treatments	Pigeonpea						Intercrops					
	Zn (ppm)			Fe (ppm)			Zn (ppm)			Fe (ppm)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	17.61	17.65	17.63	67.29	67.91	67.60	10.63	11.87	11.25	69.87	72.76	71.31
T_2 -Pigeonpea + pearl millet (1:1)	17.01	17.13	17.07	66.84	67.61	67.22	20.52	23.82	22.17	622.65	628.45	625.55
T_3-Pigeonpea + foxtail millet (1:1)	18.05	18.14	18.09	67.89	67.97	67.93	39.01	40.76	39.88	253.76	256.83	255.29
T_4 -Pigeonpea + sorghum (1:2)	16.63	16.71	16.67	66.43	66.51	66.47	10.39	11.52	10.95	69.56	72.52	71.04
T_5-Pigeonpea + pearl millet (1:2)	16.56	16.67	16.62	66.35	66.45	66.40	20.41	23.59	22.00	621.45	628.12	624.78
T_6-Pigeonpea + foxtail millet (1:2)	17.09	17.24	17.17	66.95	67.76	67.35	38.94	40.51	39.72	252.61	256.44	254.52
T_7 -Sole pigeonpea (90 cm × 30 cm)	18.21	18.29	18.25	68.13	68.41	68.27	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	-	-	-	-	-	-	10.78	12.21	11.49	70.12	72.95	71.53
T_9-Sole pearl millet (45cm × 15 cm)	-	-	-	-	-	-	20.67	24.01	22.34	625.86	628.65	627.25
T_{10}-Sole foxtail millet (30 cm × 10 cm)	-	-	-	-	-	-	39.31	40.95	40.13	255.27	256.95	256.11
S. Em.±	0.73	0.71	0.68	1.08	1.18	1.11	-	-	-	-	-	-
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	-	-	-	-	-	-

4.1.3.3 Nutritional status of the seeds after processing

Nutrient content of processed seeds (pigeonpea and intercrops) did not differ significantly when pigeonpea was intercropped with different nutri-cereal crops under varying row proportions when compared with respective sole crops during both the years and in pooled mean (Table 19). However, pooled mean revealed that higher Zn and Fe content of pigeonpea seeds was recorded with sole pigeonpea (18.25 and 68.27 ppm, respectively) and lower Zn and Fe content was observed in pigeonpea seeds when pigeonpea was intercropped with pearl millet (1:2) (16.62 and 66.40 ppm, repectively) over other treatments .

However with respect to intercrops, during both the years, irrespective of row proportion or cropping system, numerically higher Zn content was recorded with respective sole crops *viz*., foxtail millet (39.31 and 39.45 ppm, respectively), pearl millet (20.67 and 20.97 ppm, respectively) and sorghum (10.78 and 10.96 ppm, respectively) over respective intercropped treatments. Similarly during both the years, lower Zn content was recorded with sole crops when compared to respective intercropping systems.

4.1.4 Light transmission ratio

Light transmission ratio as influenced by pigeonpea and intercrops under varying row proportions are presented in Table 20.

Light transmission ratio of pigeonpea did not differ significantly when intercropped with different nutri cereal crops. However at 60 DAS, during both the years (2015 and 2016), higher light transmission ratio was registered with sole pigeonpea (0.80 and 0.83, respectively) over intercropped treatments. Among intercropped systems, higher light transmission ratio was recorded under pigeonpea with foxtail millet (1:1) (0.78 and 0.80, respectively) followed by pigeonpea with sorghum (1:1) (0.76 and 0.78, respectively), pigeonpea + foxtail millet (1:2) (0.74 and 0.76, respectively), pigeonpea + pearl millet (1:1) (0.72 and 0.74, respectively), pigeonpea + pearl millet (1:2) (0.70 and 0.72, respectively) and pigeonpea + pearl millet (1:2) (0.69 and 0.71, respectively).

Similarly with respect to intercrops at 30 DAS, during both the years (2015 and 2016), sole crops *viz*., sole foxtail millet (0.60 and 0.63, respectively), sorghum (0.51 and 0.55, respectively) and pearl millet (0.42 and 0.47, respectively) recorded higher light

Table 20. Light transmission ratio of pigeonpea and intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

treatments	Pigeonpea @ 60 DAS			Intercrop @ 30 DAS			Pigeonpea @ 90 DAS			Intercrop @ 60 DAS		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	0.76	0.78	0.77	0.40	0.44	0.42	0.86	0.89	0.88	0.53	0.56	0.55
T_2 -Pigeonpea + pearl millet (1:1)	0.72	0.74	0.73	0.35	0.39	0.37	0.83	0.85	0.84	0.40	0.44	0.42
T_3-Pigeonpea + foxtail millet (1:1)	0.78	0.80	0.79	0.47	0.53	0.50	0.88	0.91	0.89	0.58	0.62	0.60
T_4 -Pigeonpea + sorghum (1:2)	0.70	0.72	0.71	0.45	0.48	0.47	0.79	0.81	0.80	0.61	0.63	0.62
T_5-Pigeonpea + pearl millet (1:2)	0.69	0.71	0.70	0.39	0.43	0.41	0.77	0.79	0.78	0.46	0.51	0.49
T_6-Pigeonpea + foxtail millet (1:2)	0.74	0.76	0.75	0.56	0.59	0.58	0.85	0.87	0.86	0.64	0.68	0.66
T_7 -Sole pigeonpea (90 cm × 30 cm)	0.80	0.83	0.82	-	-	-	0.91	0.93	0.92	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	-	-	-	0.51	0.55	0.53	-	-	-	0.68	0.71	0.70
T_9-Sole pearl millet (45cm × 15 cm)	-	-	-	0.42	0.47	0.45	-	-	-	0.55	0.58	0.56
T_{10}-Sole foxtail millet (30 cm × 10 cm)	-	-	-	0.60	0.63	0.62	-	-	-	0.71	0.75	0.73
S. Em.±	0.03	0.04	0.04	-	-	-	0.05	0.06	0.05	-	-	-
C.D. (P=0.05)	NS	NS	NS	-	-	-	NS	NS	NS	-	-	-

transmission ratio over their respective intercropped treatments. Similar trend was followed at 60 DAS.

At 90 DAS, pooled mean revealed that numerically higher light transmission ratio was recorded under sole pigeonpea (0.92) over the intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (0.89), pigeonpea + sorghum (1:1) (0.88), pigeonpea + foxtail millet (1:2) (0.86), pigeonpea + pearl millet (1:1) (0.84), pigeonpea + sorghum (1:2) (0.80) and pigeonpea with pearl millet (1:2) (0.78).

4.1.5 Nutrient uptake

4.1.5.1 Nitrogen uptake (kg ha^{-1})

The data concerned to nitrogen uptake by pigeonpea and intercrops are presented in Table 21 and fig 10. The results indicated that the nitrogen uptake by pigeonpea was significantly influenced due to different component crops irrespective of row proportion and cropping systems.

During both the years (2015 and 2016), sole pigeonpea (154.23 and 164.44 kg ha^{-1}) recorded significantly higher nitrogen uptake of pigeonpea over intercropped treatments. Among the intercropped treatments, pigeonpea + foxtail millet (1:1) (125.16 and 135.93 kg ha^{-1}, respectively) recorded on par nitrogen uptake by pigeonpea with pigeonpea + sorghum (1:1) (115.57 and 127.56 kg ha^{-1}, respectively), pigeonpea + foxtail millet (1:2) (110.76 and 120.15 kg ha^{-1}, respectively) and pigeonpea + pearl millet (1:1) (106.74 and 116.49 kg ha^{-1}, respectively) and was significantly higher when compared to pigeonpea + pearl millet (1:2) (73.56 and 83.90 kg ha^{-1}, respectively) which was on par with pigeonpea + sorghum (1:2) (87.45 and 94.99 kg ha^{-1}, respectively).

Pooled data revealed that significantly higher nitrogen uptake by pigeonpea was recorded under sole pigeonpea (164.44 kg ha^{-1}) over intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (130.55 kg ha^{-1}), pigeonpea + sorghum (1:1) (121.57 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (115.45 kg ha^{-1}), pigeonpea + pearl millet (1:1) (111.61 kg ha^{-1}), pigeonpea + sorghum (1:2) (91.2 kg ha^{-1}) and pigeonpea + pearl millet (1:2) (78.93 kg ha^{-1}). Among the intercropped treatments, pigeonpea + foxtail millet (1:1) recorded significantly higher nitrogen uptake when compared to pigeonpea + pearl millet

Table 21. Nitrogen uptake of pigeonpea and intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Nitrogen uptake (kg ha^{-1})								
	2015			**2016**			**Pooled**		
	Pigeonpea	**Intercrop**	**Total**	**Pigeonpea**	**Intercrop**	**Total**	**Pigeonpea**	**intercrop**	**Total**
T_1 -Pigeonpea + sorghum (1:1)	115.57	75.91	191.48	127.56	77.20	204.76	121.57	76.55	198.12
T_2 -Pigeonpea + pearl millet (1:1)	106.74	23.41	130.15	116.49	26.48	142.97	111.61	24.95	136.56
T_3-Pigeonpea + foxtail millet (1:1)	125.16	9.15	134.31	135.93	11.26	147.19	130.55	10.21	140.75
T_4 -Pigeonpea + sorghum (1:2)	87.45	78.05	165.50	94.99	81.08	176.07	91.22	79.57	170.78
T_5-Pigeonpea + pearl millet (1:2)	73.56	25.60	99.16	83.90	28.38	112.28	78.73	26.99	105.72
T_6-Pigeonpea + foxtail millet (1:2)	110.76	18.13	128.89	120.15	21.78	141.93	115.45	19.96	135.41
T_7 -Sole pigeonpea (90 cm × 30 cm)	154.23	0.00	154.23	164.44	0.00	164.44	159.34	0	159.34
T_8 -Sole sorghum (45 cm × 15 cm)	-	85.83	85.83	-	89.17	89.17	-	87.50	87.50
T_9-Sole pearl millet (45cm × 15 cm)	-	27.32	27.32	-	30.80	30.80	-	29.06	29.06
T_{10}-Sole foxtail millet (30 cm × 10 cm)	-	22.38	22.38	-	24.53	24.53	-	23.45	23.45
S. Em.±	6.19	-	5.24	6.65	-	6.11	6.52	-	5.20
C.D. (P=0.05)	19.80	-	16.76	21.27	-	17.14	19.91	-	17.43

(1:2) and pigeonpea + sorghum (1:2) and was on par with pigeonpea + sorghum (1:1), pigeonpea + foxtail millet (1:2) and pigeonpea + pearl millet (1:1).

With regard to total nitrogen uptake, among the treatments, during both the years (2015 and 2016), significantly higher total nitrogen uptake was recorded with pigeonpea + sorghum (1:1) (191.48 and 204.76 kg ha^{-1}, respectively) over other intercropped treatments and sole pigeonpea. Pigeonpea + sorghum (1:2) (165.50 and 176.07 kg ha^{-1}, respectively) recorded significantly higher total nitrogen uptake which was on par with sole pigeonpea (154.23 and 164.44 kg ha^{-1}, respectively). Pooled mean also followed similar trend.

4.1.5.2 Phosphorus uptake (kg ha^{-1})

The data pertaining to phosphorus uptake by pigeonpea and intercrops are presented in Table 22 and fig 10. The results indicated that the phosphorus uptake by pigeonpea at harvest was significantly influenced by intercropping pigeonpea with nutri cereals under varied row proportions.

During both the years (2015 and 2016), sole pigeonpea (15.22 and 16.05, kg ha^{-1}, respectively) recorded on par phosphorus uptake by pigeonpea with the intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (15.10 and 15.63 kg ha^{-1}), pigeonpea + sorghum (1:1) (14.15 and 15.04 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (13.55 and 14.60 kg ha^{-1}) and pigeonpea + pearl millet (1:1) (13.18 and 14.05 kg ha^{-1}), respectively and significantly higher phosphorus uptake over other intercropped treatments, pigeonpea + pearl millet (1:2) (10.29 and 11.41 kg ha^{-1}) and pigeonpea + sorghum (1:2) (11.27 and 12.11 kg ha^{-1}), respectively.

Pooled data indicated that significantly higher phosphorus uptake by pigeonpea was recorded under intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (15.57 kg ha^{-1}), pigeonpea + sorghum (1:1) (14.60 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (14.08 kg ha^{-1}) and pigeonpea + pearl millet (1:1) (13.62 kg ha^{-1}) which were at par with sole pigeonpea (15.63 kg ha^{-1}) and significantly higher over pigeonpea with pearl millet (1:2) (10.85 kg ha^{-1}) which was on par with pigeonpea with sorghum (1:2) (11.69 kg ha^{-1}).

Total phosphorus uptake also differed significantly among treatments. During both the years (2015 and 2016), significantly higher total phosphorus uptake was

Table 22. Phosphorus uptake of pigeonpea and intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Phosphorous uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Pigeonpea	Intercrop	Total	Pigeonpea	Intercrop	Total	Pigeonpea	intercrop	Total
T_1 -Pigeonpea + sorghum (1:1)	14.15	25.44	39.58	15.04	27.58	42.62	14.60	26.51	41.10
T_2 -Pigeonpea + pearl millet (1:1)	13.18	8.26	21.44	14.05	9.85	23.90	13.62	9.05	22.67
T_3-Pigeonpea + foxtail millet (1:1)	15.10	2.26	17.36	15.63	4.36	20.41	15.57	3.31	18.89
T_4 -Pigeonpea + sorghum (1:2)	11.27	27.07	38.35	12.11	30.46	42.57	11.69	28.77	40.46
T_5-Pigeonpea + pearl millet (1:2)	10.29	10.60	20.89	11.41	12.05	23.46	10.85	11.33	22.18
T_6-Pigeonpea + foxtail millet (1:2)	13.55	4.10	17.66	14.60	6.09	20.68	14.08	5.10	19.17
T_7 -Sole pigeonpea (90 cm × 30 cm)	15.22	-	15.22	16.05	-	16.05	15.63	-	15.63
T_8 -Sole sorghum (45 cm × 15 cm)	0.00	30.13	30.13	0.00	34.32	34.32	0.00	32.23	32.23
T_9-Sole pearl millet (45cm × 15 cm)	0.00	13.51	13.51	0.00	15.36	15.36	0.00	14.44	14.44
T_{10}-Sole foxtail millet (30 cm × 10 cm)	0.00	6.22	6.22	0.00	7.96	7.96	0.00	7.09	7.09
S. Em.±	0.73	-	1.27	0.69	-	1.13	0.68	-	0.69
C.D. (P=0.05)	2.34	-	4.06	2.20	-	3.61	2.19	-	2.20

recorded with pigeonpea + sorghum (1:1) (39.58 and 42.62 kg ha^{-1}, respectively) and pigeonpea + sorghum (1:2) (38.35 and 42.57 kg ha^{-1}, respectively) over other intercropped treatments and sole pigeonpea. During both the years, sole pigeonpea (15.22 and 16.05 kg ha^{-1}) recorded significantly lower total phosphorus uptake over intercropped treatments *viz.*, pigeonpea + sorghum (1:1) (14.15 and 15.04 kg ha^{-1}), pigeonpea + pearl millet (1:1) (39.58 and 42.62 kg ha^{-1}), pigeonpea + sorghum (1:2) (38.35 and 42.57 kg ha^{-1}) and pigeonpea + pearl millet (1:2) (20.89 and 23.46 kg ha^{-1}) and was on par with pigeonpea + foxtail millet (1:1) (17.36 and 20.41 kg ha^{-1}), and pigeonpea + foxtail millet (1:2) (17.66 and 20.68 kg ha^{-1}), respectively. Pooled mean also followed similar trend.

4.1.5.3 Potassium uptake

The data pertaining to potassium uptake by pigeonpea and intercrops are presented in Table 23 and fig 10. The results indicated that the uptake of potassium at harvest was significantly influenced by intercropping of pigeonpea with nutri-cereals under varied row proportion.

During both the years (2015 and 2016), sole pigeonpea (60.34 and 63.50, kg ha^{-1}, respectively) recorded significantly higher potassium uptake by pigeonpea when compared to pigeonpea + pearl millet (1:1) (47.93 and 49.43 kg ha^{-1}), pigeonpea + sorghum (1:2) (40.35 and 42.13 kg ha^{-1}), pigeonpea + pearl millet (1:2) (38.42 and 40.49 kg ha^{-1}) and was found on par with intercropped treatments *viz.*, pigeonpea + foxtail millet (1:1) (54.91 and 56.76 kg ha^{-1}) and pigeonpea + sorghum (1:1) (52.92 and 54.45 kg ha^{-1}), respectively. However during both the years (2015 and 2016) significantly lower potassium uptake by pigeonpea was recorded with pigeonpea + pearl millet (1:2) over other intercropped treatments and was on par with pigeonpea + sorghum (1:2).

Pooled data indicated that significantly higher potassium uptake by pigeonpea was recorded under intercropped treatment *viz.*, pigeonpea + foxtail millet (1:1) (55.84 kg ha^{-1}) over ,pigeonpea + sorghum (1:2) (41.24 kg ha^{-1}), pigeonpea + pearl millet (1:2) (39.66 kg ha^{-1}) and was on par with pigeonpea + sorghum (1:1) (53.69 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (51.93 kg ha^{-1}), pigeonpea + pearl millet (1:1) (48.68 kg ha^{-1}) and sole pigeonpea (61.92 kg ha^{-1}). Among intercropped treatments, significantly lower potassium uptake of pigeonpea was recorded with pigeonpea + pearl millet (1:2) (39.66 kg ha^{-1}) which was on par with pigeonpea with sorghum (1:2) (41.24 kg ha^{-1})

Table 23. Potassium uptake of pigeonpea and intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Potassium uptake (kg ha^{-1})								
	2015			2016			Pooled		
	Pigeonpea	Intercrop	Total	Pigeonpea	Intercrop	Total	Pigeonpea	intercrop	Total
T_1 -Pigeonpea + sorghum (1:1)	52.92	43.15	96.07	54.45	45.08	99.53	53.69	44.12	97.80
T_2 -Pigeonpea + pearl millet (1:1)	47.93	21.64	69.57	49.43	23.54	72.97	48.68	22.59	71.27
T_3-Pigeonpea + foxtail millet (1:1)	54.91	7.95	62.86	56.76	9.60	66.37	55.84	8.78	64.62
T_4 -Pigeonpea + sorghum (1:2)	40.35	46.88	87.23	42.13	49.01	91.14	41.24	47.95	89.18
T_5-Pigeonpea + pearl millet (1:2)	38.82	38.82	77.65	40.49	41.67	82.16	39.66	40.25	79.91
T_6-Pigeonpea + foxtail millet (1:2)	51.19	13.55	64.75	52.67	15.63	68.30	51.93	14.59	66.52
T_7 -Sole pigeonpea (90 cm × 30 cm)	60.34	-	60.34	63.50	-	63.50	61.92	-	61.92
T_8 -Sole sorghum (45 cm × 15 cm)	0.00	50.79	50.79	0.00	54.58	54.58	0.00	52.68	52.68
T_9-Sole pearl millet (45cm × 15 cm)	0.00	43.22	43.22	0.00	45.46	45.46	0.00	44.34	44.34
T_{10}-Sole foxtail millet (30 cm × 10 cm)	0.00	14.60	14.60	0.00	17.20	17.20	0.00	15.90	15.90
S. Em.±	3.45	-	3.38	4.01	-	3.43	3.25	-	3.27
C.D. (P=0.05)	10.52	-	10.81	12.45	-	10.99	10.43	-	10.47

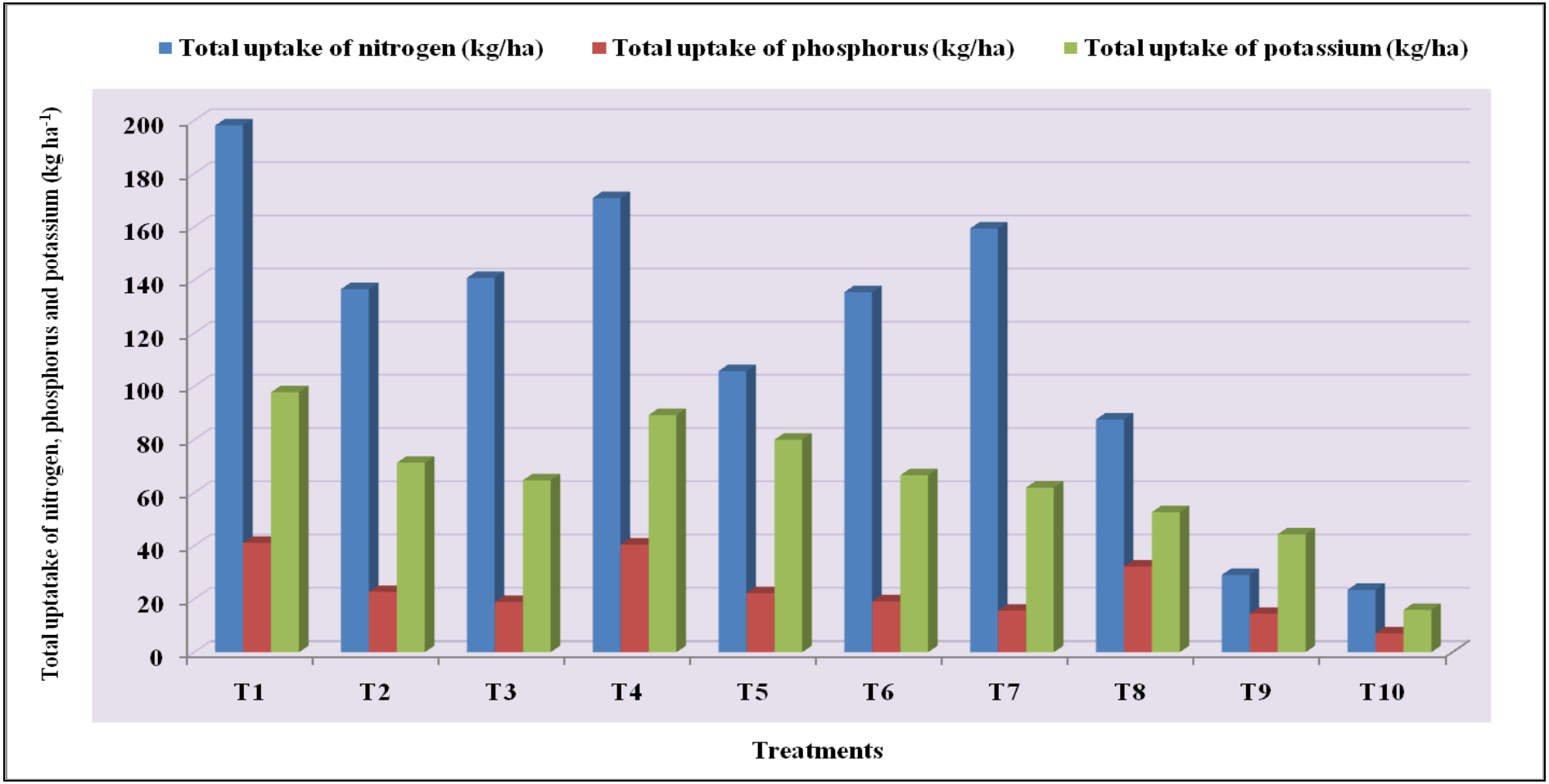

Fig. 10. Total uptake of nitrogen, phosphorus and potassium by pigeonpea and intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

With regard to total potassium uptake, among the treatments, during both the years (2015 and 2016), significantly higher total potassium uptake was recorded with pigeonpea + sorghum (1:1) (96.07 and 99.53 kg ha^{-1}) and pigeonpea + sorghum (1:2) (87.23 and 91.14 kg ha^{-1}), respectively over other intercropped treatments *viz*., pigeonpea + pearl millet (1:1) (69.57 and 72.97 kg ha^{-1}), pigeonpea + foxtail millet (1:1) (62.86 and 66.37 kg ha^{-1}), pigeonpea + pearl millet (1:2) (77.65 and 82.16 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (64.75 and 68.30 kg ha^{-1}) and sole pigeonpea (60.34 and 63.50 kg ha^{-1}), respectively. Pooled mean also followed similar trend.

4.1.6 Assessment of yield advantages in intercropping system

4.1.6.1 Pigeonpea equivalent yield (kg ha^{-1})

The data on pigeonpea equivalent yield (PEY) as influenced by varying row proportions of intercrops under pigeonpea based intercropping systems is presented in Table 24 and fig 11. Pigeonpea equivalent yield was significantly influenced by cropping systems under varying row proportions.

During the year 2015, the intercropped treatment, sole pigeonpea (1302 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield when compared to intercropped treatments *viz*., pigeonpea + sorghum (1:2) (1032 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (1027 kg ha^{-1}), pigeonpea + pearl millet (1:1) (946 kg ha^{-1}) and pigeonpea + pearl millet (1:2) (914 kg ha^{-1}) and was on par with pigeonpea + foxtail millet (1:1) (1125 kg ha^{-1}) and pigeonpea + sorghum (1:1) (1116 kg ha^{-1}).

However during the year 2016, sole pigeonpea (1419 kg ha^{-1}) was found on par with pigeonpea + sorghum (1:1) (1294 kg ha^{-1}), pigeonpea + sorghum (1:2) (1288 kg ha^{-1}) and pigeonpea + foxtail millet (1:1) (1262 kg ha^{-1}) and significantly higher over other treatments *viz*., pigeonpea + pearl millet (1:1) (1095 kg ha^{-1}), pigeonpea + pearl millet (1:2) (1083 kg ha^{-1}) and pigeonpea + foxtail millet (1:2) (1148 kg ha^{-1}) which were on par with one another with respect to pigeonpea equivalent yield.

Pooled mean indicated that pigeonpea with sorghum (1:1) (1205 kg ha^{-1}) recorded on par pigeonpea equivalent yield with sole pigeonpea (1360 kg ha^{-1}), pigeonpea + sorghum (1:2) (1160 kg ha^{-1}), pigeonpea + foxtail millet (1:1) (1193 kg ha^{-1}) and pigeonpea + foxtail millet (1:2) (1087 kg ha^{-1}) and was significantly higher when

compared to pigeonpea + pearl millet (1:1) (1020 kg ha^{-1}) and pigeonpea + pearl millet (1:2) (998 kg ha^{-1}).

4.1.6.2 Land equivalent ratio

The data on land equivalent ratio (LER) as influenced by varying row proportion of intercrops under pigeonpea intercropping systems is presented in Table 24 and fig 11. The results revealed that the land equivalent ratio differed significantly between sole crop and intercropping systems due to row proportion with different intercrops during both the years and in pooled mean.

All the intercropped treatments recorded significantly higher land equivalent ratio when compared to sole crop. The observation on land equivalent ratio during 2015 indicated that pigeonpea with sorghum (1:2) (1.41) recorded significantly higher land equivalent ratio over sole pigeonpea (1.00) and was on par with other intercropped treatments *viz.*, pigeonpea + sorghum (1:1) (1.41), pigeonpea + pearl millet (1:2) (1.36), pigeonpea + foxtail miilet (1:1) (1.30), pigeonpea + foxtail miilet (1:2) (1.31) and pigeonpea + pearl millet (1:1) (1.26).

Land equivalent ratio during 2016 revealed that pigeonpea with sorghum (1:2) (1.50) recorded significantly higher land equivalent ratio over sole pigeonpea (1.00), pigeonpea + pearl millet (1:1) (1.30), pigeonpea + foxtail millet (1:1) (1.29) and pigeonpea + foxtail millet (1:2) (1.28) and was found on par with pigeonpea + pearl millet (1:2) (1.44) and pigeonpea + sorghum (1:1) (1.40).

Pooled mean revealed that significantly higher land equivalent ratio was recorded under pigeonpea + sorghum (1:2) (1.45) over the intercropped treatments, pigeonpea + pearl millet (1:1) (1.28) and sole pigeonpea (1.00) and was on par with pigeonpea + sorghum (1:1) (1.40), pigeonpea + pearl millet (1:2) (1.40), pigeonpea + foxtail millet (1:2) (1.30) and pigeonpea + foxtail millet (1:2) (1.30).

4.1.6.3 Area time equivalent ratio (ATER)

The intercropping of pigeonpea with different intercrops under varying row proportions significantly influenced the area time equivalent ratio (ATER) as presented in Table 24and fig 11. The results revealed that during 2015, significantly higher ATER was recorded with pigeonpea + sorghum (1:1) (1.24) compared to intercropped treatments *viz.*,

Table 24. Pigeonpea equivalent yield (kg ha^{-1}), land equivalent ratio (LER) and area time equivalent ratio (ATER) as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Pigeonpea equivalent yield (kg ha^{-1})			LER			ATER		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	1116	1294	1205	1.41	1.40	1.40	1.24	1.22	1.23
T_2 -Pigeonpea + pearl millet (1:1)	946	1095	1020	1.26	1.30	1.28	0.96	0.98	0.97
T_3-Pigeonpea + foxtail millet (1:1)	1125	1262	1193	1.30	1.29	1.30	1.05	1.08	1.07
T_4 -Pigeonpea + sorghum (1:2)	1032	1288	1160	1.41	1.50	1.45	1.21	1.29	1.25
T_5-Pigeonpea + pearl millet (1:2)	914	1083	998	1.36	1.44	1.40	0.99	1.03	1.01
T_6-Pigeonpea + foxtail millet (1:2)	1027	1148	1087	1.31	1.28	1.30	1.01	1.02	1.02
T_7 -Sole pigeonpea (90 cm × 30 cm)	1302	1419	1360	1.00	1.00	1.00	1.00	1.00	1.00
T_8 -Sole sorghum (45 cm × 15 cm)	318	493	406	1.00	1.00	1.00	1.00	1.00	1.00
T_9-Sole pearl millet (45cm × 15 cm)	344	523	433	1.00	1.00	1.00	1.00	1.00	1.00
T_{10}-Sole foxtail millet (30 cm × 10 cm)	289	431	360	1.00	1.00	1.00	1.00	1.00	1.00
S. Em.±	59	58	55	0.05	0.05	0.05	0.05	0.05	0.05
C.D. (P=0.05)	189	184	182	0.15	0.15	0.16	0.19	0.18	0.20

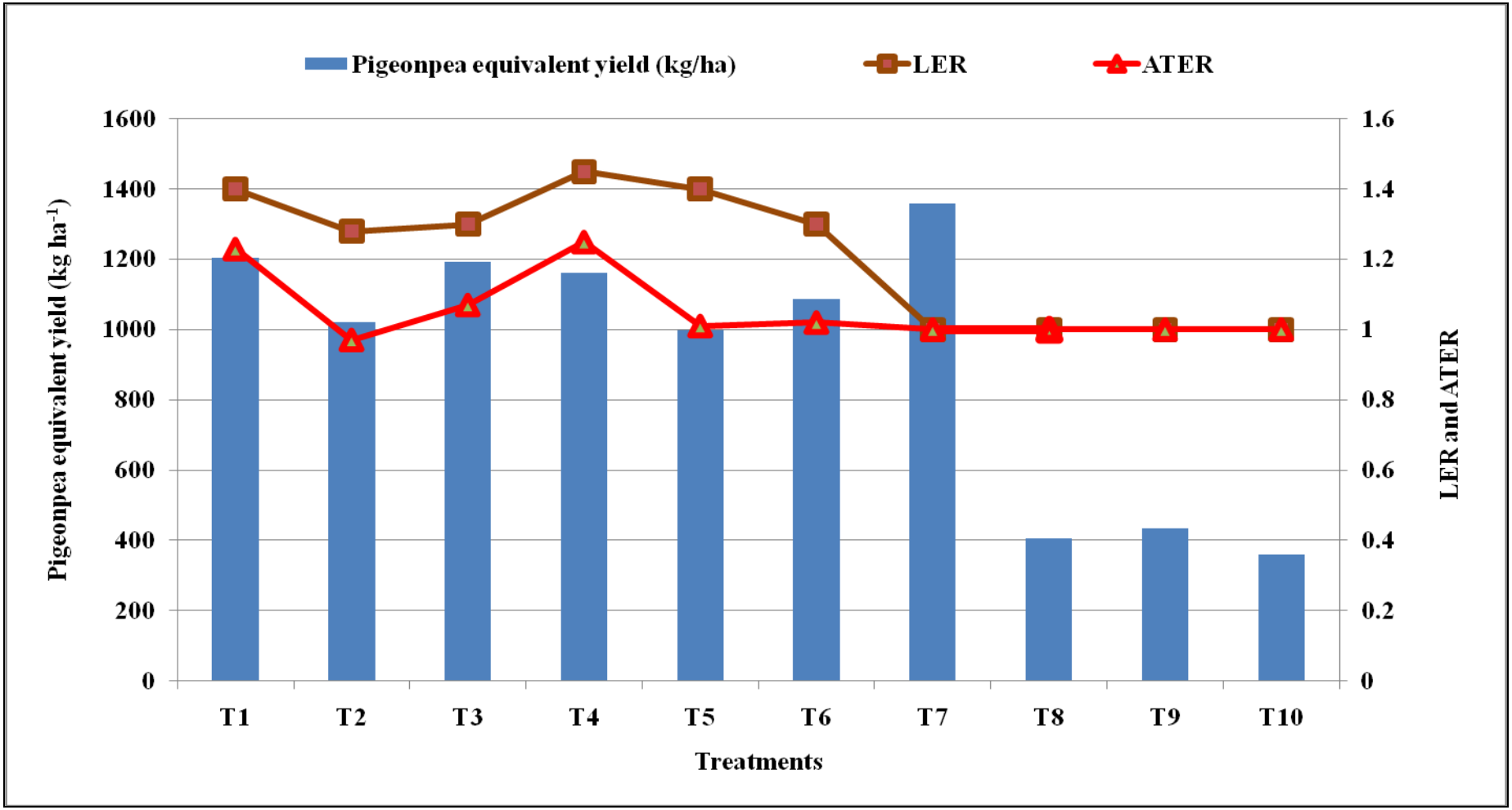

Fig. 11. Pigeonpea equivalent yield (kg ha^{-1}), land equivalent ratio (LER) and area time equivalent ratio (ATER) as influenced by varying row proportion in intercropping systems under rainfed condition

pigeonpea with pearl millet (1:1) (0.96), pigeonpea + pearl millet (1:2) (0.99), pigeonpea + foxtail millet (1:2) (1.01) and sole pigeonpea (1.00) and was on par with pigeonpea + sorghum (1:2) (1.21) and pigeonpea + foxtail millet (1:1) (1.05).

However during 2016, significantly higher ATER was recorded under pigeonpea + sorghum (1:2) (1.29) over other treatments *viz*., pigeonpea + pearl millet (1:1) (0.98), pigeonpea + foxtail millet (1:1) (1.08), pigeonpea + pearl millet (1:2) (1.03), pigeonpea + foxtail millet (1:2) (1.02) and sole pigeonpea (1.00) was on par with pigeonpea + sorghum (1:1) (1.22).

Pooled data indicated that significantly higher ATER was obtained under the intercropped treatment of pigeonpea with sorghum (1:2) (1.25) when compared to pigeonpea + foxtail millet (1:2) (1.02), pigeonpea + pearl millet (1:1) (0.97), pigeonpea + pearl millet (1:2) (1.01) and sole pigeonpea (1.00) and was on par with pigeonpea + sorghum (1:1) (1.23), pigeonpea + foxtail millet (1:1) (1.07).

4.1.7 Economics of pigeonpea and nutri-cereals in traditional intercropping systems

4.1.7.1 Cost of cultivation

The cost of cultivation recorded under different treatments is presented in Table 25 and and fig 12. The pooled results revealed that the lower cost of cultivation was recorded in sole pearl millet (Rs.17684 ha^{-1}) compared to sole pigeonpea (Rs.24417 ha^{-1}) and sole sorghum (Rs.18272 ha^{-1}) over their respective intercropping systems. Among the intercropped treatments, higher cost of cultivation was recorded by pigeonpea + foxtail millet (1:2) (Rs.27498 ha^{-1}) compared to all the other treatments *viz*., pigeonpea + pearl millet (1:2) (Rs.26585 ha^{-1}), pigeonpea + sorghum (1:1) (Rs.26958 ha^{-1}), pigeonpea + pearl millet (1:1) (Rs.26539 ha^{-1}) and pigeonpea + foxtail millet (1:1) (Rs.27423 ha^{-1}).

4.1.7.2 Gross returns

The gross returns recorded under different treatments are presented in Table 25 and and fig 12. The pooled data revealed that sole pigeonpea recorded highest gross returns (Rs. 81084 ha^{-1}) over the intercropped treatments and sole crops of sorghum, pearl millet and foxtail millet. Among the intercropped treatments pigeonpea + sorghum (1:1) (Rs.73680 ha^{-1}) recorded higher gross returns followed by pigeonpea + sorghum (1:2) (Rs.71383 ha^{-1}), pigeonpea + foxtail millet (1:1) (Rs. 71491 ha^{-1}), pigeonpea + foxtail

millet (1:2) (Rs.65394 ha^{-1}), pigeonpea + pearl millet (1:1) (Rs.61492 ha^{-1}) and pigeonpea + pearl millet (1:2) (Rs.60268 ha^{-1}).

4.1.7.3 Net returns

The net returns recorded under different treatments are presented in Table 25 and fig 12. During the year 2015, sole pigeonpea recorded significantly higher net returns (Rs.65578 ha^{-1}) when compared to pigeonpea + foxtail millet (1:1) (Rs.50861 ha^{-1}), pigeonpea + sorghum (1:2) (Rs.47093 ha^{-1}), pigeonpea + foxtail millet (1:2) (Rs.44235 ha^{-1}), pigeonpea + pearl millet (1:2) (Rs.37714 ha^{-1}), pigeonpea + pearl millet (1:1) (Rs.39790 ha^{-1}) and pigeonpea + sorghum (1:1) (Rs.52239 ha^{-1}). However, among intercropped treatments, pigeonpea + sorghum (1:1) (Rs.52239 ha^{-1}), pigeonpea + foxtail millet (1:1) (Rs.50861
ha^{-1}), pigeonpea + sorghum (1:2) (Rs.47093 ha^{-1}) and pigeonpea + foxtail millet (1:2) (Rs.44235 ha^{-1}) recorded on par net returns with one another.

During 2016, sole pigeonpea recorded significantly higher net returns (Rs.47755 ha^{-1}) over the intercropped treatments *viz*., pigeonpea + foxtail millet (1:1) (Rs.37275 ha^{-1}), pigeonpea + foxtail millet (1:2) (Rs.31557 ha^{-1}), pigeonpea + pearl millet (1:1) (Rs.30116 ha^{-1}) and pigeonpea + pearl millet (1:2) (Rs.29653 ha^{-1}) and was on par with pigeonpea + sorghum (1:2) (41330 Rs. ha^{-1}) and pigeonpea + sorghum (1:1) (Rs.41205 ha^{-1}). However among the intercropped treatments pigeonpea + sorghum (1:2) (Rs.41330 ha^{-1}) recorded significantly higher net returns and was on par with pigeonpea + sorghum (1:1) (Rs.41205 ha^{-1}) and pigeonpea + foxtail millet (1:1) (Rs.37275 ha^{-1}).

The pooled data indicated that significantly higher net returns was recorded with sole pigeonpea (Rs.56507 ha^{-1}) over other treatments *viz*., pigeonpea + foxtail millet (1:1) (Rs.44068 ha^{-1}), pigeonpea + foxtail millet (1:2) (Rs.37928 ha^{-1}), pigeonpea + pearl millet (1:1) (Rs.34953 ha^{-1}), pigeonpea + pearl millet (1:2) (Rs.33721 ha^{-1}) and pigeonpea + sorghum (1:2) (Rs.44257 ha^{-1}) and was found on par with pigeonpea + sorghum (1:1) (Rs.46597 ha^{-1}). However, among the intercropped treatments pigeonpea + sorghum (1:1) (Rs.46597 ha^{-1}) recorded significantly higher net returns when compared to other intercropped treatments pigeonpea + pearl millet (1:1) (Rs.34953 ha^{-1}) and pigeonpea + pearl millet (1:2) (Rs.33721 ha^{-1}) and was found on par with pigeonpea + sorghum (1:2) (Rs.44257 ha^{-1}), pigeonpea + foxtail millet (1:1) (Rs.44068 ha^{-1}), pigeonpea + foxtail millet (1:2) (Rs.37928 ha^{-1}).

During both the years (2015 and 2016) and in pooled data, significantly lower net returns was recorded in sole stand *viz*., sorghum (Rs.6995, 10652 and 8823 ha^{-1}), foxtail millet (Rs.2232, 4508 and 3370 ha^{-1}) and pearl millet (Rs. 1916, 4284 and 3100 ha^{-1}) respectively, when compared to intercropped treatments.

4.1.7.4 Benefit cost ratio (B:C)

Significant variations were visible in B:C of different intercropping systems as presented in Table 25 and fig 12.

During the year 2015, significantly higher B:C was recorded with sole pigeonpea (3.71) over intercropped treatments. However among intercropped treatments, pigeonpea + sorghum (1:1) (2.94) recorded significantly higher B:C compared to pigeonpea + pearl millet (1:1) (2.51) and pigeonpea + pearl millet (1:1) (2.43) and was on par with pigeonpea + foxtail millet (1:1) (2.87), pigeonpea + sorghum (1:2) (2.74), pigeonpea + foxtail millet (1:2) (2.62).

During the year 2016, sole pigeonpea (2.94) recorded significantly higher B:C when compared to other treatments *viz*., pigeonpea + foxtail millet (1:1) (2.35), pigeonpea + foxtail millet (1:2) (2.15), pigeonpea + pearl millet (1:1) (2.13), pigeonpea + pearl millet (1:2) (2.11), pigeonpea + sorghum (1:2) (2.52) and pigeonpea + sorghum (1:1) (2.53). However among the intercropped treatments, pigeonpea + sorghum (1:1) (2.53) and pigeonpea + sorghum (1:2) (2.52) recorded significantly higher B:C when compared to pigeonpea + pearl millet (1:2) (2.11), pigeonpea + pearl millet (1:1) (2.13) and pigeonpea + foxtail millet (1:2) (2.15) and were on par with pigeonpea + foxtail millet (1:1) (2.35).

The pooled data revealed that significantly higher B:C was recorded with sole pigeonpea (3.33) over intercropped treatments *viz*., pigeonpea + sorghum (1:1) (2.74), pigeonpea + sorghum (1:2) (2.2.63), pigeonpea + foxtail millet (1:1) (2.61), pigeonpea + foxtail millet (1:2) (2.38), pigeonpea + pearl millet (1:1) (2.32) and pigeonpea + pearl millet (1:2) (2.27). Among the treatments, pigeonpea + sorghum (1:1) (2.74), pigeonpea + sorghum (1:2) (2.63), pigeonpea + foxtail millet (1:1) (2.61) and pigeonpea + foxtail millet (1:2) (2.38) recorded significantly higher B:C when compared to sole sorghum (0.91), sole pearl millet (0.70) and sole foxtail millet (0.51) and were on par with one another.

During both the years (2015 and 2016) and in pooled data, significantly lower B:C was recorded under sole pearl millet (1.11, 1.24 and 1.18, respectively), sole foxtail millet

Table 25. Cost of cultivation (Rs.ha^{-1}), gross returns (Rs.ha^{-1}), net returns (Rs.ha^{-1}) and benefit cost ratio as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Cost of cultivation (Rs.ha^{-1})			Gross returns (Rs.ha^{-1})			Net returns (Rs.ha^{-1})			Benefit cost ratio		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	26903	27013	26958	79142	68218	73680	52239	41205	46597	2.94	2.53	2.74
T_2 -Pigeonpea + pearl millet (1:1)	26359	26719	26539	66149	56835	61492	39790	30116	34953	2.51	2.13	2.32
T_3-Pigeonpea + foxtail millet (1:1)	27243	27603	27423	78104	64878	71491	50861	37275	44068	2.87	2.35	2.61
T_4 -Pigeonpea + sorghum (1:2)	26988	27354	27171	74081	68684	71383	47093	41330	44257	2.74	2.52	2.63
T_5-Pigeonpea + pearl millet (1:2)	26375	26794	26585	64089	56447	60268	37714	29653	33721	2.43	2.11	2.27
T_6-Pigeonpea + foxtail millet (1:2)	27329	27667	27498	71564	59224	65394	44235	31557	37928	2.62	2.15	2.38
T_7 -Sole pigeonpea (90 cm × 30 cm)	24237	24597	24417	89815	72352	81084	65578	47755	56507	3.71	2.94	3.33
T_8 -Sole sorghum (45 cm × 15 cm)	18432	18112	18272	25427	28764	27095	6995	10652	8823	1.38	1.59	1.48
T_9-Sole pearl millet (45cm × 15 cm)	17844	17524	17684	19760	21808	20784	1916	4284	3100	1.11	1.24	1.18
T_{10}-Sole foxtail millet (30 cm × 10 cm)	18632	18312	18472	20864	22820	21842	2232	4508	3370	1.12	1.25	1.18
S. Em.±	-	-	-	-	-	-	3967	2929	3398	0.12	0.11	0.13
C.D. (P=0.05)	-	-	-	-	-	-	12129	9371	10871	0.39	0.35	0.41

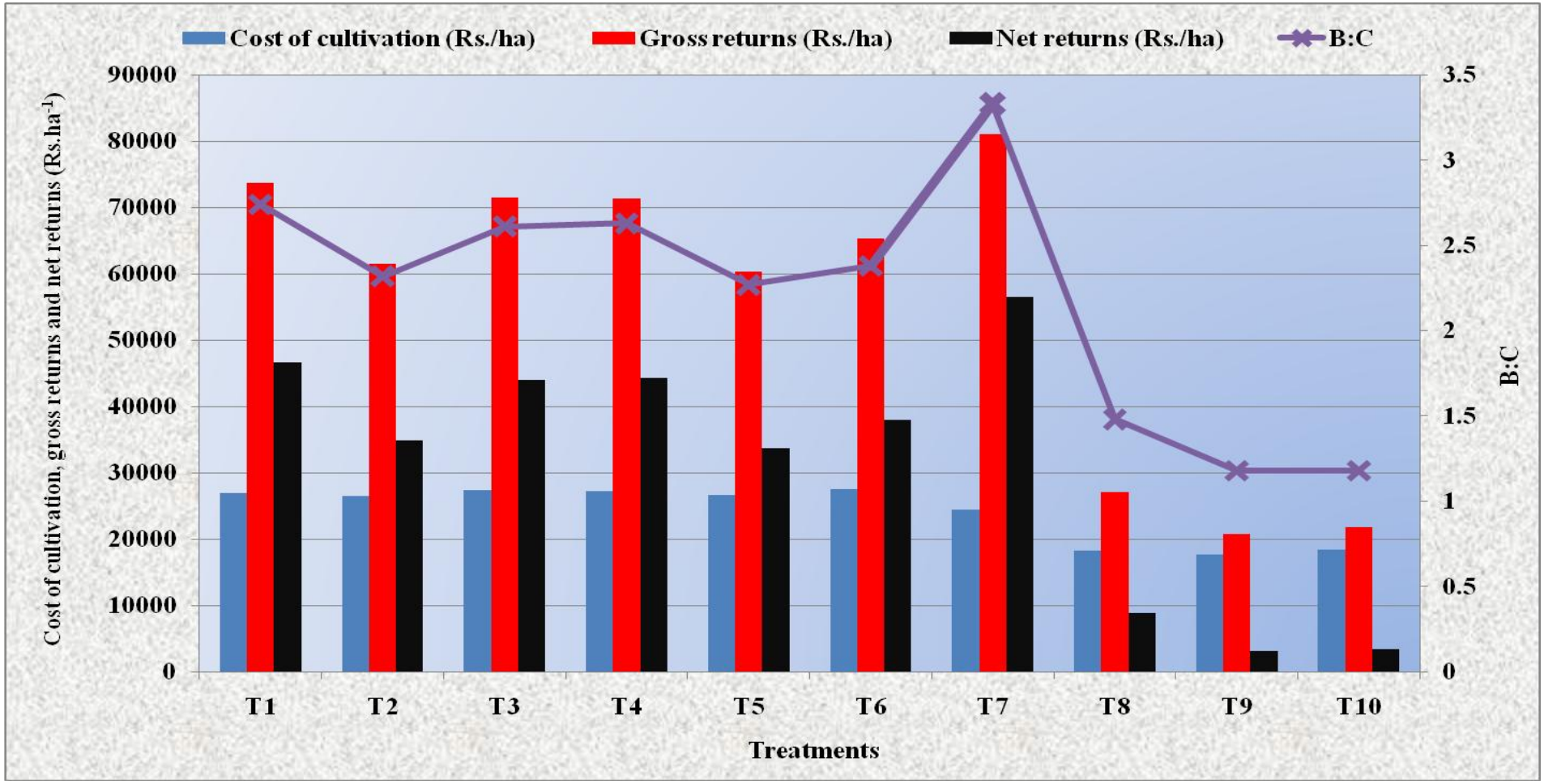

Fig. 12. Cost of cultivation (Rs. ha^{-1}), Gross returns (Rs. ha^{-1}), Net returns (Rs. ha^{-1}) and B:C as influenced by varying row proportion in intercropping systems under rainfed condition

(1.12, 1.25 and 1.18) and sole sorghum (1.38, 1.59 and 1.48), respectively over all treatments.

4.2 Experiment II: Performance of different nutri-cereals in strip cropping with pigeonpea under varied fertility levels

The results of the field experiment on "Performance of different nutri-cereals in strip cropping with pigeonpea under varied fertility levels" conducted during *kharif* season of 2015 and 2016 at College of Agriculture, Raichur, are presented in this chapter.

4.2.1 Growth parameters of pigeonpea

4.2.1.1 Plant height

The results of the investigation indicated that the strip cropping and fertility levels had significant influence on the plant height at all the growth stages of pigeonpea except 30 DAS as presented in Table 26**.** Plant height of pigeonpea did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Non significant effect due to different strip cropping systems and fertility levels on plant height of pigeonpea was noticed at 30 DAS during both the years (2015 and 2016) and in the pooled data.

During both the years (2015 and 2016), at 60 DAS, pigeonepa + foxtail millet (2:4) (54.09 and 56.18 cm, respectively) recorded significantly higher plant height than pigeonepea + pearl millet (2:4) (48.63 and 48.87 cm, respectively) but was found on par with pigeonepea + sorghum (2:4) (52.01 and 52.97 cm, respectively). Among fertility levels, significantly higher plant height (54.76 and 56.30 cm, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (46.96 and 47.17 cm, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (51.54 and 52.79 cm, respectively) during both the years. Among the strip cropping systems, pooled mean indicated that strip cropping of pigeonpea with foxtail millet (2:4) recorded significantly higher plant height (55.13 cm) when compared to intercropped treatment of pigeonpea with pearl millet (2:4) (48.75 cm) and was found to be on par with pigeonpea with sorghum (2:4) (52.49 cm). With respect to fertility levels, 100 % RDF to both component crops (55.53 cm) recorded significantly higher plant height when compared to

50 % RDF to both component crops (47.07 cm) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (52.01 cm)

At 90 DAS, during both the years, among the strip cropped treatments, pigeonpea + foxtail millet (2:4) (117.03 and 120.83 cm, respectively) and pigeonpea + sorghum (2:4) (113.78 and 118.06 cm, respectively) recorded significantly higher plant height when compared to pigeonpea + pearl millet (2:4) (108.94 and 112.49 cm, respectively) and were on par with each other. However, among fertility levels, 100 % RDF to both component crops (117.20 and 121.69 cm, respectively) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (113.19 and 118.01 cm, respectively) recorded significantly higher plant height when compared to 50 % RDF to both component crops (108.01 and 110.54 cm, respectively) and were on par with each other. The pooled mean revealed that among strip cropped treatments, significantly lower plant height was recorded with pigeonpea + pearl millet (2:4) (110.72 cm) when compared to pigeonpea + foxtail millet (2:4) (118.93 cm) and pigeonpea + sorghum (2:4) (115.92 cm) which were on par with each other. However, among fertility levels, 50 % RDF to both component crops (109.28 cm) recorded significantly lower plant height when compared to 100 % RDF to both component crops (119.44 cm) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (115.60 cm) which were on par with each other. Similar trend was followed at 120 DAS during both the years (2015 and 2016) and in pooled mean.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (151.63 and 154.40 cm, respectively) and pigeonpea + sorghum (2:4) (148.01 and 151.58 cm, respectively) recorded on par plant height and were significantly higher when compared to pigeonpea + pearl millet (2:4) (142.02 and 144.40 cm, respectively). During both the years, pigeonpea + pearl millet (2:4) recorded significantly lower plant height over other strip cropped systems. Among fertility levels, significantly higher plant height was recorded with 100 % RDF to both component crops (153.33 and 155.04 cm, respectively) over 50 % RDF to both component crops (138.19 and 143.02 cm, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (147.67 and 151.25 cm, respectively). Significantly lower plant height was recorded with 50 % RDF to both component crops when compared to other strip cropped systems. The pooled mean indicated that pigeonpea + foxtail millet (2:4) (153.01 cm) recorded significantly higher plant height when compared

Table 26. Plant height of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Plant height (cm)														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping System (M)															
M_1	30.99	31.79	31.39	52.01	52.97	52.49	113.78	118.06	115.92	138.63	140.21	139.42	148.01	151.58	149.80
M_2	30.09	30.87	30.48	48.63	48.87	48.75	108.94	112.49	110.72	134.81	136.18	135.50	142.02	144.40	143.21
M_3	33.27	34.13	33.70	54.09	56.18	55.13	117.03	120.83	118.93	141.71	143.27	142.49	151.63	154.40	153.01
S.Em.±	1.27	1.17	1.21	0.82	1.01	0.90	1.21	0.97	1.06	0.93	0.73	1.00	1.23	1.55	1.36
C.D. (P=0.05)	NS	NS	NS	3.20	4.04	3.56	4.76	3.82	4.18	3.67	2.86	3.94	4.81	6.09	5.32
Subplot :Fertility Levels (S)															
S_1	29.83	30.41	30.12	46.96	47.17	47.07	108.01	110.54	109.28	129.16	133.38	131.27	138.19	143.02	140.61
S_2	31.47	32.05	31.76	51.54	52.79	52.01	113.19	118.01	115.60	139.07	140.65	139.86	147.67	151.25	149.46
S_3	33.06	34.33	33.69	54.76	56.30	55.53	117.20	121.69	119.44	143.75	144.02	143.89	153.33	155.04	154.19
S.Em.±	1.51	1.29	1.37	1.47	1.76	1.56	1.67	2.06	1.93	2.68	1.94	1.82	2.57	2.28	1.89
C.D. (P=0.05)	NS	NS	NS	4.52	5.44	4.80	5.15	6.36	5.94	8.26	5.98	5.60	7.92	7.03	5.82
Interaction (M x S)															
S at the same M level															
S.Em+	2.62	2.22	2.37	2.59	3.05	2.70	2.89	3.58	3.34	4.63	3.36	3.15	4.45	3.95	3.27
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels															
S.Em+	2.91	2.51	2.66	2.71	3.31	2.94	3.13	3.71	3.51	4.74	3.44	3.30	4.61	4.24	3.54
CD (P=0.05)	NS	NS	NS	3.84	4.68	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:

M_1- Pigeonpea + Sorghum (2:4)

M_2- Pigeonpea + Pearl millet (2:4)

M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot

S_1-50 % RDF to both component crops

S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops

S_3-100 % RDF to both component crops

to pigeonepa + pearl millet (2:4) (149.79 cm) and was found to be on par with pigeonpea + sorghum (2:4) (149.80 cm). Among fertility levels, 100 % RDF to both component crops (154.19 cm) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (149.46 cm) recorded on par plant height and were significantly higher when compared to 50 % RDF to both component crops (140.61 cm).

The interaction effect of strip cropping systems and fertility levels on plant height of pigeonpea was found to be non significant at all the stages of crop growth.

4.2.1.2 Number of leaves per plant

The results of the study revealed that the strip cropping and fertility levels had significant influence on the number of leaves per plant at all the growth stages of pigeonpea except at 30 DAS as presented in Table 27**.** However, it did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Effect of strip cropping systems and fertility levels did not cause significant difference on number of leaves per plant of pigeonpea at 30 DAS during both the years and in pooled data.

At 60 DAS, during both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (79.16 and 80.26, respectively) recorded significantly higher number of leaves per plant when compared to pigeonpea + pearl millet (2:4) (73.05 and 74.42, respectively), and was on par with pigeonpea + sorghum (2:4) (76.68 and 77.98, respectively). Among different fertility levels, significantly higher number of leaves per plant (79.04 and 80.09, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (72.57 and 73.97, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.35 and 77.31, respectively) during both the years.

At 60 DAS, pooled data of two years indicated that strip cropping of pigeonpea with foxtail millet (2:4) (79.71) recorded significantly higher number of leaves per plant when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (73.74), and was found to be on par with pigeonpea with sorghum (2:4) (77.11). However, application of 100 % RDF to both component crops (79.57) recorded significantly higher number leaves per plant in comparison with 50 % RDF to both component crops (2:4)

(73.27), and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.83).

At 90 DAS, during both the years (2015 and 2016), among the strip cropped treatments, significantly lower number of leaves per plant was recorded with pigeonpea + pearl millet (2:4) (105.19 and 106.23, respectively) when compared to pigeonpea + foxtail millet (2:4) (113.46 and 115.26, respectively) which was on par with pigeonpea + sorghum (2:4) (110.14 and 111.08, respectively). However, among the fertility levels, 100 % RDF to both component crops (113.18 and 114.77, respectively) recorded significantly higher number leaves per plant when compared to 50 % RDF to both component crops (106.51 and 108.05, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (110.22 and 111.77, respectively). The pooled mean revealed that among strip cropped treatments significantly higher number of leaves per plant was recorded with pigeonpea + foxtail millet (2:4) (114.36) when compared to pigeonpea + pearl millet (2:4) (105.71) and was on par with pigeonpea + sorghum (2:4) (110.61). The pooled mean indicated that among the fertility levels, 100 % RDF to both component crops (113.97) recorded significantly higher number of leaves per plant when compared to 50 % RDF to both component crops (107.28) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (111.00). Similar trend was followed at 120 DAS during both the years and pooled data.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (79.78 and 81.47, respectively) recorded on par number of leaves per plant with pigeonpea + sorghum (2:4) (75.85 and 77.88, respectively) and was significantly higher when compared to pigeonpea + pearl millet (2:4) (71.52 and 73.29, respectively). However, pigeonpea + pearl millet (2:4) recorded significantly lower number of leaves per plant over other strip cropping systems. Among the fertility levels, significantly higher number of leaves per plant was recorded with 100 % RDF to both component crops (80.74 and 81.41, respectively) when compared to 50 % RDF to both component crops (71.27 and 73.31, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (77.35 and 78.02, respectively) during both the years. Significantly lower number of leaves per plant was recorded with 50 % RDF to both component crops when compared to other fertility levels. The pooled data of two years indicated that pigeonpea + foxtail millet (2:4) (80.63)

Table 27. Number of leaves per plant of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Number of leaves per plant														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping System (M)															
M_1	20.27	21.07	20.67	76.68	77.98	77.11	110.14	111.08	110.61	130.57	131.49	131.03	75.85	77.88	76.87
M_2	19.45	20.32	19.88	73.05	74.42	73.74	105.19	106.23	105.71	124.35	126.06	125.21	71.72	73.29	72.51
M_3	21.60	22.59	22.10	79.16	80.26	79.71	113.46	115.26	114.36	133.30	135.55	134.92	79.78	81.47	80.63
S.Em.±	0.47	0.64	0.75	0.89	0.84	0.77	1.09	1.23	1.09	1.18	1.12	1.42	0.98	1.13	1.01
C.D. (P=0.05)	NS	NS	NS	3.50	3.30	3.04	4.29	4.82	4.30	4.62	4.38	5.57	3.85	4.45	3.95
Subplot :Fertility Levels (S)															
S_1	19.71	20.30	20.00	72.57	73.97	73.27	106.51	108.05	107.28	126.63	127.51	127.07	71.27	73.31	72.29
S_2	20.40	21.40	20.90	76.35	77.31	76.83	110.22	111.77	111.00	130.63	131.77	131.20	77.35	78.02	77.69
S_3	21.22	22.27	21.75	79.04	80.09	79.57	113.18	114.77	113.97	132.72	134.02	133.37	80.74	81.41	81.07
S.Em.±	0.45	0.51	0.61	1.10	1.06	0.97	1.16	1.13	1.07	1.25	1.31	1.27	1.91	1.41	1.34
C.D. (P=0.05)	NS	NS	NS	3.38	3.28	3.00	3.56	3.48	3.31	3.84	4.03	3.91	5.89	4.34	4.12
Interaction (M **x S**)															
S at the same M level															
S.Em+	0.78	0.89	1.05	1.90	1.84	1.68	2.00	1.95	1.86	2.16	3.26	2.20	3.31	2.44	2.32
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels															
S.Em+	0.91	1.10	1.30	2.09	2.02	1.85	2.28	3.31	2.15	2.46	2.52	2.62	3.45	2.68	2.53
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

recorded significantly higher number of leaves per plant when compared to pigeonpea + pearl millet (2:4) (72.51) which was found on par with pigeonepa + sorghum (2:4) (76.87). Among the fertility levels, 100 % RDF to both component crops (81.07) recorded on par number of leaves per plant with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (77.69) and was significantly higher when compared to 50 % RDF to both component crops (72.29) which recorded significantly lower number of leaves per plant over other two fertility levels.

The interaction effect of strip cropping and fertility levels on number leaves per plant of pigeonpea was found to be non significant at all the stages of crop growth during both the years and in pooled analysis.

4.2.1.3 Number of primary branches per plant

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the number of primary branches per plant at all the growth stages of pigeonpea except at 30 DAS as presented in Table 28**.** The number of primary branches per plant of pigeonpea did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Influence of strip cropping systems and fertility levels on number of primary branches per plant of pigeonpea was not significant at 30 DAS during both the years (2015 and 2016) and in pooled mean.

At 60 DAS, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (6.06 and 6.97, respectively) recorded significantly higher number of primary branches per plant when compared to pigeonpea + pearl millet (2:4) (4.95 and 5.22, respectively), and was on par with pigeonpea + sorghum (2:4) (5.59 and 6.15, respectively), during both the years. The significantly lower number of primary branches per plant was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher number of primary branches per plant was noticed with 100 % RDF to both component crops (6.18 and 6.90, respectively) when compared to 50 % RDF to both component crops (4.53 and 5.17, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (5.53 and 6.23, respectively). The pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (6.52) recorded significantly higher

number of primary branches per plant when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (5.09) and was found to be on par with pigeonpea with sorghum (2:4) (5.87). Application of 100 % RDF to both component crops (6.54) recorded significantly higher number of primary branches per plant in comparison with 50 % RDF to both component crops (2:4) (4.85) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (5.88).

At 90 DAS, during both the years, among the strip cropped treatments, significantly lower number of primary branches per plant was recorded with pigeonpea + pearl millet (2:4) (6.09 and 6.71, respectively) when compared to other strip cropped treatments of pigeonpea + foxtail millet (2:4) (7.91 and 8.79, respectively) and pigeonpea + sorghum (2:4) (7.19 and 7.97, respectively). However, significantly higher number of primary branches per plant was recorded with pigeonpea + foxtail millet (2:4) (7.91 and 8.79, respectively) and pigeonpea + sorghum (2:4) (7.19 and 7.97, respectively) which were on par with each other. However, among fertility levels, 50 % RDF to both component crops (6.09 and 6.83, respectively) recorded significantly lower number of primary branches per plant when compared to 100 % RDF to both component crops (7.85 and 8.64, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (7.15 and 8.07, respectively). While 100 % RDF to both component crops and 50 % RDF through organic + 50 % RDF through inorganic to both component crops were on par with each other with respect to number of primary branches per plant. The pooled mean revealed that among strip cropped treatments, significantly higher number of primary branches per plant was recorded with pigeonpea + foxtail millet (2:4) (8.35) when compared to pigeonpea + pearl millet (2:4) (6.40) and was on par with pigeonpea + sorghum (2:4) (7.58). With respect to fertility levels, 100 % RDF to both component crops (8.25) recorded significantly higher number of primary branches per plant when compared to 50 % RDF to both component crops (6.46) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (7.61). Similar trend was followed at 120 DAS during both the years and pooled data.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (12.53 and 13.02, respectively) recorded on par number of primary branches per plant with pigeonpea + sorghum (2:4) (11.68 and 12.66, respectively) and was significantly higher when compared to pigeonpea + pearl millet (2:4) (10.42 and

Table 28. Number of primary branches per plant of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Number of primary branches per plant														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping System (M)															
M_1	2.73	3.11	2.92	5.59	6.15	5.87	7.19	7.97	7.58	9.52	10.58	10.05	11.68	12.66	12.17
M_2	2.57	2.83	2.70	4.95	5.22	5.09	6.09	6.71	6.40	8.29	9.57	8.93	10.42	11.44	10.93
M_3	2.88	3.29	3.03	6.06	6.97	6.52	7.91	8.79	8.35	10.32	11.39	10.85	12.53	13.02	12.78
S.Em.±	0.25	0.19	0.17	0.16	0.20	0.22	0.26	0.29	0.27	0.26	0.23	0.27	0.29	0.14	0.20
C.D. (P=0.05)	NS	NS	NS	0.61	0.78	0.76	1.02	1.13	1.07	1.03	0.89	1.07	1.12	0.55	0.80
Subplot :Fertility Levels (S)															
S_1	2.50	2.81	2.66	4.53	5.17	4.85	6.09	6.83	6.46	8.30	8.69	8.50	10.08	11.43	10.76
S_2	2.73	3.00	2.87	5.53	6.23	5.88	7.15	8.07	7.61	9.54	10.55	10.05	11.52	12.65	12.23
S_3	2.95	3.30	3.13	6.18	6.90	6.54	7.85	8.64	8.25	10.51	11.79	11.15	12.68	13.47	13.08
S.Em.±	0.13	0.13	0.11	0.29	0.32	0.30	0.32	0.37	0.36	0.38	0.56	0.49	0.43	0.35	0.29
C.D. (P=0.05)	NS	NS	NS	0.89	0.99	0.92	1.00	1.15	1.10	1.16	1.72	1.51	1.32	1.09	0.90
Interaction (M **x S**)															
S at the same M level															
S.Em+	0.22	0.22	0.39	0.50	0.56	0.52	0.56	0.64	0.62	0.65	0.97	0.85	0.74	0.61	0.51
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels															
S.Em+	0.33	0.29	0.48	0.53	0.61	0.56	0.62	0.70	0.67	0.70	0.99	0.89	0.79	0.63	0.54
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

11.44, respectively). The strip cropped treatment of pigeonpea + pearl millet (2:4) recorded significantly lower number of primary branches per plant over other treatments. Among fertility levels, significantly higher number of primary branches per plant was recorded with 100 % RDF to both component crops (12.68 and 13.47, respectively) when compared to 50 % RDF to both component crops (10.08 and 11.43, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (11.52 and 12.65, respectively) during both the years. Significantly lower number of primary branches per plant was recorded with 50 % RDF to both component crops when compared to other two fertility levels. The pooled data of two years indicated that pigeonpea + foxtail millet (2:4) (12.78) recorded significantly higher number of primary branches per plant when compared to pigeonpea + pearl millet (2:4) (10.93) and was found on par with pigeonpea + sorghum (2:4) (12.17). Among the fertility levels, 100 % RDF to both component crops (13.08) was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (12.23) and was significantly higher when compared to 50 % RDF to both component crops (10.76).

The interaction effect of strip cropping systems and fertility levels did not influence significantly the number of primary branches per plant of pigeonpea at all the stages of crop growth.

4.2.1.4 Number of secondary branches per plant

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the number of secondary branches per plant at all the growth stages of pigeonpea (120 DAS and harvest) except at 90 DAS as presented in Table 29**.** The number of secondary branches per plant of pigeonpea did not differ significantly at 90 DAS, but differed significantly at 120 DAS and harvest.

At 120 DAS, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (7.12 and 7.39, respectively) recorded significantly higher number of secondary branches per plant when compared to pigeonpea + pearl millet (2:4) (6.47 and 6.69, respectively), and was on par with pigeonpea + sorghum (2:4) (6.96 and 7.27, respectively), during both the years. The significantly lower number of secondary branches per plant was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher number of secondary branches per

plant was noticed with 100 % RDF to both component crops (7.22 and 7.47, respectively) when compared to 50 % RDF to both component crops (6.28 and 6.48, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (6.89 and 7.21, respectively). The pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (7.25) recorded significantly higher number of secondary branches per plant when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (6.58) and was found to be on par with pigeonpea with sorghum (2:4) (7.11). Application of 100 % RDF to both component crops (7.34) recorded significantly higher number of secondary branches per plant in comparison with 50 % RDF to both component crops (2:4) (6.38) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (7.05).

At harvest, during both the years, among the strip cropped treatments, significantly lower number of secondary branches per plant was recorded with pigeonpea + pearl millet (2:4) (8.28 and 8.45, respectively) when compared to other strip cropped treatments of pigeonpea + foxtail millet (2:4) (8.98 and 9.25, respectively) and pigeonpea + sorghum (2:4) (8.86 and 9.08, respectively). However, significantly higher number of secondary branches per plant was recorded with pigeonpea + foxtail millet (2:4) (8.98 and 9.25, respectively) and pigeonpea + sorghum (2:4) (8.86 and 9.08, respectively) which were on par with each other. However, among fertility levels, 50 % RDF to both component crops (8.02 and 8.28, respectively) recorded significantly lower number of secondary branches per plant when compared to 100 % RDF to both component crops (9.12 and 9.42, respectively) which was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (8.80 and 9.00, respectively). The pooled mean revealed that among strip cropped treatments, significantly higher number of secondary branches per plant was recorded with pigeonpea + foxtail millet (2:4) (9.12) when compared to pigeonpea + pearl millet (2:4) (8.37) and was on par with pigeonpea + sorghum (2:4) (8.97). With respect to fertility levels, 100 % RDF to both component crops (9.27) recorded significantly higher number of secondary branches per plant when compared to 50 % RDF to both component crops (8.15) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (8.90).

The interaction effect of strip cropping systems and fertility levels did not influence significantly the number of secondary branches per plant of pigeonpea at all the stages of crop growth.

Table 29. Number of secondary branches per plant of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Number of secondary branches per plant								
	90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping System (M)									
M_1	5.77	5.94	5.85	6.96	7.27	7.11	8.86	9.08	8.97
M_2	5.48	5.51	5.50	6.47	6.69	6.58	8.28	8.45	8.37
M_3	5.92	6.04	5.98	7.12	7.39	7.25	8.98	9.25	9.12
S.Em.±	0.08	0.07	0.08	0.09	0.13	0.12	0.12	0.14	0.12
C.D. (P=0.05)	NS	NS	NS	0.36	0.50	0.49	0.49	0.56	0.46
Subplot :Fertility Levels (S)									
S_1	5.18	5.26	5.22	6.28	6.48	6.38	8.02	8.28	8.15
S_2	5.89	5.95	5.89	6.89	7.21	7.05	8.80	9.00	8.90
S_3	6.10	6.28	6.19	7.22	7.47	7.34	9.12	9.42	9.27
S.Em.±	0.23	0.20	0.21	0.17	0.20	0.19	0.22	0.21	0.21
C.D. (P=0.05)	NS	NS	NS	0.54	0.62	0.58	0.68	0.65	0.63
Interaction (M **x S**)									
S at the same M level									
S.Em+	0.39	0.35	0.36	0.30	0.35	0.32	0.38	0.37	0.35
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels									
S.Em+	0.40	0.36	0.37	0.32	0.37	0.35	0.40	0.39	0.38
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

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

The results of the investigation indicated that the strip cropping and fertility levels had significant influence on leaf area at all the growth stages of pigeonpea except 30 DAS as presented in Table 30 and fig 13**.** Leaf area of pigeonpea did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Non significant effect due to different strip cropping systems and fertility levels on leaf area per plant of pigeonpea was noticed at 30 DAS during both the years (2015 and 2016) and in the pooled data.

During both the years (2015 and 2016), at 60 DAS, pigeonpea + foxtail millet (2:4) (12.11 and 12.49 dm^2 $plant^{-1}$, respectively) recorded significantly higher leaf area than pigeonepea + pearl millet (2:4) (9.59 and 9.86 dm^2 $plant^{-1}$, respectively) but was found on par with pigeonepea + sorghum (2:4) (10.99 and 11.25 dm^2 $plant^{-1}$, respectively). Among fertility levels, significantly higher leaf area (12.02 and 12.45 dm^2 $plant^{-1}$, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (9.68 and 10.30 dm^2 $plant^{-1}$, respectively) and found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (11.10 and 11.46 dm^2 $plant^{-1}$, respectively) during both the years. Among the strip cropping systems, pooled mean indicated that strip cropping of pigeonpea with foxtail millet (2:4) recorded significantly higher leaf area (12.31 dm^2 $plant^{-1}$) when compared to intercropped treatment of pigeonpea with pearl millet (2:4) (9.73 dm^2 $plant^{-1}$) and was found to be on par with pigeonpea with sorghum (2:4) (11.12 dm^2 $plant^{-1}$). With respect to fertility levels, 100 % RDF to both component crops (12.24 dm^2 $plant^{-1}$) recorded significantly higher leaf area when compared to 50 % RDF to both component crops (9.99 dm^2 $plant^{-1}$) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (11.28 dm^2 $plant^{-1}$).

At 90 DAS, during both the years, among the strip cropped treatments, pigeonpea + foxtail millet (2:4) (23.75 and 24.14 dm^2 $plant^{-1}$, respectively) and pigeonpea + sorghum (2:4) (22.23 and 22.51 dm^2 $plant^{-1}$, respectively) recorded significantly higher leaf area when compared to pigeonpea + pearl millet (2:4) (20.19 and 20.52 dm^2 $plant^{-1}$, respectively) and were on par with each other. However, among fertility levels, 100 % RDF to both component crops (23.28 and 23.68 dm^2 $plant^{-1}$, respectively) and 50 % RDF

through organic + 50 % RDF through inorganic to both component crops (22.40 and 22.65 dm^2 $plant^{-1}$, respectively) recorded significantly higher leaf area when compared to 50 % RDF to both component crops (20.94 and 21.29 dm^2 $plant^{-1}$, respectively) and were on par with each other. The pooled mean revealed that among strip cropped treatments, significantly lower leaf area was recorded with pigeonpea + pearl millet (2:4) (20.36 dm^2 $plant^{-1}$) when compared to pigeonpea + foxtail millet (2:4) (23.95 dm^2 $plant^{-1}$) and pigeonpea + sorghum (2:4) (22.37 dm^2 $plant^{-1}$) which were on par with each other. However, among fertility levels, 50 % RDF to both component crops (21.12 dm^2 $plant^{-1}$) recorded significantly lowerleaf area when compared to 100 % RDF to both component crops (23.48 dm^2 $plant^{-1}$) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (22.53 dm^2 $plant^{-1}$) which were on par with each other. Similar trend was followed at 120 DAS during both the years (2015 and 2016) and in pooled mean.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (7.46 and 7.90 dm^2 $plant^{-1}$, respectively) and pigeonpea + sorghum (2:4) (6.72 and 7.13 dm^2 $plant^{-1}$, respectively) recorded on par leaf area with each other and were significantly higher when compared to pigeonpea + pearl millet (2:4) (5.79 and 6.19 dm^2 $plant^{-1}$, respectively). During both the years, pigeonpea + pearl millet (2:4) recorded significantly lower leaf area over other strip cropped systems. Among fertility levels significantly higher leaf area was recorded with 100 % RDF to both component crops (7.36 and 7.75 dm^2 $plant^{-1}$, respectively) over 50 % RDF to both component crops (5.95 and 6.43 dm^2 $plant^{-1}$, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (6.75 and 7.19 dm^2 $plant^{-1}$, respectively). Significantly lower leaf area was recorded with 50 % RDF to both component crops (5.95 and 6.43 dm^2 $plant^{-1}$, respectively) when compared to other fertility levels. The pooled mean indicated that pigeonpea + foxtail millet (2:4) (7.68 dm^2 $plant^{-1}$) recorded significantly higher leaf area when compared to pigeonpea + pearl millet (2:4) (5.99 dm^2 $plant^{-1}$) and was found to be on par with pigeonpea + sorghum (2:4) (6.92 dm^2 $plant^{-1}$). Among fertility levels, 100 % RDF to both component crops (7.55 dm^2 $plant^{-1}$) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (6.97 dm^2 $plant^{-1}$) recorded on par leaf area and were significantly higher when compared to 50 % RDF to both component crops (6.19 dm^2 $plant^{-1}$).

Table 30. Leaf area of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Leaf area (dm^2 $plant^{-1}$)														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Main plot :Strip cropping System (M)															
M_1	4.68	5.10	4.89	10.99	11.25	11.12	22.23	22.51	22.37	15.94	16.27	16.11	6.72	7.13	6.92
M_2	4.24	4.59	4.41	9.59	9.86	9.73	20.19	20.52	20.36	14.20	14.58	14.39	5.79	6.19	5.99
M_3	5.28	5.78	5.53	12.11	12.49	12.31	23.75	24.14	23.95	17.39	17.82	17.60	7.46	7.90	7.68
S.Em.±	0.31	0.24	0.31	0.35	0.32	0.33	0.47	0.47	0.47	0.42	0.41	0.42	0.20	0.22	0.20
C.D. (P=0.05)	NS	NS	NS	1.38	1.27	1.31	1.86	1.85	1.84	1.65	1.60	1.63	0.80	0.88	0.79
Subplot :Fertility Levels (S)															
S_1	4.45	4.74	4.60	9.68	10.30	9.99	20.94	21.29	21.12	15.01	15.06	15.04	5.95	6.43	6.19
S_2	4.70	5.13	4.92	11.10	11.46	11.28	22.40	22.65	22.53	16.05	16.41	16.23	6.75	7.19	6.97
S_3	5.04	5.60	5.32	12.02	12.45	12.24	23.28	23.68	23.48	16.96	17.51	17.24	7.36	7.75	7.55
S.Em.±	0.21	0.25	0.26	0.43	0.38	0.42	0.43	0.38	0.39	0.31	0.41	0.34	0.25	0.20	0.24
C.D. (P=0.05)	NS	NS	NS	1.34	1.16	1.29	1.33	1.17	1.21	0.97	1.26	1.06	0.76	0.62	0.73
Interaction (M **x S**)															
S at the same M level															
S.Em+	0.36	0.55	0.45	0.75	0.65	0.72	0.75	0.66	0.68	0.55	0.71	0.60	0.43	0.35	0.41
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels															
S.Em+	0.47	0.64	0.54	0.83	0.73	0.80	0.89	0.81	0.83	0.69	0.82	0.73	0.48	0.42	0.46
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

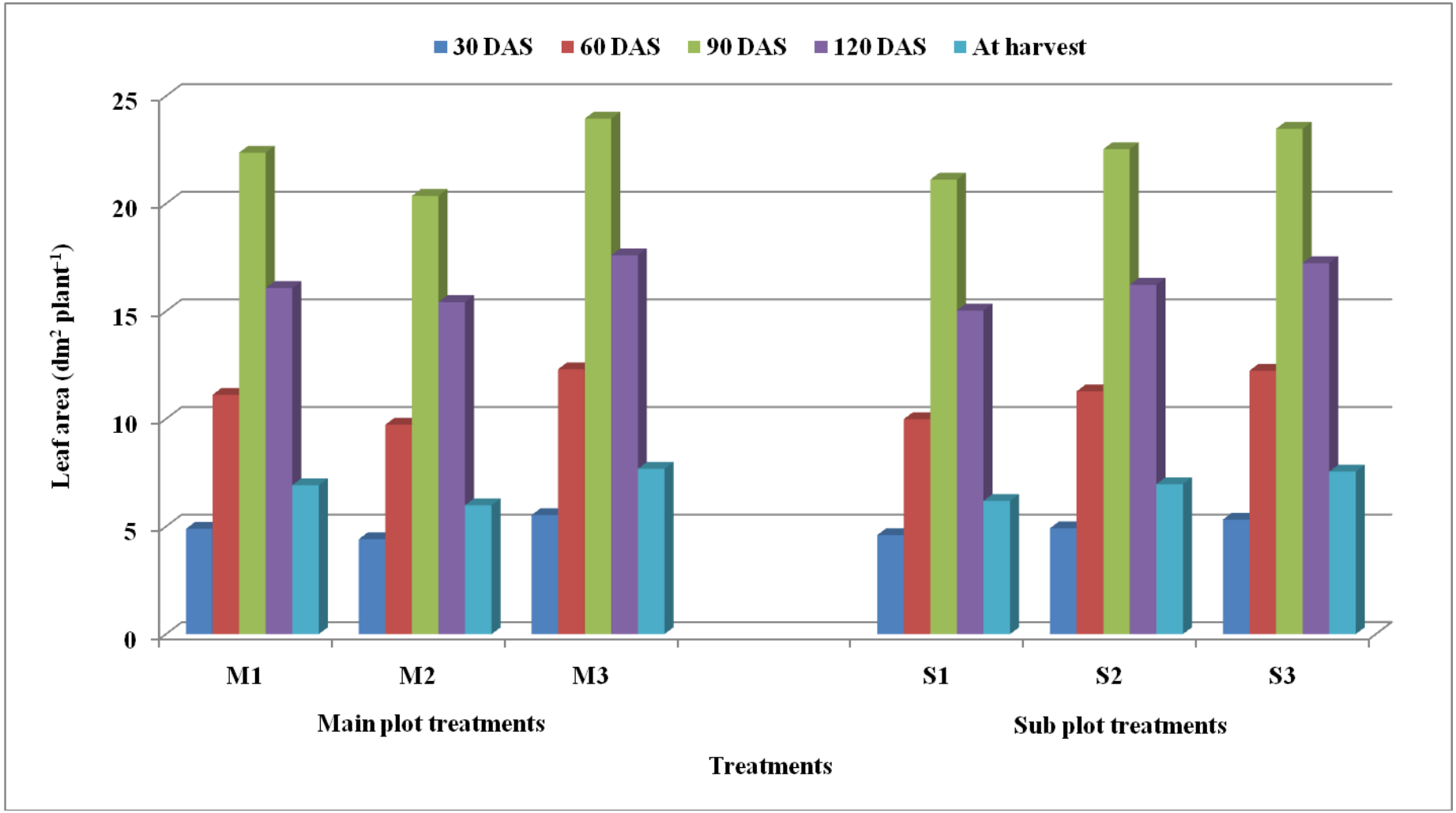

Fig 13. Leaf area plant^{-1} of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

However, significantly lower leaf area was recorded by 50 % RDF to both component crops over other fertility levels.

The interaction effect of strip cropping systems and fertility levels on plant height of pigeonpea was found to be non significant at all the stages of crop growth.

4.2.1.6 Leaf area index

The results of the study revealed that the strip cropping and fertility levels had significant influence on the leaf area index at all the growth stages of pigeonpea except at 30 DAS as presented in Table 31 and fig 14**.** However, leaf area index of pigeonpea did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Effect of strip cropping systems and combinations of fertility levels did not cause significant difference on leaf area index of pigeonpea at 30 DAS during both the years and in pooled data.

At 60 DAS, during both the years (2015 and 2016), among strip cropped treatments, pigeonepea + foxtail millet (2:4) (0.449 and 0.463, respectively) recorded significantly higher leaf area index when compared to pigeonpea + pearl millet (2:4) (0.355 and 0.365, respectively) and was on par with pigeonpea + sorghum (2:4) (0.407 and 0.417, respectively). Among different fertility levels, significantly higher leaf area index (0.445 and 0.461, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (0.359 and 0.381, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.411 and 0.424, respectively) during both the years. The pooled data of two years indicated that strip cropping of pigeonpea with foxtail millet (2:4) (0.456) recorded significantly higher leaf area index when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (0.360) and was found to be on par with pigeonpea with sorghum (2:4) (0.412). However, application of 100 % RDF to both component crops (0.453) recorded significantly higher leaf area index in comparison with 50 % RDF to both component crops (2:4) (0.370) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.418).

At 90 DAS, during both the years (2015 and 2016), among the strip cropped treatments, significantly lower leaf area index was recorded with pigeonpea + pearl millet

(2:4) (0.748 and 0.760, respectively) when compared to pigeonpea + foxtail millet (2:4) (0.880 and 0.894, respectively) which was on par with pigeonpea + sorghum (2:4) (0.823 and 0.834, respectively). However, among the fertility levels 100 % RDF to both component crops (0.862 and 0.877, respectively) recorded significantly higher leaf area index when compared to 50 % RDF to both component crops (0.776 and 0.789, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.830 and 0.839, respectively). The pooled mean revealed that among strip cropped treatments significantly higher leaf area index was recorded with pigeonpea + foxtail millet (2:4) (0.887) when compared to pigeonpea + pearl millet (2:4) (0.754) and was on par with pigeonpea + sorghum (2:4) (0.829). However, 100 % RDF to both component crops (0.870) recorded significantly higher leaf area index when compared to 50 % RDF to both component crops (0.783) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.835). Similar trend was followed at 120 DAS during both the years and in pooled data.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (0.276 and 0.293, respectively) recorded on par leaf area index with pigeonpea + sorghum (2:4) (0.249 and 0.264, respectively) and was significantly higher when compared to pigeonpea + pearl millet (2:4) (0.214 and 0.229, respectively). However, pigeonpea + pearl millet (2:4) recorded significantly lower leaf area index over other strip cropping systems. Among the fertility levels, significantly higher leaf area index was recorded with 100 % RDF to both component crops (0.0.273 and 0.287, respectively) when compared to 50 % RDF to both component crops (0.220 and 0.238, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.250 and 0.266, respectively) during both the years. Significantly lower leaf area index was recorded with 50 % RDF to both component crops when compared to other fertility levels. The pooled data of two years indicated that pigeonpea + foxtail millet (2:4) (0.285) recorded significantly higher leaf area index when compared to pigeonpea + pearl millet (2:4) (0.222) and was found on par with pigeonpea + sorghum (2:4) (0.257). Among the fertility levels, 100 % RDF to both component crops (0.280) recorded on par leaf area index with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.258) and was significantly higher when

compared to 50 % RDF to both component crops (0.229) which recorded significantly lower leaf area index over other two fertility levels.

Table 31. Leaf area index of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Leaf area index														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping System (M)															
M_1	0.173	0.189	0.181	0.407	0.417	0.412	0.823	0.834	0.829	0.590	0.603	0.597	0.249	0.264	0.257
M_2	0.157	0.170	0.164	0.355	0.365	0.360	0.748	0.760	0.754	0.526	0.540	0.533	0.214	0.229	0.222
M_3	0.196	0.214	0.205	0.449	0.463	0.456	0.880	0.894	0.887	0.644	0.660	0.652	0.276	0.293	0.285
S.Em.±	0.014	0.016	0.014	0.014	0.016	0.014	0.018	0.020	0.019	0.018	0.018	0.018	0.008	0.008	0.009
C.D. (P=0.05)	NS	NS	NS	0.044	0.048	0.045	0.058	0.061	0.059	0.055	0.058	0.056	0.028	0.030	0.032
Subplot :Fertility Levels (S)															
S_1	0.165	0.176	0.171	0.359	0.381	0.370	0.776	0.789	0.783	0.556	0.558	0.557	0.220	0.238	0.229
S_2	0.174	0.190	0.182	0.411	0.424	0.418	0.830	0.839	0.835	0.594	0.608	0.601	0.250	0.266	0.258
S_3	0.187	0.207	0.197	0.445	0.461	0.453	0.862	0.877	0.870	0.628	0.649	0.639	0.273	0.287	0.280
S.Em.±	0.008	0.011	0.010	0.012	0.013	0.013	0.011	0.013	0.013	0.011	0.014	0.013	0.09	0.007	0.007
C.D. (P=0.05)	NS	NS	NS	0.037	0.039	0.038	0.035	0.040	0.036	0.035	0.042	0.039	0.024	0.022	0.023
Interaction (M **x S**)															
S at the same M level															
S.Em+	0.009	0.009	0.009	0.010	0.009	0.009	0.014	0.014	0.013	0.018	0.016	0.016	0.010	0.012	0.013
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels															
S.Em+	0.010	0.010	0.011	0.011	0.010	0.010	0.018	0.016	0.015	0.021	0.020	0.019	0.012	0.014	0.015
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

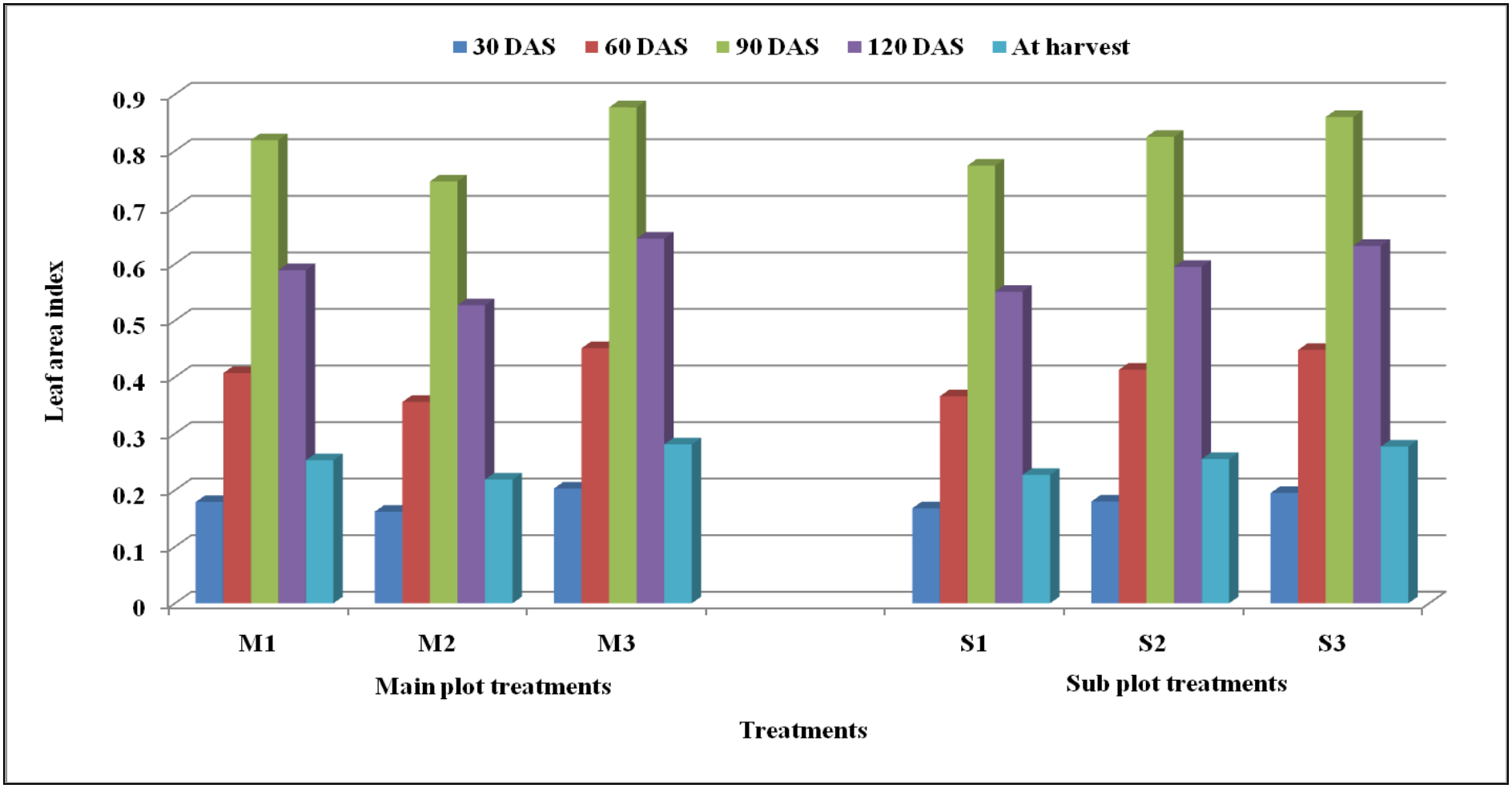

Fig. 14. Leaf area index of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

The interaction effect of strip cropping and fertility levels on leaf area index of pigeonpea was found to be non significant at all the stages of crop growth during both the years and in pooled analysis.

4.2.1.7 Dry matter accumulation in leaves (g plant^{-1})

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the dry matter accumulation in leaves at all the growth stages of pigeonpea except at 30 DAS, as presented in Table 32**.** The dry matter accumulation in leaves of pigeonpea did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Influence of strip cropping systems and fertility levels on dry matter accumulation in leaves of pigeonpea was not significant at 30 DAS during both the years (2015 and 2016) and in pooled mean.

At 60 DAS, among the strip cropped treatments, pigeonpea + foxtail millet (2:4) (4.09 and 4.30 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in leaves when compared to pigeonpea + pearl millet (2:4) (3.41 and 3.59 g plant^{-1}, respectively) and was on par with pigeonpea + sorghum (2:4) (3.84 and 4.01 g plant^{-1}, respectively), during both the years. The significantly lower dry matter accumulation in leaves was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher dry matter accumulation in leaves was noticed with 100 % RDF to both component crops (4.01 and 4.26 g plant^{-1}, respectively) when compared to 50 % RDF to both component crops (3.51 and 3.58 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (3.87 and 4.03 g plant^{-1}, respectively). The pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (4.19 g plant^{-1}) recorded significantly higher dry matter accumulation in leaves when compared to pigeonpea with pearl millet (2:4) (3.50 g plant^{-1}) and was found to be on par with pigeonpea with sorghum (2:4) (3.92 g plant^{-1}). Application of 100 % RDF to both component crops (4.13 g plant^{-1}) recorded significantly higher dry matter accumulation in leaves in comparison with 50 % RDF to both component crops (2:4) (3.55 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (3.95 g plant^{-1}).

At 90 DAS, during both the years, among the strip cropped treatments, significantly lower dry matter accumulation in leaves was recorded with pigeonpea + pearl millet (2:4) (9.23 and 9.89 g plant^{-1}, respectively) when compared to other strip cropped treatments of pigeonpea + foxtail millet (2:4) (10.21 and 10.73 g plant^{-1}, respectively) and pigeonpea + sorghum (2:4) (9.87 and 10.44 g plant^{-1}, respectively). However, significantly higher dry matter accumulation in leaves was recorded with pigeonpea + foxtail millet (2:4) which was on par with pigeonpea + sorghum (2:4). However, among fertility levels, 50 % RDF to both component crops (9.21 and 9.71 g plant^{-1}, respectively) recorded significantly lower dry matter accumulation in leaves when compared to 100 % RDF to both component crops (10.18 and 10.82 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (9.98 and 10.41 g plant^{-1}, respectively). The pooled mean revealed that among strip cropped treatments, significantly higher dry matter accumulation in leaves was recorded with pigeonpea + foxtail millet (2:4) (10.47 g plant^{-1}) when compared to pigeonpea + pearl millet (2:4) (9.56 g plant^{-1}) and was on par with pigeonpea + sorghum (2:4) (10.15 g plant^{-1}). However, pigeonpea + pearl millet (2:4) recorded significantly lower dry matter accumulation in leaves over other two strip cropped treatments. However among the fertility levels, 100 % RDF to both component crops (10.50 g plant^{-1}) recorded significantly higher dry matter accumulation in leaves when compared to 50 % RDF to both component crops (9.46 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (10.19 g plant^{-1}). Similar trend was followed at 120 DAS during both the years and pooled data.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (3.64 and 4.01 g plant^{-1}, respectively) recorded on par dry matter accumulation in leaves with pigeonpea + sorghum (2:4) (3.28 and 3.67 g plant^{-1}, respectively) and was significantly higher when compared to pigeonpea + pearl millet (2:4) (2.73 and 3.19 g plant^{-1}, respectively). Among the fertility levels, significantly higher dry matter accumulation in leaves was recorded with 100 % RDF to both component crops (3.62 and 3.98 g plant^{-1}, respectively) when compared to 50 % RDF to both component crops (2.89 and 3.02 g plant^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (3.30 and 3.62 g plant^{-1}, respectively) during both the years. Significantly lower dry matter accumulation in leaves was recorded with 50 % RDF to both component crops when

Table 32. Dry matter accumulation in leaves of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Dry matter accumulation in leaves (g plant^{-1})														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping Systems (M)															
M_1	2.44	2.80	2.62	3.84	4.01	3.92	9.87	10.44	10.15	7.94	8.51	8.23	3.28	3.67	3.47
M_2	2.38	2.61	2.50	3.41	3.59	3.50	9.23	9.89	9.56	7.01	7.69	7.35	2.73	3.19	2.96
M_3	2.61	2.93	2.77	4.09	4.30	4.19	10.21	10.73	10.47	8.48	9.09	8.78	3.64	4.01	3.83
S.Em.±	0.13	0.16	0.13	0.09	0.09	0.09	0.13	0.13	0.12	0.22	0.18	0.24	0.09	0.11	0.12
C.D. (P=0.05)	NS	NS	NS	0.34	0.36	0.35	0.51	0.50	0.48	0.86	0.71	0.93	0.40	0.42	0.46
Subplot :Fertility Levels (S)															
S_1	2.32	2.60	2.46	3.51	3.58	3.55	9.21	9.71	9.46	7.15	7.69	7.42	2.89	3.02	2.96
S_2	2.47	2.78	2.63	3.87	4.03	3.95	9.98	10.41	10.19	7.94	8.54	8.24	3.30	3.62	3.46
S_3	2.64	2.96	2.80	4.01	4.26	4.13	10.18	10.82	10.50	8.33	8.84	8.59	3.62	3.98	3.80
S.Em.±	0.12	0.13	0.12	0.09	0.11	0.08	0.19	0.21	0.19	0.22	0.23	0.19	0.12	0.17	0.14
C.D. (P=0.05)	NS	NS	NS	0.26	0.34	0.26	0.60	0.64	0.57	0.67	0.72	0.58	0.36	0.51	0.45
Interaction (M **x S**)															
S at the same M level															
S.Em+	0.21	0.23	0.21	0.15	0.19	0.15	0.34	0.36	0.32	0.38	0.40	0.33	0.20	0.41	0.25
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M at the same or different S levels															
S.Em+	0.25	0.28	0.24	0.17	0.21	0.17	0.36	0.38	0.34	0.43	0.44	0.40	0.23	0.43	0.28
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

compared to other two fertility levels. The pooled data of two years indicated that pigeonpea + foxtail millet (2:4) (3.83 g plant^{-1}) recorded significantly higher dry matter accumulation in leaves when compared to pigeonpea + pearl millet (2:4) (2.96 g plant^{-1}) and was found on par with pigeonpea + sorghum (2:4) (3.47 g plant^{-1}). Among the fertility levels, 100 % RDF to both component crops (3.80 g plant^{-1}) recorded on par dry matter accumulation in leaves with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (3.46 g plant^{-1}) and was significantly higher when compared to 50 % RDF to both component crops (2.96 g plant^{-1}).

The interaction effect of strip cropping and fertility levels did not influence significantly the dry matter accumulation in leaves of pigeonpea at all the stages of crop growth during both the years and in pooled mean.

4.2.1.8 Dry matter accumulation in stem (g plant^{-1})

The results of the investigation indicated that the strip cropping and fertility levels had significant influence on the dry matter accumulation in stem at all the growth stages of pigeonpea except at 30 DAS, as presented in Table 33**.** The dry matter accumulation in stem of pigeonpea did not differ significantly at 30 DAS, but differed significantly at 60, 90, 120 DAS and harvest.

Non significant effect due to the effect of strip cropping and fertility levels on dry matter accumulation in stem was noticed at 30 DAS during both the years and in the pooled data.

During both the years (2015 and 2016), at 60 DAS, pigeonpea + foxtail millet (2:4) (11.23 and 11.96 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem than pigeonpea + pearl millet (2:4) (10.25 and 10.72 g plant^{-1}, respectively) but was found on par with pigeonepea + sorghum (2:4) (10.89 and 11.46 g plant^{-1} respectively). Among fertility levels, significantly higher dry matter accumulation in stem (11.52 and 11.92 g plant^{-1}, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (9.94 and 10.70 g plant^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (10.91 and 11.52 g plant^{-1}, respectively) during both the years. Among the strip cropping systems, the pooled mean indicated that strip cropping of pigeonpea with foxtail millet (2:4) recorded significantly higher dry

matter accumulation in stem (11.60 g plant^{-1}) when compared to intercropped treatment of pigeonpea with pearl millet (2:4) (10.49 g plant^{-1}) and was found to be on par with pigeonpea with sorghum (2:4) (11.17 g plant^{-1}). With respect to fertility levels, 100 % RDF to both component crops (11.72 g plant^{-1}) recorded significantly higher dry matter accumulation in stem when compared to 50 % RDF to both component crops (10.32 g plant^{-1}) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (11.22 g plant^{-1}).

At 90 DAS, during both the years, among the strip cropped treatments, pigeonpea + foxtail millet (2:4) (30.22 and 31.57 g plant^{-1}, respectively) and pigeonpea + sorghum (2:4) (26.36 and 28.22 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem when compared to pigeonpea + pearl millet (2:4) (21.14 and 23.31 g plant^{-1}, respectively) and were on par with each other. However, significantly lower dry matter accumulation in stem was recorded with pigeonpea + pearl millet (2:4) over other strip cropped systems. However, among fertility levels, 100 % RDF to both component crops (29.95 and 32.45 g plant^{-1}, respectively) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (26.67 and 28.70 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem when compared to 50 % RDF to both component crops (21.10 and 22.55 g plant^{-1}, respectively) and were on par with each other. However, significantly lower dry matter accumulation in stem was recorded by 50 % RDF to both component crops over other fertility levels. The pooled mean revealed that among strip cropped treatments significantly lower dry matter accumulation in stem was recorded with pigeonpea + pearl millet (2:4) (22.22 g plant^{-1}) when compared to pigeonpea + foxtail millet (2:4) (31.20 g plant^{-1}) and pigeonpea + sorghum (2:4) (27.29 g plant^{-1}) which were on par with each other. However, among fertility levels, 50 % RDF to both component crops (21.83 g plant^{-1}) recorded significantly lower dry matter accumulation in stem when compared to 100 % RDF to both component crops (31.20 g plant^{-1}) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (27.69 g plant^{-1}) which were on par with each other. Similar trend was followed at 120 DAS during both the years (2015 and 2016) and in pooled mean.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (67.17 and 70.49 g plant^{-1}, respectively) and pigeonpea + sorghum (2:4) (60.13 and 62.70 g plant^{-1}, respectively) recorded on par dry matter accumulation in

Table 33. Dry matter accumulation in stem of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Dry matter accumulation in stem (g plant^{-1})														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Main plot :Strip cropping Systems (M)															
M_1	2.40	2.62	2.51	10.89	11.46	11.17	26.36	28.22	27.29	31.43	34.32	32.87	60.13	62.70	61.41
M_2	2.31	2.54	2.43	10.25	10.72	10.49	21.14	23.31	22.22	25.07	27.40	26.23	51.24	53.28	52.26
M_3	2.49	2.77	2.63	11.23	11.96	11.60	30.22	31.57	31.20	36.78	40.63	38.70	67.17	70.49	68.83
S.Em.±	0.06	0.14	0.07	0.14	0.13	0.13	1.42	1.17	1.38	1.46	1.68	1.67	2.32	2.04	1.99
C.D. (P=0.05)	NS	NS	NS	0.54	0.502	0.51	5.59	4.61	5.42	5.96	6.87	6.57	8.34	8.11	7.81
Subplot :Fertility Levels (S)															
S_1	2.28	2.51	2.39	9.94	10.70	10.32	21.10	22.55	21.83	24.51	27.03	25.77	51.07	53.49	52.28
S_2	2.38	2.61	2.50	10.91	11.52	11.22	26.67	28.70	27.69	31.74	34.41	33.07	60.08	62.53	61.31
S_3	2.54	2.82	2.68	11.52	11.92	11.72	29.95	32.45	31.20	37.02	40.91	38.96	67.39	70.45	68.92
S.Em.±	0.13	0.11	0.11	0.20	0.23	0.19	1.10	1.40	1.17	2.09	2.15	1.63	2.67	2.76	2.56
C.D. (P=0.05)	NS	NS	NS	0.62	0.70	0.59	3.40	4.30	3.41	7.12	6.65	6.02	7.70	8.56	7.96
Interaction (M **x S**)															
S at the same M level															
S.Em+	0.22	0.19	0.19	0.35	0.39	0.30	1.91	2.02	2.03	2.53	3.37	2.82	3.56	3.77	3.65
CD (P=0.05)	NS	NS	NS	NS	NS	NS	5.89	6.45	6.25	7.78	10.38	8.70	10.61	11.61	11.52
M at the same or different S levels															
S.Em+	0.23	0.24	0.20	0.38	0.41	0.33	2.01	2.25	2.45	2.94	3.92	3.28	4.22	4.18	4.16
CD (P=0.05)	NS	NS	NS	NS	NS	NS	6.50	6.75	7.56	9.06	12.07	10.11	12.63	12.89	12.81

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

stem with each other and were significantly higher when compared to pigeonpea + pearl millet (2:4) (51.24 and 53.28 g plant^{-1}, respectively). During both the years, pigeonpea + pearl millet (2:4) recorded significantly lower dry matter accumulation in stem over other strip cropped systems. Among fertility levels, significantly higher dry matter accumulation in stem was recorded with 100 % RDF to both component crops (67.39 and 70.45 g plant^{-1}, respectively) over 50 % RDF to both component crops (51.07 and 53.49 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (60.08 and 62.53 g plant^{-1}, respectively). Significantly lower dry matter accumulation in stem was recorded with 50 % RDF to both component crops when compared to other strip cropped systems. The pooled mean indicated that pigeonpea + foxtail millet (2:4) (68.83 g plant^{-1}) recorded significantly higher dry matter accumulation in stem when compared to pigeonpea + pearl millet (2:4) (52.26 g plant^{-1}) and was found to be on par with pigeonepa + sorghum (2:4) (61.41 g plant^{-1}). Among fertility levels, 100 % RDF to both component crops (68.92 g plant^{-1}) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (61.31 g plant^{-1}) recorded on par dry matter accumulation in stem were significantly higher when compared to 50 % RDF to both component crops (52.28 g plant^{-1}). However, significantly lower dry matter accumulation in stem was recorded by 50 % RDF to both component crops.

The interaction effect of strip cropping systems and fertility levels on dry matter accumulation in stem was significant at 90, 120 and at harvest during both the years and in pooled mean.

At 90 DAS, the pooled mean indicated that interaction effect of pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (35.67 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem compared to other treatment interactions *viz*., pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (24.26 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (17.60 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (21.18 g plant^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (24.63 g plant^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (21.45 g plant^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF

Table 33a. Dry matter accumulation in stem of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at 90 DAS

Treatments	Dry matter accumulation in stem (g plant^{-1}) at 90 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	21.45	28.09	29.55	26.36	22.34	30.27	32.04	28.21	21.90	29.18	30.80	27.29
M_2	17.60	21.18	24.63	21.14	20.18	22.63	27.13	23.31	18.89	21.91	25.88	22.22
M_3	24.26	30.75	35.67	30.22	25.14	33.21	38.19	31.57	24.70	31.98	36.93	31.20
Mean	21.10	26.67	29.95		22.55	28.70	32.18		21.83	27.69	31.20	

	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Strip cropping (M)	1.42	5.59	1.17	4.61	1.38	5.42
Fertility levels (S)	1.10	3.40	1.40	4.30	1.17	3.41
S at the same M level	1.91	5.89	2.02	6.45	2.03	6.25
M at the same or different S levels	2.01	6.50	2.25	6.75	2.45	7.56

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 33b. Dry matter accumulation in stem of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at 120 DAS

Treatments	Dry matter accumulation in stem (g plant^{-1}) at 120 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	25.12	31.93	37.24	31.43	27.44	34.26	41.24	34.32	26.28	33.10	39.24	32.87
M_2	21.22	25.01	28.97	25.07	23.22	27.34	31.64	27.40	22.22	26.17	30.30	26.23
M_3	27.19	38.29	44.85	36.78	30.42	41.62	49.85	40.63	28.80	39.95	47.35	38.70
Mean	24.51	31.74	37.02		27.03	34.41	40.91		25.77	33.07	38.96	

	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Strip cropping (M)	1.46	5.96	1.68	6.87	1.67	6.57
Fertility levels (S)	2.09	7.12	2.15	6.65	1.63	6.02
S at the same M level	2.53	7.78	3.37	10.38	2.82	8.70
M at the same or different S levels	2.94	9.06	3.92	12.07	3.28	10.11

Main plot:

M_1- Pigeonpea + Sorghum (2:4)

M_2- Pigeonpea + Pearl millet (2:4)

M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot

S_1-50 % RDF to both component crops

S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops

S_3-100 % RDF to both component crops

Table 33c. Dry matter accumulation in stem of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at harvest

Treatments	Dry matter accumulation in stem (g plant^{-1}) at harvest											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	51.33	62.04	67.01	60.13	53.64	64.34	70.11	62.70	52.49	63.19	68.56	61.41
M_2	43.41	50.54	59.78	51.24	45.12	52.21	62.52	53.28	44.26	51.37	61.15	52.26
M_3	58.47	67.67	75.38	67.17	61.71	71.04	78.71	70.49	60.09	69.36	77.04	68.83
Mean	51.07	60.08	67.39		53.49	62.53	70.45		52.28	61.31	68.92	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	2.32		8.34		2.04		8.11		1.99		7.81	
Fertility levels (S)	2.67		7.70		2.76		8.56		2.56		7.96	
S at the same M level	3.56		10.61		3.77		11.61		3.65		11.52	
M at the same or different S levels	4.22		12.63		4.18		12.89		4.16		12.81	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

through inorganic to both component crops (28.09 g plant^{-1}) and was on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (30.75 g plant^{-1}, respectively) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (29.55 g plant^{-1}) (Table 33a).

At 120 DAS, the pooled mean revealed that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (47.35 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in stem compared to other interactions *viz.*, pigeonpea + foxtail millet(2:4) with 50 % RDF to both component crops (28.80 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (22.22 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (26.17 g plant^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (30.30 g plant^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (26.28 g plant^{-1}) and pigeonpea + sorghum(2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (33.10 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (39.95 g plant^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (39.24 g plant^{-1}) (Table 33b). Similar trend was followed at harvest during both the years (2015 and 2016) and in pooled mean (33c).

4.2.1.9 Dry matter accumulation in reproductive parts (g plant^{-1})

The results of the study revealed that the strip cropping and fertility levels had significant influence on the dry matter accumulation in reproductive parts at all the growth stages of pigeonpea as presented in Table 34**.** The dry matter accumulation in reproductive parts of pigeonpea differed significantly at 90, 120 DAS and harvest.

At 90 DAS, during both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (2.54 and 2.81 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in reproductive parts when compared to pigeonpea + pearl millet (2:4) (2.10 and 2.24 g plant^{-1}, respectively) and was on par with pigeonpea + sorghum (2:4) (2.37 and 2.59 g plant^{-1}, respectively). The significantly lower dry matter accumulation in reproductive parts was recorded by pigeonpea + pearl millet (2:4) over other two strip cropping systems during both the

years. Among different fertility levels, significantly higher dry matter accumulation in reproductive parts (2.75 and 2.90 g plant^{-1}, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (2.02 and 2.13 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (2.34 and 2.53 g plant^{-1}, respectively) during both the years. While, significantly lower dry matter accumulation in reproductive parts was observed with 50 % RDF to both component crops during both the years over other two fertility levels. The pooled data of two years indicated that strip cropping of pigeonpea with foxtail millet (2:4) (2.65 g plant^{-1}) recorded significantly higher dry matter accumulation in reproductive parts when compared to pigeonpea with pearl millet (2:4) (2.17 g plant^{-1}) and was found to be on par with pigeonpea with sorghum (2:4) (2.48 g plant^{-1}). However, application of 100 % RDF to both component crops (2.82 g plant^{-1}) recorded significantly higher dry matter accumulation in reproductive parts in comparison with 50 % RDF to both component crops (2:4) (2.08 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (2.44 g plant^{-1}).

At 120 DAS, during both the years (2015 and 2016), among the strip cropped treatments, significantly lower dry matter accumulation in reproductive parts was recorded with pigeonpea + pearl millet (2:4) (5.76 and 6.88 g plant^{-1}, respectively) when compared to pigeonpea + foxtail millet (2:4) (10.37 and 11.76 g plant^{-1}, respectively) which was on par with pigeonpea + sorghum (2:4) (8.76 and 10.04 g plant^{-1}, respectively). However, among the fertility levels, 100 % RDF to both component crops (10.62 and 12.10 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in reproductive parts when compared to 50 % RDF to both component crops (5.53 and 6.54 g plant^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (8.73 and 10.03 g plant^{-1}, respectively). While 50 % RDF to both component crops recorded significantly lower dry matter accumulation in reproductive parts over other fertility levels. The pooled mean revealed that among strip cropped treatments, significantly higher dry matter accumulation in reproductive parts was recorded with pigeonpea + foxtail millet (2:4) (11.06 g plant^{-1}) when compared to pigeonpea + pearl millet (2:4) (6.32 g plant^{-1}) and was on par with pigeonpea + sorghum (2:4) (9.40 g plant^{-1}). However, pigeonpea + pearl millet (2:4) recorded significantly lower dry matter accumulation in reproductive parts

Table 34. Dry matter accumulation in reproductive parts of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Dry matter accumulation in reproductive parts (g plant^{-1})								
	90 DAS			120 DAS			At harvest		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Main plot :Strip cropping System (M)									
M_1	2.37	2.59	2.48	8.76	10.04	9.40	18.26	19.38	18.82
M_2	2.10	2.24	2.17	5.76	6.88	6.32	15.12	16.37	15.75
M_3	2.54	2.81	2.65	10.37	11.76	11.06	20.09	21.62	20.85
S.Em.±	0.08	0.08	0.05	0.65	0.78	0.72	0.71	0.70	0.70
C.D. (P=0.05)	0.30	0.31	0.21	2.57	3.07	2.81	2.79	2.77	2.75
Subplot :Fertility Levels (S)									
S_1	2.02	2.13	2.08	5.53	6.54	6.03	13.84	14.90	14.37
S_2	2.34	2.53	2.44	8.73	10.03	9.38	18.09	19.35	18.72
S_3	2.75	2.90	2.82	10.62	12.10	11.36	21.54	23.12	22.33
S.Em.±	0.10	0.13	0.13	0.66	0.84	0.71	1.13	1.24	1.18
C.D. (P=0.05)	0.29	0.38	0.38	2.04	2.78	2.18	3.49	3.84	3.65
Interaction (M **x S**)									
S at the same M level									
S.Em+	0.15	0.20	0.16	0.85	1.00	1.05	1.96	2.16	2.05
CD (P=0.05)	NS	NS	NS	2.54	3.08	3.24	6.04	6.65	6.32
M at the same or different S levels									
S.Em+	0.17	0.22	0.17	1.01	1.27	1.27	1.81	2.01	1.83
CD (P=0.05)	NS	NS	NS	3.08	3.45	3.92	5.43	6.21	6.01

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

over other two strip cropped treatments. With regard to fertility levels, the pooled mean indicated that 100 % RDF to both component crops (11.36 g plant^{-1}) recorded significantly higher dry matter accumulation in reproductive parts when compared to 50 % RDF to both component crops (6.03 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (9.38 g plant^{-1}). Significantly lower dry matter accumulation in reproductive parts was recorded with 50 % RDF to both component crops over other fertility levels. Similar trend was followed at harvest during both the years and in pooled data.

The interaction effect of strip cropping systems and fertility levels on dry matter accumulation in reproductive parts was significant at 120 DAS and harvest during both the years and pooled mean (Table 34a and 34b).

At 120 DAS, the pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (13.67 g plant^{-1}, respectively) recorded significantly higher dry matter accumulation in reproductive parts compared to the other treatment interactions *viz.*, pigeonpea + foxtail millet(2:4) with 50 % RDF to both component crops (7.41 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (4.44 g plant^{-1}), pigeonpea + pearl millet(2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (6.16 g plant^{-1}), pigeonpea + pearl millet(2:4) with 100 % RDF to both component crops (8.35 g plant^{-1}) and pigeonpea + sorghum(2:4) with 50 % RDF to both component crops (6.25 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (12.11 g plant^{-1}), pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (12.07 g plant^{-1}, respectively) and pigeonpea + sorghum(2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (9.87 g plant^{-1}).

At harvest, the pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (25.06 g plant^{-1}) recorded significantly higher dry matter accumulation in reproductive parts compared to the other treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (15.28 g plant^{-1}), pigeonpea + pearl millet(2:4) with 50 % RDF to both component crops (13.76 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (14.94 g plant^{-1}), pigeonpea + pearl millet

Table 34a. Dry matter accumulation in reproductive parts of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at 120 DAS

Treatments	Dry matter accumulation in reproductive parts at 120 DAS (g plant^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	5.86	9.11	11.30	8.76	6.65	10.63	12.83	10.04	6.25	9.87	12.07	9.40
M_2	3.88	5.60	7.79	5.76	4.99	6.72	8.92	6.88	4.44	6.16	8.35	6.32
M_3	6.84	11.49	12.78	10.37	7.99	12.73	14.55	11.76	7.41	12.11	13.67	11.06
Mean	5.53	8.73	10.62		6.54	10.03	12.10		6.03	9.38	11.36	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	0.65		2.57		0.78		3.07		0.72		2.81	
Fertility levels (S)	0.66		2.04		0.84		2.78		0.71		2.18	
S at the same M level	0.85		2.54		1.00		3.08		1.05		3.24	
M at the same or different S levels	1.01		3.08		1.27		3.45		1.27		3.92	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 34b. Dry matter accumulation in reproductive parts of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at harvest

Treatments	Dry matter accumulation in reproductive parts at harvest (g plant^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	13.70	18.37	22.71	18.26	14.44	19.62	24.08	19.38	14.07	18.99	23.40	18.82
M_2	13.12	14.37	17.88	15.12	14.41	15.51	19.19	16.37	13.76	14.94	18.53	15.75
M_3	14.71	21.52	24.03	20.09	15.84	22.91	26.09	21.62	15.28	22.22	25.06	20.85
Mean	13.84	18.09	21.54		14.90	19.35	23.12		14.37	18.72	22.33	

	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Strip cropping (M)	0.71	2.79	0.70	2.77	0.70	2.75
Fertility levels (S)	1.13	3.49	1.24	3.84	1.18	3.65
S at the same M level	1.96	6.04	2.16	6.65	2.05	6.32
M at the same or different S levels	1.81	5.43	2.01	6.21	1.83	6.01

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

(2:4) with 100 % RDF to both component crops (18.53 g plant^{-1}) and pigeonpea + sorghum with 50 % RDF to both component crops (14.07 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (22.22 g plant^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (23.40 g plant^{-1}, respectively).

4.2.1.10 Dry matter production (g plant^{-1})

The results of the study revealed that the strip cropping and fertility levels had significant influence on the dry matter production at all the growth stages of pigeonpea except 30 DAS as presented in Table 35 and fig 15**.**

Effect of strip cropping systems and fertility levels did not cause significant difference on dry matter production of pigeonpea at 30 DAS during both the years and in pooled data.

At 60 DAS, during both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (15.32 and 16.26 g plant^{-1}, respectively) recorded significantly higher dry matter production when compared to pigeonpea + pearl millet (2:4) (13.88 and 14.53 g plant^{-1}, respectively) and was on par with pigeonpea + sorghum (2:4) (14.72 and 15.47 g plant^{-1}, respectively). The significantly lower dry matter production per plant was recorded by pigeonepa + pearl millet (2:4) over other two strip cropping systems during both the years. Among different fertility levels, significantly higher dry matter production (15.53 and 16.18 g plant^{-1}, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (13.61 and 14.52 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (14.78 and 15.55 g plant^{-1}, respectively) during both the years. While, significantly lower dry matter production was observed with 50 % RDF to both component crops during both the years over other two fertility levels. The pooled data of two years indicated that strip cropping of pigeonpea with foxtail millet (2:4) (15.79 g plant^{-1}) recorded significantly higher dry matter production when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (14.20 g plant^{-1}) and was found to be on par with pigeonpea with sorghum (2:4) (15.10 g plant^{-1}). However, application of 100 % RDF to both component crops (15.86 g plant^{-1}) recorded significantly higher dry matter production in comparison with

Table 35. Dry matter production of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Dry matter production (g plant^{-1})														
	30 DAS			60 DAS			90 DAS			120 DAS			At harvest		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Main plot :Strip cropping System (M)															
M_1	4.84	5.42	5.13	14.72	15.47	15.10	38.60	41.24	39.92	48.12	52.86	50.49	81.66	85.74	83.70
M_2	4.69	5.15	4.92	13.88	14.53	14.20	32.75	35.60	34.18	38.14	41.96	40.05	69.45	72.90	71.17
M_3	5.10	5.71	5.40	15.32	16.26	15.79	42.97	45.67	44.32	55.62	61.47	58.55	90.91	96.11	93.51
S.Em.±	0.16	0.19	0.10	0.25	0.24	0.27	1.47	1.46	1.45	2.54	2.96	2.34	2.73	3.45	2.71
C.D. (P=0.05)	NS	NS	NS	0.98	0.93	1.06	5.78	5.74	4.51	7.62	9.21	8.46	10.74	11.86	10.44
Subplot :Fertility Levels (S)															
S_1	4.60	5.11	4.85	13.61	14.52	14.07	32.56	34.68	33.62	37.50	41.48	39.49	68.00	71.71	69.85
S_2	4.85	5.40	5.12	14.78	15.55	15.17	38.99	41.64	40.31	48.42	52.97	50.69	81.48	85.49	83.48
S_3	5.18	5.78	5.48	15.53	16.18	15.86	42.77	46.20	44.48	55.97	61.85	58.91	92.55	97.55	95.05
S.Em.±	0.24	0.16	0.17	0.37	0.31	0.28	1.52	1.41	1.47	2.91	3.05	2.58	3.01	3.95	3.87
C.D. (P=0.05)	NS	NS	NS	1.13	0.95	0.86	4.55	4.34	4.36	8.73	9.08	8.56	11.45	13.23	12.89
Interaction (M **x S**)															
S at the same M level															
S.Em+	42	0.28	0.29	0.63	0.53	0.48	1.99	2.44	1.89	3.78	3.54	4.48	3.75	3.81	3.64
CD (P=0.05)	NS	NS	NS	NS	NS	NS	6.16	7.52	5.81	11.65	10.91	13.81	11.55	11.74	11.22
M at the same or different S levels															
S.Em+	45	0.34	0.31	0.68	0.58	0.55	2.48	2.85	2.16	4.04	3.86	4.87	4.64	4.81	4.36
CD (P=0.05)	NS	NS	NS	NS	NS	NS	7.65	8.77	6.66	12.46	11.91	15.00	14.30	13.60	13.45

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

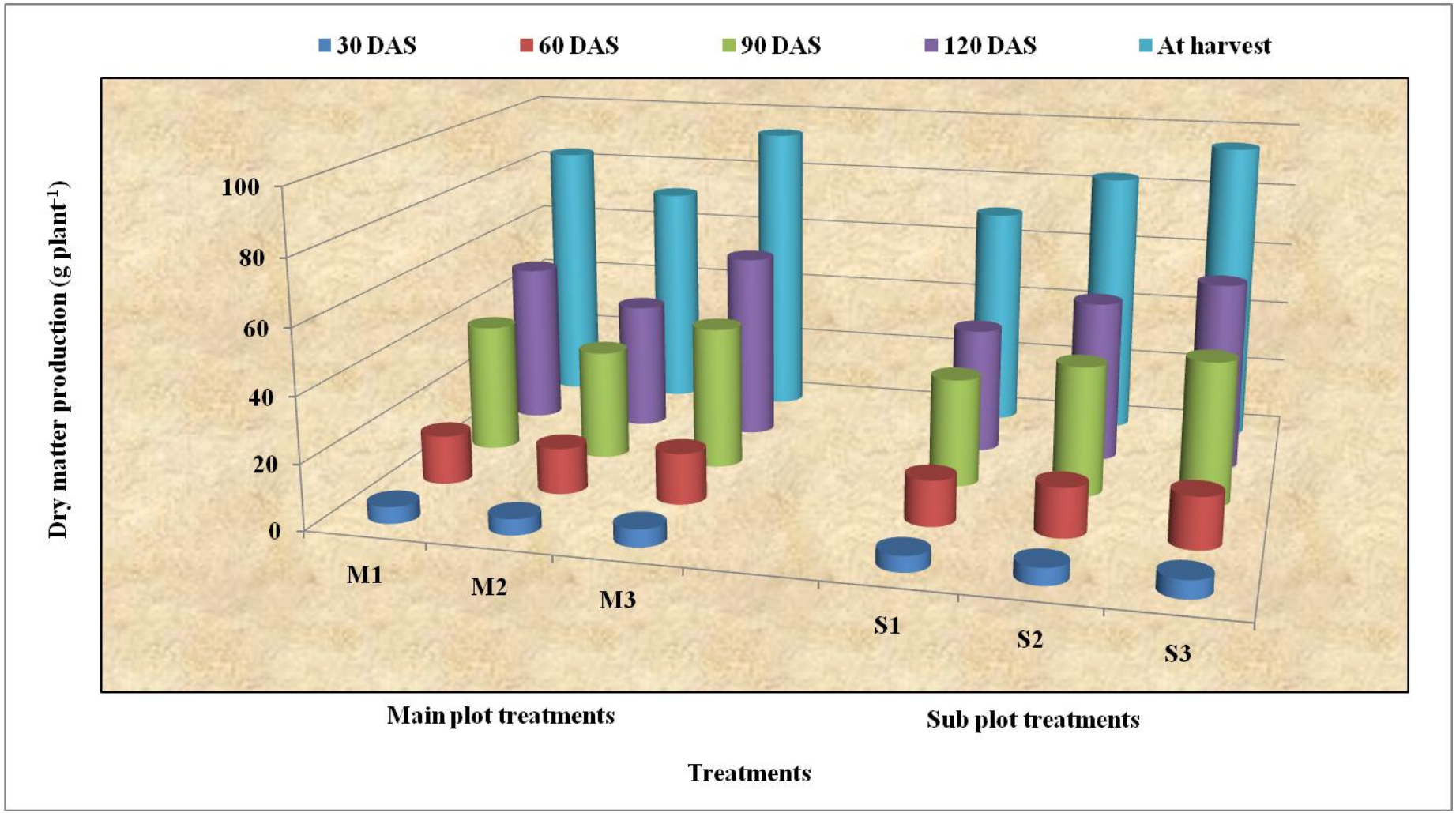

Fig. 15. Dry matter production of pigeonpea at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

50 % RDF to both component crops (2:4) (14.07 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (15.17 g plant^{-1}).

At 90 DAS, during both the years (2015 and 2016), among the strip cropped treatments, significantly lower dry matter production was recorded with pigeonpea + pearl millet (2:4) (32.75 and 35.60 g plant^{-1}, respectively) when compared to strip cropped treatments of pigeonpea + foxtail millet (2:4) (42.97 and 45.67 g plant^{-1}, respectively) and pigeonpea + sorghum (2:4) (38.60 and 41.24 g plant^{-1}, respectively) which were on par with each other. However, among the fertility levels, 100 % RDF to both component crops (42.77 and 46.20 g plant^{-1}, respectively) recorded significantly higher dry matter production when compared to 50 % RDF to both component crops (32.56 and 34.68 g plant^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (38.99 and 41.64 g plant^{-1}, respectively). While 50 % RDF to both component crops recorded significantly lower dry matter production over other fertility levels. The pooled mean revealed that among strip cropped treatments, significantly higher dry matter production was recorded with pigeonpea + foxtail millet (2:4) (44.32 g plant^{-1}) when compared to pigeonpea + pearl millet (2:4) (34.18 g plant^{-1}) and was on par with pigeonpea + sorghum (2:4) (39.92 g plant^{-1}). However, pigeonpea + pearl millet (2:4) recorded significantly lower dry matter production over other two strip cropped treatments. The pooled mean indicated that among the fertility levels, 100 % RDF to both component crops (44.48 g plant^{-1}) recorded significantly higher dry matter production when compared to 50 % RDF to both component crops (33.62 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (40.31 g plant^{-1}). Significantly lower dry matter production was recorded with 50 % RDF to both component crops over other fertility levels. Similar trend was followed at 120 DAS during both the years and in pooled data.

At harvest, during both the years, among strip cropped treatments, pigeonpea + foxtail millet (2:4) (90.91 and 96.11 g plant^{-1}, respectively) recorded on par dry matter production with pigeonpea + sorghum (2:4) (81.66 and 85.74 g plant^{-1}, respectively) and both were significantly higher when compared to pigeonpea + pearl millet (2:4) (69.45 and 72.90 g plant^{-1}, respectively). However, pigeonpea + pearl millet (2:4) recorded

significantly lower dry matter production over other strip cropping systems. Among the fertility levels significantly higher dry matter production was recorded with 100 % RDF to both component crops (92.55 and 97.55 g plant^{-1}, respectively) when compared to 50 % RDF to both component crops (68.00 and 71.71 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (81.48 and 85.49 g plant^{-1}, respectively) during both the years. The pooled data of two years indicated that pigeonpea + foxtail millet (2:4) (93.51 g plant^{-1}) recorded significantly higher dry matter production when compared to pigeonpea + pearl millet (2:4) (71.17 g plant^{-1}) and was found on par with pigeonpea + sorghum (2:4) (83.70 g plant^{-1}). Among the fertility levels, 100 % RDF to both component crops (95.05 g plant^{-1}) recorded on par dry matter production with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (83.48 g plant^{-1}) and both were significantly higher when compared to 50 % RDF to both component crops (69.85 g plant^{-1}).

The interaction effect of strip cropping and fertility levels on dry matter production of pigeonpea was found to be significant at 90, 120 DAS and harvest.

At 90 DAS, the interaction effect of strip cropping systems and fertility levels on dry matter production was significant during both the years and in pooled mean as presented in Table 35a. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (50.74 g plant^{-1}) recorded significantly higher dry matter production compared to the other treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (37.12 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (29.85 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (34.06 g plant^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (38.63 g plant^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (33.90 g plant^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (41.78 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (45.11 g plant^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (44.08 g plant^{-1}).

At 120 DAS, the interaction effect of strip cropping systems and fertility levels on dry matter production was significant during both the years and in pooled mean as

presented in Table 35b. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (70.23 g plant^{-1}) recorded significantly higher dry matter production in comparison to treatment interactions *viz.*, pigeonpea + foxtail millet with 50 % RDF to both component crops (44.61 g plant^{-1}), pigeonpea + pearl millet with 50 % RDF to both component crops (33.54 g plant^{-1}), pigeonpea + pearl millet with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (39.94 g plant^{-1}), pigeonpea + pearl millet with 100 % RDF to both component crops (46.68 g plant^{-1}), pigeonpea + sorghum with 50 % RDF to both component crops (40.32 g plant^{-1}) and pigeonpea + sorghum with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (51.34 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (60.81 g plant^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (59.82 g plant^{-1}).

At harvest, the interaction effect of strip cropping systems and fertility levels on dry matter production was significant during both the years and in pooled mean as presented in Table 35c. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (106.28 g plant^{-1}) recorded significantly higher dry matter production when compared to the other treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (78.89 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (60.94 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (69.48 g plant^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (83.10 g plant^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (69.73 g plant^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (85.62 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (95.35 g plant^{-1}) and pigeonpea + sorghum (2:4) with100 % RDF to both component crops (95.76 g plant^{-1}).

Table 35a. Dry matter production of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at 90 DAS

Treatments	Dry matter production (g plant^{-1}) at 90 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	33.08	40.37	42.35	38.60	34.72	43.19	45.82	41.24	33.90	41.78	44.08	39.92
M_2	28.16	33.03	37.06	32.75	31.53	35.08	40.19	35.60	29.85	34.06	38.63	34.18
M_3	36.43	43.58	48.90	42.97	37.81	46.64	52.58	45.67	37.12	45.11	50.74	44.32
Mean	32.56	38.99	42.77		34.68	41.64	46.20		33.62	40.31	44.48	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	1.47		5.78		1.46		5.54		1.45		4.51	
Fertility levels (S)	1.52		4.55		1.41		4.34		1.47		4.36	
S at the same M level	1.99		6.16		2.44		7.52		1.89		5.81	
M at the same or different S levels	2.48		7.65		2.85		8.77		2.16		6.66	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 35b. Dry matter production of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at 120 DAS

Treatments	Dry matter production (g plant^{-1}) at 120 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	38.56	49.04	56.77	48.12	42.09	53.63	62.87	52.86	40.32	51.34	59.82	50.49
M_2	31.73	38.02	44.68	38.14	35.34	41.86	48.69	41.96	33.54	39.94	46.68	40.05
M_3	42.22	58.19	66.47	55.62	47.00	63.43	73.99	61.47	44.61	60.81	70.23	58.55
Mean	37.50	48.42	55.97		41.48	52.97	61.85		39.49	50.69	58.91	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	2.54		7.62		2.96		9.21		2.34		8.46	
Fertility levels (S)	2.91		8.73		3.05		9.08		2.58		8.56	
S at the same M level	3.78		11.65		3.54		10.91		4.48		13.81	
M at the same or different S levels	4.04		12.46		3.86		11.91		4.87		15.00	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 35c. Dry matter production of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system at harvest

Treatments	Dry matter production (g plant^{-1}) at harvest											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	68.05	83.63	93.31	81.66	71.41	87.61	98.21	85.74	69.73	85.62	95.76	83.70
M_2	59.44	67.99	80.92	69.45	62.44	70.97	85.28	72.90	60.94	69.48	83.10	71.17
M_3	76.50	92.81	103.41	90.91	81.28	97.89	109.16	96.11	78.89	95.35	106.28	93.51
Mean	68.00	81.48	92.55		71.71	85.49	97.55		69.85	83.48	95.05	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	2.73		10.73		3.45		11.86		2.71		10.44	
Fertility levels (S)	3.01		11.45		3.95		13.23		3.87		12.89	
S at the same M level	3.75		11.55		3.81		11.74		3.64		11.22	
M at the same or different S levels	4.64		14.30		4.41		13.60		4.36		13.45	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

4.2.2 Yield and yield parameters of pigeonpea

4.2.2.1 Number of pods per plant

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the number of pods per plant of pigeonpea as presented in Table 36 and fig 16.

Influence of strip cropping systems and fertility levels on number of pods per plant of pigeonpea was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (79.88 and 80.77, respectively) recorded significantly higher number of pods per plant when compared to pigeonpea + pearl millet (2:4) (70.51 and 71.42, respectively), and was on par with pigeonpea + sorghum (2:4) (75.67 and 76.41, respectively). The significantly lower number of pods per plant was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher number of pods per plant was noticed with 100 % RDF to both component crops (79.28 and 80.23, respectively) when compared to 50 % RDF to both component crops (70.53 and 71.21, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.26 and 77.15, respectively). While, significantly lower number of pods per plant was observed with 50 % RDF to both component crops over other two fertility levels during both the years.

The pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (80.33) recorded significantly higher number of pods per plant when compared to strip cropped treatments of pigeonpea with pearl millet (2:4) (70.97) and was found to be on par with pigeonpea with sorghum (2:4) (76.04). Application of 100 % RDF to both component crops (79.76) recorded significantly higher number of pods per plant in comparison with 50 % RDF to both component crops (2:4) (70.87) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.70).

Table 36. Number of pods plant^{-1} of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Number of pods plant^{-1}											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	73.43	76.06	77.53	75.67	73.94	76.75	78.53	76.41	73.68	76.41	78.03	76.04
M_2	63.34	72.66	75.54	70.51	64.04	73.66	76.54	71.42	63.69	73.16	76.04	70.97
M_3	74.82	80.04	84.78	79.88	75.66	81.04	85.61	80.77	75.24	80.54	85.20	80.33
Mean	70.53	76.26	79.28		71.21	77.15	80.23		70.87	76.70	79.76	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	1.23		4.82		1.43		5.62		1.33		4.97	
Fertility levels (S)	1.69		5.19		1.66		5.13		1.66		5.12	
S at the same M level	2.63		8.18		2.88		8.89		2.73		8.02	
M at the same or different S levels	2.71		8.01		2.80		8.70		2.55		7.87	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

The interaction effect of strip cropping systems and fertility levels on number of pods per plant was significant during both the years and in pooled mean. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (85.20) recorded significantly higher number of pods per plant compared to the other treatments interactions *viz*., pigeonpea + foxtail millet with 50 % RDF to both component crops (75.24), pigeonpea + pearl millet with 50 % RDF to both component crops (63.69), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (73.16), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (76.04), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (73.68) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.41) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (80.54) and pigeonpea + sorghum (2:4) and 100 % RDF to both component crops (78.03).

4.2.2.2 Number of seeds per pod

Number of seeds per pod was not influenced significantly either by strip cropping systems or due to fertility levels and their interactions during both the years as well as in pooled data (Table 37).

4.2.2.3 Seed yield per plant (g)

The results of the study revealed that the strip cropping and fertility levels had significant influence on the seed yield per plant of pigeonpea during both the years (2015 and 2016) and in pooled mean as presented in Table 38 and fig 16**.**

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (22.02 and 22.60 g plant^{-1}, respectively) recorded significantly higher seed yield per plant when compared to pigeonpea + pearl millet (2:4) (19.45 and 19.82 g plant^{-1}, respectively) and was on par with pigeonpea + sorghum (2:4) (21.13 and 21.54 g plant^{-1}, respectively). The significantly lower seed yield per plant was recorded by pigeonpea + pearl millet (2:4) (19.26 and 19.45 g plant^{-1}, respectively) over other two strip cropping systems during both the years.

Table 37. Number of seeds pod^{-1} of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Number of seeds pod^{-1}											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	3.10	3.14	3.15	3.13	3.12	3.18	3.19	3.16	3.11	3.16	3.17	3.15
M_2	3.09	3.10	3.12	3.10	3.08	3.12	3.16	3.12	3.09	3.11	3.14	3.11
M_3	3.14	3.17	3.22	3.18	3.17	3.21	3.29	3.22	3.16	3.19	3.26	3.20
Mean	3.11	3.14	3.17		3.12	3.17	3.21		3.12	3.15	3.19	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	0.02		NS		0.03		NS		0.02		NS	
Fertility levels (S)	0.03		NS		0.03		NS		0.03		NS	
S at the same M level	0.05		NS		0.05		NS		0.04		NS	
M at the same or different S levels	0.05		NS		0.06		NS		0.05		NS	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 38. Seed yield plant^{-1} of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Seed yield plant^{-1} (g)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	19.87	21.21	22.31	21.13	20.27	21.38	22.98	21.54	20.07	21.30	22.65	21.34
M_2	17.91	20.00	20.44	19.45	18.28	20.34	20.86	19.82	18.09	20.17	20.65	19.64
M_3	20.70	21.92	23.43	22.02	21.29	22.60	23.93	22.60	20.99	22.26	23.68	22.31
Mean	19.49	21.04	22.06		19.94	21.44	22.59		19.72	21.24	22.33	

	S.Em.±	CD at 5%	S.Em.±	CD at 5%	S.Em.±	CD at 5%
Strip cropping (M)	0.41	1.62	0.47	1.62	0.42	1.64
Fertility levels (S)	0.41	1.26	0.43	1.31	0.39	1.19
S at the same M level	0.71	2.19	0.74	2.27	0.67	2.06
M at the same or different S levels	0.69	2.18	0.89	2.73	0.78	2.27

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Among different fertility levels significantly higher seed yield per plant (22.06 and 22.59 g plant^{-1}, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (19.49 and 19.94 g plant^{-1}, respectively) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (21.04 and 21.44 g plant^{-1}, respectively) during both the years.

Pooled data of two years indicated that strip cropping of pigeonpea with foxtail millet (2:4) (22.31 g plant^{-1}) recorded significantly higher seed yield per plant when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (19.64 g plant^{-1}) and was found to be on par with pigeonpea with sorghum (2:4) (21.34 g plant^{-1}). However, application of 100 % RDF to both component crops (22.33 g plant^{-1}) recorded significantly higher seed yield per plant in comparison with 50 % RDF to both component crops (2:4) (19.72 g plant^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (21.24 g plant^{-1}).

The interaction effect of strip cropping systems and fertility levels on seed yield per plant was significant during both the years and in pooled mean as presented in Table 37. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (23.60 g plant^{-1}) recorded significantly higher seed weight per plant compared to the other treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (20.99 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (18.09 g plant^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (20.17 g plant^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (20.65 g plant^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (20.07 g plant^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (21.30 g plant^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (22.26 g plant^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (22.65 g plant^{-1}).

4.2.2.4 Hundred seed weight

Hundred seed weight of pigeonpea recorded under strip cropping systems and fertility levels is presented in Table 39 and fig 16. Hundred seed weight was not influenced

Table 39. Hundred seed weight of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	100 seed weight (g)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	10.15	10.41	10.73	10.43	10.33	10.59	10.98	10.63	10.24	10.50	10.86	10.53
M_2	10.19	10.28	10.40	10.29	10.33	10.42	10.55	10.43	10.26	10.35	10.47	10.36
M_3	10.45	10.58	10.92	10.65	10.58	10.85	11.18	10.87	10.51	10.71	11.05	10.76
Mean	10.26	10.42	10.68		10.41	10.62	10.91		10.34	10.52	10.80	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	0.15		NS		0.17		NS		0.16		NS	
Fertility levels (S)	0.14		NS		0.14		NS		0.12		NS	
S at the same M level	0.24		NS		0.24		NS		0.22		NS	
M at the same or different S levels	0.28		NS		0.29		NS		0.27		NS	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

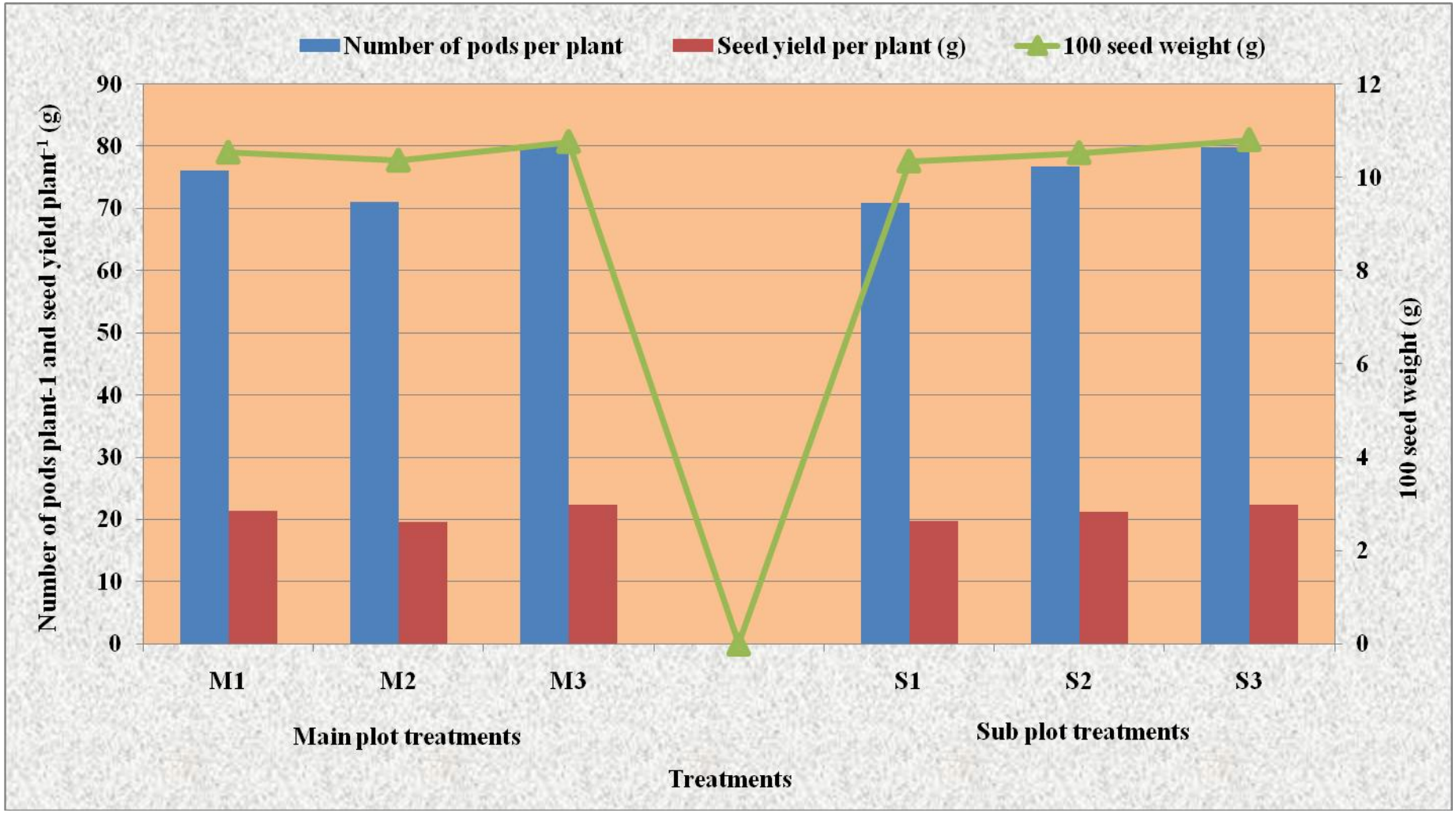

Fig. 16. Number of pods plant^{-1}, seed yield plant^{-1} and hundred seed weight of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutria-cereals (2:4) intercropping system

significantly either by strip cropping systems or due to fertility levels and their interactions during both the years as well as in pooled data.

4.2.2.5 Seed yield (kg ha^{-1})

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the seed yield of pigeonpea as presented in Table 40 and fig 17.

Influence of strip cropping systems and fertility levels on seed yield of pigeonpea was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (711 and 750 kg ha^{-1}, respectively) recorded significantly higher seed yield when compared to pigeonpea + pearl millet (2:4) (571 and 601 kg ha^{-1}, respectively), and was found on par with pigeonpea + sorghum (2:4) (660 and 694 kg ha^{-1}, respectively). The significantly lower seed yield was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher seed yield was noticed with 100 % RDF to both component crops (700 and 740 kg ha^{-1}, respectively) when compared to 50 % RDF to both component crops (580 and 615 kg ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (661 and 690 kg ha^{-1}, respectively) during both the years. While, significantly lower seed yield was observed with 50 % RDF to both component crops over other two fertility levels during both the years.

Pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (729 kg ha^{-1}) recorded significantly higher seed yield when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (586 kg ha^{-1}) and was found on par with pigeonpea with sorghum (2:4) (679 kg ha^{-1}). Application of 100 % RDF to both component crops (722 kg ha^{-1}) recorded significantly higher seed yield in comparison with 50 % RDF to both component crops (2:4) (598 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (674 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on seed yield was significant during both the years and in pooled mean. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (805 kg ha^{-1})

Table 40. Seed yield of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Seed yield (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	576	685	719	660	635	708	738	694	606	697	733	679
M_2	535	569	608	571	563	592	648	601	549	580	628	586
M_3	630	728	774	711	645	768	835	750	638	744	805	729
Mean	580	661	700		615	690	740		598	674	722	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	21		83		17		66		16		62	
Fertility levels (S)	20		62		20		62		18		54	
S at the same M level	32		98		35		107		30		93	
M at the same or different S levels	28		87		39		119		34		105	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

recorded significantly higher seed yield compared to other treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (638 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (549 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (580 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (628 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (606 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (697 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (744 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (733 kg ha^{-1}).

4.2.2.6 Stalk yield (kg ha^{-1})

The results of the study indicated that the strip cropping and fertility levels had significant influence on the stalk yield of pigeonpea during both the years (2015 and 2016) and in pooled mean as presented in Table 41 and fig 17**.**

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (1830 and 1933 kg ha^{-1}) recorded significantly higher stalk yield when compared to pigeonpea + pearl millet (2:4) (1574 and 1620 kg ha^{-1}) and was found on par with pigeonpea + sorghum (2:4) (1735 and 1794 kg ha^{-1}) respectively. The significantly lower stalk yield was recorded by pigeonpea + pearl millet (2:4) over other two strip cropping systems during both the years.

Among different fertility levels significantly higher stalk yield (1810 and 1895 kg ha^{-1}, respectively) was noticed with 100 % RDF to both component crops when compared to 50 % RDF to both component crops (1604 and 1667 kg ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1726 and 1785 kg ha^{-1}, respectively) during both the years. While, significantly lower stalk yield was observed with 50 % RDF to both component crops during both the years over other two fertility levels.

Pooled data of two years indicated that strip cropping of pigeonpea with foxtail millet (2:4) (1882 kg ha^{-1}) recorded significantly higher stalk yield when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (1597 kg ha^{-1}) and was found

Table 41. Stalk yield of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Stalk yield (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1638	1752	1815	1735	1678	1808	1894	1794	1658	1780	1855	1764
M_2	1492	1561	1670	1574	1552	1614	1695	1620	1522	1588	1682	1597
M_3	1682	1864	1944	1830	1772	1932	2096	1933	1727	1898	2020	1882
Mean	1604	1726	1810		1667	1785	1895		1636	1755	1852	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	33		131		48		189		37		144	
Fertility levels (S)	36		111		37		116		35		109	
S at the same M level	62		192		65		200		61		189	
M at the same or different S levels	61		190		81		249		71		220	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

to be on par with pigeonpea with sorghum (2:4) (1764 kg ha^{-1}). However, application of 100 % RDF to both component crops (1852 kg ha^{-1}) recorded significantly higher stalk yield in comparison with 50 % RDF to both component crops (2:4) (1636 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1755 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on stalk yield was significant during both the years and in pooled mean as presented in Table 41. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (2020 kg ha^{-1}) recorded significantly higher stalk yield compared to the other interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (1727 kg ha^{-1}), pigeonpea + pearl millet(2:4) with 50 % RDF to both component crops (1522 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1588 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (1682 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (1658 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1780 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1898 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (1855 kg ha^{-1}).

4.2.2.7 Husk yield (kg ha^{-1})

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the husk yield of pigeonpea as presented in Table 42 and fig 17.

Influence of strip cropping systems and fertility levels on husk yield of pigeonpea was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (517 and 579 kg ha^{-1}, respectively) recorded significantly higher husk yield when compared to pigeonpea + pearl millet (2:4) (402 and 427 kg ha^{-1}, respectively), and was found on par with pigeonpea + sorghum (2:4) (462 and 526 kg ha^{-1}, respectively). The significantly lower husk yield was recorded by pigeonpea + pearl

Table 42. Husk yield of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Husk yield (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	410	471	506	462	481	522	577	526	445	514	524	494
M_2	389	393	423	402	389	423	467	427	389	423	430	414
M_3	430	534	588	517	488	592	657	579	459	590	596	548
Mean	410	466	506		453	513	567		431	509	517	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	17		58		23		92		20		79	
Fertility levels (S)	18		55		18		57		11		34	
S at the same M level	34		104		32		98		19		59	
M at the same or different S levels	36		114		40		122		26		80	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

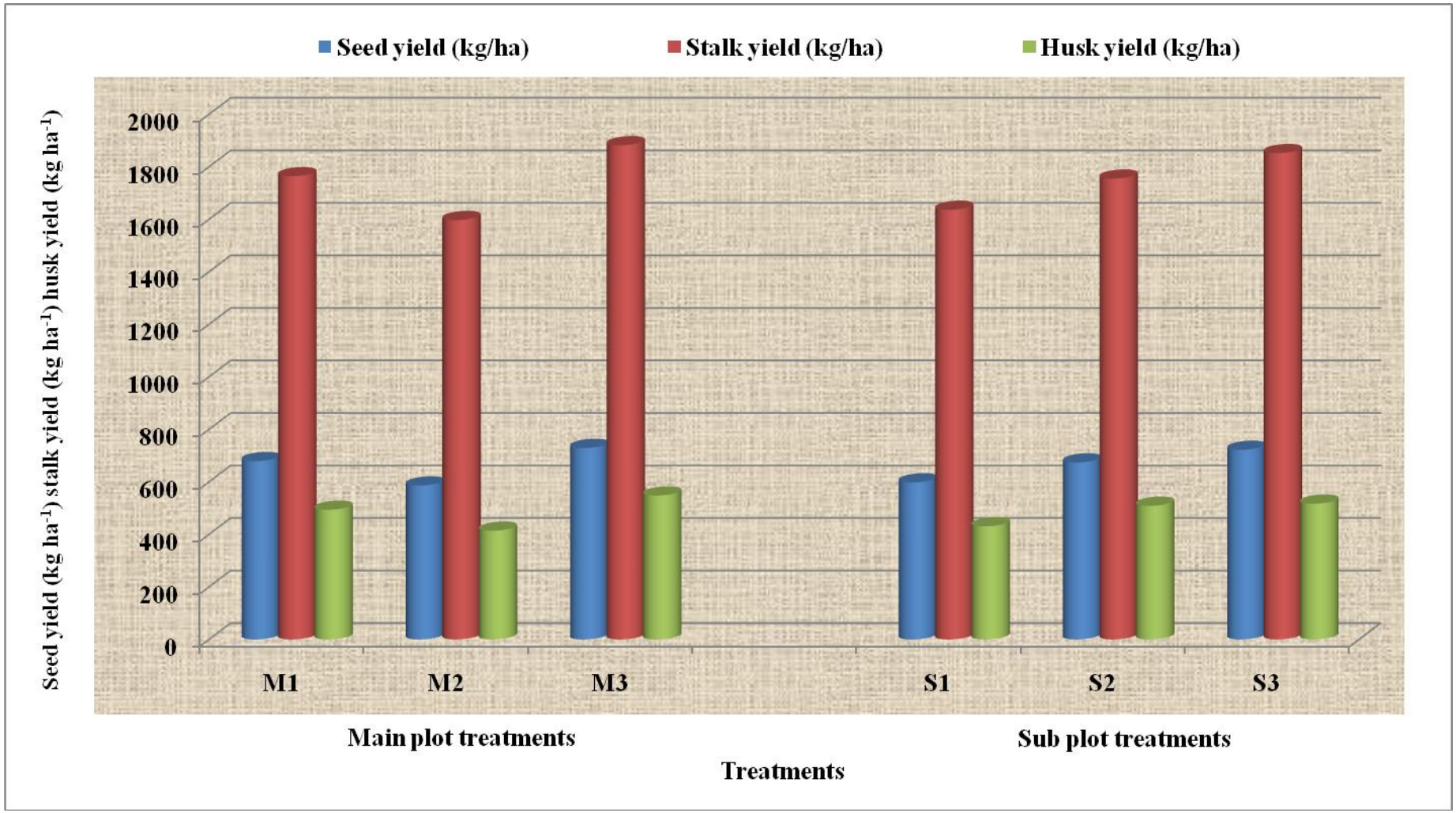

Fig. 17. Seed yield, stalk yield and husk yield of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutria-cereals (2:4) intercropping system

millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher husk yield was noticed with 100 % RDF to both component crops (506 and 567 kg ha^{-1}, respectively) when compared to 50 % RDF to both component crops (410 and 453 kg ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (466 and 513 kg ha^{-1}, respectively) during both the years. While, significantly lower husk yield was observed with 50 % RDF to both component crops over other two fertility levels during both the years.

Pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (548 kg ha^{-1}) recorded significantly higher husk yield when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (414 kg ha^{-1}) and was found on par with pigeonpea with sorghum (2:4) (494 kg ha^{-1}). Application of 100 % RDF to both component crops (517 kg ha^{-1}) recorded significantly higher husk yield in comparison with 50 % RDF to both component crops (2:4) (431 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (509 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on husk yield was significant during both the years and in pooled mean and presented in Table 42. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (596 kg ha^{-1}) recorded significantly higher husk yield compared to other interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (459 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (389 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (423 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (430 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (445 kg ha^{-1}) and pigeonpea + sorghum (2:4) with
50 % RDF through organic + 50 % RDF through inorganic to both component crops (514 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (590 kg ha^{-1}) and pigeonpea + sorghum (2:4) and 100 % RDF to both component crops (524 kg ha^{-1}).

Table 43. Harvest index of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Harvest index (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	0.217	0.236	0.239	0.231	0.227	0.234	0.231	0.230	0.222	0.235	0.235	0.230
M_2	0.222	0.225	0.225	0.224	0.225	0.225	0.231	0.227	0.224	0.225	0.228	0.226
M_3	0.231	0.231	0.233	0.232	0.222	0.234	0.233	0.230	0.227	0.233	0.233	0.231
Mean	0.223	0.231	0.232		0.225	0.231	0.231		0.224	0.231	0.232	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	0.01		NS		0.01		NS		0.01		NS	
Fertility levels (S)	0.01		NS		0.01		NS		0.01		NS	
S at the same M level	0.01		NS		0.01		NS		0.01		NS	
M at the same or different S levels	0.01		NS		0.01		NS		0.01		NS	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

4.2.2.8 Harvest index (kg ha^{-1})

Harvest index of pigeonpea was not influenced significantly either by strip cropping systems or due to fertility levels and their interactions during both the years as well as in pooled data (Table 43)

4.2.3 Estimation of nutritional quality of nutri-cereals

4.2.3.1 Nutritional status of the seeds after harvesting

4.2.3.1.1 Nutrient content of pigeonpea

Zinc (Zn) and iron (Fe) content of pigeonpea seeds after harvesting was not influenced significantly either by strip cropping systems or due to fertility levels and their interactions during both the years as well as in pooled data as presented in Table 44. However, during both the years numerically higher Zn (17.56 and 17.73 ppm) and Fe (67.54 and 68.75 ppm) content of pigeonpea seeds was recorded under pigeonpea + foxtail millet (2:4) when compared to pigeonpea + sorghum (2:4) (17.41 and 17.52 ppm, and 67.32 and 68.45 ppm, respectively) and pigeonpea + pearl millet (2:4) (17.24 and 17.29 ppm, and 67.08 and 67.73 ppm, respectively). Pooled mean also followed similar trend.

During both the years (2015 and 2016), among fertility levels, numerically higher Zn and Fe content in pigeonpea seeds was recorded by 100 % RDF to both component crops (17.51 and 17.68 ppm, and 67.71 and 68.83 ppm, respectively) when compared to 50 % RDF through organic + 50 % RDF through inorganic to both component crops (17.25 and 17.35 ppm, and 67.45 and 67.65 ppm, respectively) and 50 % RDF to both component crops (17.17 and 17.23 ppm, and 67.11 and 67.19 ppm, respectively). Pooled mean also followed similar trend.

4.2.3.1.2 Nutrient content of intercrop seeds

Among intercrops, during both the years, numerically higher Zn content was found with foxtail millet (38.89 and 41.49 ppm) when compared to pearl millet (20.46 and 24.51 ppm) and sorghum (10.47 and 11.83 ppm), respectively when strip cropped with pigeonpea (2:4) (Table 45).

Table 44. Estimated Zn and Fe content of pigeonpea after harvest of seeds and after processing of seeds as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Micronutrient content of pigeonpea (ppm)					
	After harvest of seeds					
	Zn			Fe		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Main plot :Strip cropping System (M)						
M_1	17.41	17.52	17.47	67.32	68.45	67.38
M_2	17.24	17.29	17.26	67.08	67.73	67.15
M_3	17.56	17.73	17.65	67.54	68.75	67.64
S.Em.±	0.48	0.49	0.47	0.54	0.62	0.59
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Subplot :Fertility Levels (S)						
S_1	17.17	17.23	17.20	67.11	68.03	67.15
S_2	17.25	17.35	17.30	67.45	68.65	67.55
S_3	17.51	17.68	17.59	67.71	68.83	67.78
S.Em.±	0.39	0.47	0.41	0.74	0.72	0.73
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (M **x S**)						
S at the same M level						
S.Em.+	0.29	0.33	0.31	1.28	1.26	1.26
C. D. at 5%	NS	NS	NS	NS	NS	NS
M at the same or different S levels						
S.Em+	0.48	0.48	0.48	1.32	1.30	1.31
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 45. Estimated Zn and Fe content of intercrops after harvest of seeds as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Micronutrient content of intercrops after harvest of seeds											
	Zn (ppm)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	10.28	10.47	10.65	10.47	11.55	11.87	12.08	11.83	10.92	11.17	11.37	11.15
M_2	20.27	20.39	20.72	20.46	24.30	24.49	24.75	24.51	22.29	22.44	22.74	22.48
M_3	38.73	38.93	39.01	38.89	41.21	41.42	41.84	41.49	39.97	40.18	40.43	40.19
Mean	23.09	23.26	23.46		25.69	25.93	26.22		24.39	24.60	24.85	

Treatments	Micronutrient content in intercrops after harvest of seeds											
	Fe (ppm)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	69.51	69.81	70.21	69.84	73.41	73.96	74.28	73.88	69.40	69.82	70.25	71.86
M_2	622.52	622.74	623.29	622.85	630.97	631.83	632.47	631.76	622.56	622.78	623.38	627.30
M_3	256.60	257.71	258.10	257.47	259.34	260.78	261.21	260.44	253.32	253.75	254.15	258.95
Mean	316.21	316.75	317.20		321.24	322.19	322.65		315.09	315.45	315.93	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

With respect to fertility levels, during both the years and in pooled mean irrespective of intercrops, numerically higher Zn content was recorded by 100 % RDF to both component crops when compared to 50 % RDF through organic + 50 % RDF through inorganic to both component crops and 50 % RDF to both component crops

During both the years, among fertility levels, numerically higher Zn content was recorded by foxtail millet under pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (39.01 and 41.84 ppm) when compared to foxtail millet under pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (38.93 and 41.42 ppm) and foxtail millet under pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (38.73 and 41.21 ppm), respectively. Similar trend was noticed with other intercrops with respective fertility levels.

Among intercrops, during both the years, numerically higher Fe content was recorded with pearl millet (622.85 and 631.76 ppm) when compared to sorghum (69.84 and 73.88 ppm) and foxtail millet (257.47 and 260.44), respectively when strip cropped with pigeonpea (2:4).

During both the years, among fertility levels, numerically higher Fe content was recorded by pearl millet under pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (623.29 and 632.47 ppm) when compared to pearl millet under pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (622.74 and 631.83 ppm) and pearl millet under pigeonpe + pearl millet (2:4) with 50 % RDF to both component crops (622.52 and 630.97 ppm), respectively. Similar trend was noticed with other intercrops with varied fertility levels.

Zinc (Zn) and iron (Fe) content of pigeonpea and intercrops seeds after harvesting was not influenced significantly by strip cropping systems and fertility levels during both the years as well as in pooled data.

4.2.3.2 Nutritional status of seeds after processing

4.2.3.2.1 Nutrient content of pigeonpea seeds after processing

Zinc (Zn) and iron (Fe) content in seeds of pigeonpea after processing was not influenced significantly either by strip cropping systems or due to fertility levels and their interactions during both the years as well as in pooled data as presented in Table 46.

During both the years (2015 and 2016), among the strip cropping systems, pigeonpea + foxtail millet (2:4) (15.63 and 15.76 ppm, and 64.86 and 65.02 ppm, respectively) recorded numerically higher Zn and Fe content of pigeonpea seeds when compared to pigeonpea + sorghum (2:4) (15.54 and 15.70 ppm, and 64.75 and 64.89 ppm, respectively) and pigeonpea with pearl millet (2:4) (15.26 and 15.37 ppm, and 64.31 and 64.45 ppm, respectively). Pooled mean also followed similar trend.

During both the years (2015 and 2016), among fertility levels, numerically higher Zn and Fe content of pigeonpea seeds was recorded by 100 % RDF to both component crops (15.75 and 15.76, and 64.88 and 65.09 ppm, respectively) when compared to 50 % RDF through organic + 50 % RDF through inorganic to both component crops (15.60 and 15.65 and 64.61 and 64.78 ppm, respectively) and 50 % RDF to both component crops (15.08 and 15.42, and 64.43 and 64.49 ppm, respectively). Pooled mean also followed similar trend.

4.2.3.2.2 Nutrient content of intercrop seeds after processing

Among intercrops during both the years, numerically higher Zn content was found in foxtail millet under pigeonpea + foxtail millet (2:4) (38.26 and 38.41 ppm) when compared to pearl millet under pigeonpea + pearl millet (2:4) (20.27 and 20.39 ppm) and sorghum under pigeonpea + sorghum (2:4) (10.37 and 10.46 ppm), respectively (Table 47).

During both the years, among fertility levels, numerically higher Zn content was recorded by foxtail millet under pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (38.46 and 38.58 ppm) when compared to foxtail millet under pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (38.26 and 38.43 ppm) and foxtail millet under pigeonpea + foxtail millet (2:4) 50 % RDF to both component crops (38.07 and 38.22

Table 46. Estimated Zn and Fe content of pigeonpea after processing of seeds as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Micronutrient content of pigeonpea (ppm)					
	After processing of seeds					
	Zn			Fe		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Main plot :Strip cropping System (M)						
M_1	15.54	15.70	15.62	64.75	64.89	64.82
M_2	15.26	15.37	15.32	64.31	64.45	64.38
M_3	15.63	15.76	15.69	64.86	65.02	64.94
S.Em.±	0.24	0.50	0.31	0.45	0.55	0.47
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Subplot :Fertility Levels (S)						
S_1	15.08	15.42	15.25	64.43	64.49	64.46
S_2	15.60	15.65	15.63	64.61	64.78	64.70
S_3	15.75	15.76	15.75	64.88	65.09	64.98
S.Em.±	0.24	0.30	0.23	0.60	0.53	0.55
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (M **x S**)						
S at the same M level						
S.Em.+	0.42	0.52	0.40	1.05	0.91	0.94
C. D. at 5%	NS	NS	NS	NS	NS	NS
M at the same or different S levels						
S.Em+	0.49	0.72	0.51	1.14	1.06	1.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 47. Estimated Zn and Fe content of intercrops after processing of seeds as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Micronutrient content in intercrops after processing of seeds											
	Zn (ppm)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	10.21	10.38	10.52	10.37	10.32	10.45	10.63	10.46	10.27	10.41	10.58	10.42
M_2	20.09	20.23	20.48	20.27	20.15	20.37	20.63	20.39	20.12	20.30	20.56	20.33
M_3	38.07	38.26	38.46	38.26	38.22	38.43	38.58	38.41	38.15	38.35	38.52	38.34
Mean	22.79	22.96	23.15		22.90	23.08	23.28		22.85	23.02	23.22	

Treatments	Micronutrient content in intercrops after processing of seeds											
	Fe (ppm)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	68.63	69.27	69.69	69.20	68.82	69.49	69.90	69.40	68.73	69.38	69.79	69.30
M_2	621.34	621.67	622.05	621.69	621.82	622.08	622.80	622.23	621.58	621.88	622.42	621.96
M_3	251.52	251.98	252.94	252.15	252.01	252.45	253.26	252.57	251.77	252.22	253.10	252.36
Mean	313.83	314.31	314.89		314.22	314.67	315.32		314.02	314.49	315.11	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

ppm), respectively. Similar trend was noticed with other intercrops with their respective fertility levels.

Among intercrops during both the years, numerically higher Fe content was recorded with pearl millet under pigeonpea + pearl millet (2:4) (621.69 and 622.23 ppm) when compared to sorghum under pigeonpea + sorghum (2:4) (69.20 and 69.40 ppm) and foxtail under pigeonpea + foxtail millet (2:4) (252.15 and 253.26), respectively.

With respect to fertility levels, irrespective of intercrops, during both the years and in pooled mean, numerically higher Fe content was recorded under 100 % RDF to both component crops when compared to 50 % RDF through organic + 50 % RDF through inorganic to both component crops and 50 % RDF to both component crops.

4.2.4 Light transmission ratio

4.2.4.1 Light transmission ratio of pigeonpea

Light transmission ratio of pigeonpea was not influenced significantly either by strip cropping systems or due to fertility levels and their interactions during both the years as well as in pooled data as presented in Table 48

At 60 DAS, both the years (2015 and 2016) and pooled mean indicated that numerically higher light transmission ratio was recorded by pigeonpea when strip cropped with foxtail millet (2:4) (0.71, 0.76 and 0.74, respectively) when compared to strip cropping with pearl millet (2:4) (0.68, 0.73 and 0.71, respectively) and sorghum (2:4) (0.70, 0.74 and 0.72, respectively). Similar trend was followed at 90 DAS during both the years and in pooled data.

During both the years and in pooled mean, among fertility levels, 100 % RDF to both component crops recorded higher light transmission ratio (0.72, 0.77 and 0.75, respectively) when compared to 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.70, 0.75 and 0.72, respectively) and 50 % RDF to both component crops (0.67, 0.72 and 0.70, respectively). Similar trend followed at 90 DAS during both the years and in pooled data.

Table 48. Light transmission ratio of pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Light transmission ratio of pigeonpea					
	60 DAS			90 DAS		
	2015	2016	Pooled	2015	2016	Pooled
Main plot :Strip cropping System (M)						
M_1	0.70	0.74	0.72	0.89	0.90	0.89
M_2	0.68	0.73	0.71	0.88	0.89	0.89
M_3	0.71	0.76	0.74	0.90	0.91	0.90
S. Em.±	0.03	0.01	0.01	0.01	0.01	0.01
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS
Subplot :Fertility Levels (S)						
S_1	0.67	0.72	0.70	0.87	0.88	0.88
S_2	0.70	0.75	0.72	0.89	0.90	0.90
S_3	0.72	0.77	0.75	0.90	0.92	0.91
S. Em.±	0.02	0.01	0.02	0.01	0.01	0.01
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS
Interaction (M **x S**)						
S at the same M level						
S. Em.±	0.03	0.02	0.03	0.02	0.02	0.02
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS
M at the same or different S levels						
S. Em.±	0.04	0.03	0.03	0.02	0.02	0.02
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

4.2.4.2 Light transmission ratio of intercrops

At 30 DAS, among strip cropping systems, during both the years and in pooled data (Table 49) numerically higher light interception ratio was recorded by foxtail millet under pigeonpea + foxtail millet (2:4) (0.55, 0.59 and 0.57, respectively) when compared to sorghum under pigeonpea + sorghum (2:4) (0.48, 0.54 and 0.51, respectively) and pearl millet under pigeonpea + pearl millet (2:4) (0.40, 0.44 and 0.42, respectively). Similar trend was followed at 60 DAS during both the years and in pooled data.

Irrespective of the intercrops, at 30 DAS, data during both the years and pooled mean indicated that numerically higher light transmission ratio was recorded under 100 % RDF to both component crops (0.49, 0.54 and 0.51) when compared to 50 % RDF through organic + 50 % RDF through inorganic to both component crops (0.47, 0.52 and 0.50) and 50 % RDF to both component crops (0.47, 0.51 and 0.49), respectively. Similar trend was followed at 60 DAS during both the years and in pooled data.

4.2.5 Nutrient uptake

4.2.5.1 Nitrogen uptake by pigeonpea

The results of two years and pooled mean indicated that the strip cropping and fertility levels had significant influence on the nitrogen uptake by pigeonpea as presented in Table 50 and fig 18.

Influence of strip cropping systems and fertility levels on nitrogen uptake by pigeonpea was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (129.33 and 134.48 kg ha^{-1}) recorded significantly higher nitrogen uptake by pigeonpea when compared to pigeonpea + pearl millet (2:4) (108.47 and 115.95 kg ha^{-1}) and was found on par with pigeonpea + sorghum (2:4) (121.50 and 127.89 kg ha^{-1}), respectively. The significantly lower nitrogen uptake by pigeonpea was recorded by pigeonepa + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher nitrogen uptake by pigeonpea was noticed with 100 % RDF to both component crops (124.98 and 132.09 kg ha^{-1}) when compared to 50 % RDF to both component crops (113.17 and 118.25 kg ha^{-1})

Table 49. Light transmission ratio of intercrops as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Light transmission ratio of intercrops @ 30 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	0.48	0.48	0.49	0.48	0.53	0.54	0.55	0.54	0.51	0.51	0.52	0.51
M_2	0.39	0.40	0.41	0.40	0.43	0.44	0.46	0.44	0.41	0.42	0.44	0.42
M_3	0.53	0.55	0.56	0.55	0.58	0.59	0.61	0.59	0.56	0.57	0.59	0.57
Mean	0.47	0.47	0.49		0.51	0.52	0.54		0.49	0.50	0.51	

Treatments	Light transmission ratio of intercrops @ 60 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	0.59	0.61	0.63	0.61	0.64	0.65	0.66	0.65	0.62	0.63	0.65	0.63
M_2	0.50	0.51	0.53	0.51	0.55	0.56	0.58	0.56	0.52	0.54	0.55	0.54
M_3	0.64	0.66	0.67	0.65	0.68	0.69	0.71	0.70	0.66	0.68	0.69	0.67
Mean	0.58	0.59	0.61		0.62	0.63	0.65		0.60	0.61	0.63	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 50. Uptake of nitrogen by pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Uptake of nitrogen (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	115.85	123.41	125.23	121.50	120.12	129.37	134.19	127.89	117.99	126.39	129.71	124.70
M_2	101.29	109.70	114.41	108.47	108.51	117.01	122.34	115.95	104.90	113.36	118.38	112.21
M_3	122.37	130.30	135.31	129.33	129.12	134.56	139.75	134.48	125.75	132.43	137.53	131.90
Mean	113.17	121.14	124.98		119.25	126.98	132.09		116.21	124.06	128.54	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	2.60		10.20		2.60		10.21		2.60		10.19	
Fertility levels (S)	2.32		7.14		2.08		6.42		1.75		5.39	
S at the same M level	4.01		12.37		3.61		11.12		3.03		9.34	
M at the same or different S levels	4.03		12.73		3.03		10.02		3.65		11.29	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (121.14 and 126.98 kg ha^{-1}), respectively, during both the years.

Pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (131.90 kg ha^{-1}) recorded significantly higher nitrogen uptake by pigeonpea when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (112.21 kg ha^{-1}) and was found on par with pigeonpea with sorghum (2:4) (124.70 kg ha^{-1}). Application of 100 % RDF to both component crops (128.54 kg ha^{-1}) recorded significantly higher nitrogen uptake by pigeonpea in comparison with 50 % RDF to both component crops (2:4) (116.21 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (124.06 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on nitrogen uptake by pigeonpea was significant during both the years and in pooled mean. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (137.53 kg ha^{-1}) recorded significantly higher nitrogen uptake by pigeonpea when compared to treatment interactions *viz.*, pigeonpea + foxtail millet with 50 % RDF to both component crops (125.75 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (104.90 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (113.36 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (118.38 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (117.99 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (132.43 kg ha^{-1}), pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (129.71 kg ha^{-1}) and pigeonpea + sorghum (2:4) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (126.39 kg ha^{-1}).

4.2.5.2 Phosphorus uptake by pigeonpea

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the phosphorus uptake by pigeonpea and intercrops as presented in Table 51 and fig 18.

Influence of strip cropping systems and fertility levels on phosphorus uptake by pigeonpea was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (14.37 and 15.58 kg ha^{-1}, respectively) recorded significantly higher phosphorus uptake by pigeonpea when compared to pigeonpea + pearl millet (2:4) (11.01 and 12.65 kg ha^{-1}, respectively) and was found on par with pigeonpea + sorghum (2:4) (13.34 and 14.26 kg ha^{-1}, respectively). The significantly lower phosphorus uptake by pigeonpea was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher phosphorus uptake by pigeonpea was noticed with 100 % RDF to both component crops (14.77 and 15.71 kg ha^{-1}) when compared to 50 % RDF to both component crops (10.80 and 12.41 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (13.10 and 14.38 kg ha^{-1}), respectively.

Pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (14.88 kg ha^{-1}) recorded significantly higher phosphorus uptake by pigeonpea when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (11.85 kg ha^{-1}) and was found on par with pigeonpea with sorghum (2:4) (13.80 kg ha^{-1}). Application of 100 % RDF to both component crops (15.24 kg ha^{-1}) recorded significantly higher phosphorus uptake by pigeonpea in comparison with 50 % RDF to both component crops (2:4) (11.61 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (13.74 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on phosphorus uptake by pigeonpea was significant during both the years and in pooled mean. Pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (16.84 kg ha^{-1}) recorded significantly higher phosphorus uptake by pigeonpea over treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (12.29 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (10.04 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (11.82 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (13.70 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (12.50 kg ha^{-1}) and

Table 51. Uptake of phosphorus by pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Uptake of phosphorus (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	11.98	13.37	14.67	13.34	13.01	14.12	15.67	14.26	12.50	13.75	15.17	13.80
M_2	9.01	10.86	13.30	11.05	11.07	12.78	14.11	12.65	10.04	11.82	13.70	11.85
M_3	11.42	15.06	16.34	14.27	13.15	16.23	17.34	15.58	12.29	15.65	16.84	14.92
Mean	10.80	13.10	14.77		12.41	14.38	15.71		11.61	13.74	15.24	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	0.48		1.89		0.39		1.52		0.32		1.27	
Fertility levels (S)	0.71		2.20		0.63		1.93		0.59		1.81	
S at the same M level	1.24		3.82		1.08		3.34		0.98		2.94	
M at the same or different S levels	1.33		4.09		0.94		3.01		1.02		3.14	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (15.65 kg ha^{-1}), pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (15.17 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (13.75 kg ha^{-1}).

4.2.5.3 Potassium uptake by pigeonpea

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the potassium uptake by pigeonpea and intercrops as presented in Table 52 and fig 18.

Influence of strip cropping systems and fertility levels on potassium uptake by pigeonpea was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (40.79 and 43.19 kg ha^{-1}, respectively) recorded significantly higher potassium uptake by pigeonpea when compared to pigeonepea + pearl millet (2:4) (30.80 and 32.92 kg ha^{-1}, respectively) and was found on par with pigeonpea + sorghum (2:4) (37.46 and 39.31 kg ha^{-1}, respectively). The significantly lower potassium uptake by pigeonpea was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, during both the years, significantly lower potassium uptake by pigeonpea was noticed with 50 % RDF to both component crops (31.84 and 33.59 kg ha^{-1}, respectively) when compared to 100 % RDF to both component crops (40.79 and 42.39 kg ha^{-1}, respectively) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (36.72 and 39.45 kg ha^{-1}, respectively), which were on par with each other.

The pooled data of two years indicated that pigeonpea with foxtail millet (2:4) (41.99 kg ha^{-1}) recorded significantly higher potassium uptake by pigeonpea when compared to strip cropped treatment of pigeonpea with pearl millet (2:4) (32.14 kg ha^{-1}) and was found on par with pigeonpea with sorghum (2:4) (38.39 kg ha^{-1}). Application of 100 % RDF to both component crops (41.72 kg ha^{-1}) recorded significantly higher potassium uptake by pigeonpea in comparison with 50 % RDF to both component crops (32.71 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (38.08 kg ha^{-1}).

Table 52. Uptake of potassium by pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Uptake of potassium (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	33.64	37.75	41.01	37.46	35.26	40.12	42.56	39.31	34.45	38.93	41.79	38.39
M_2	26.23	30.60	35.56	30.80	27.72	34.45	36.59	32.92	26.98	32.53	36.91	32.14
M_3	35.64	41.80	44.93	40.79	37.78	43.78	48.01	43.19	36.71	42.79	46.47	41.99
Mean	31.84	36.72	40.79		33.59	39.45	42.39		32.71	38.08	41.72	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	1.55		6.07		1.41		5.53		1.43		5.62	
Fertility levels (S)	1.69		5.21		1.87		5.78		1.56		4.82	
S at the same M level	2.93		9.02		3.25		10.00		2.71		8.36	
M at the same or different S levels	3.01		9.20		3.32		10.11		3.06		9.45	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

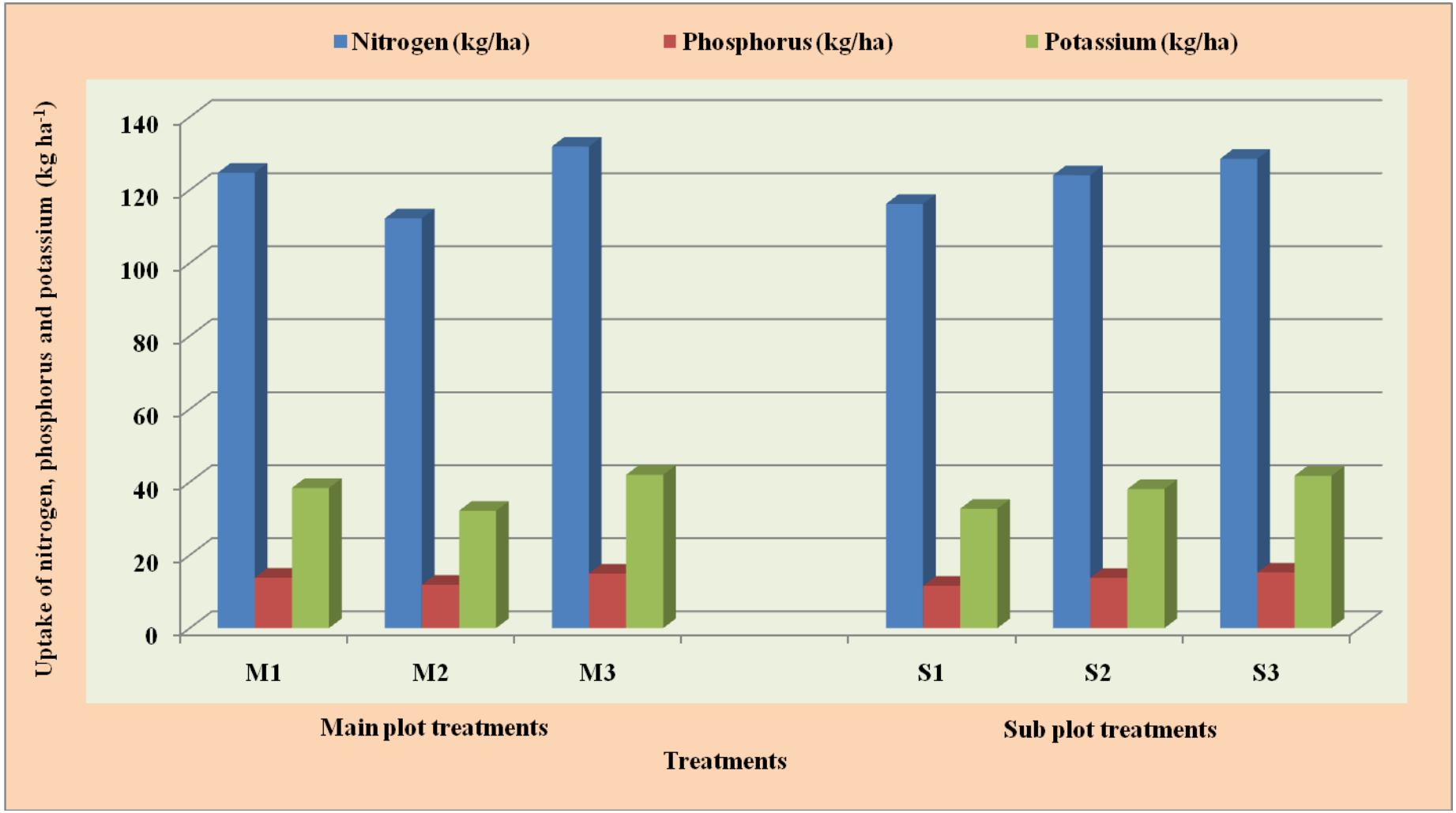

Fig. 18. Uptake of nitrogen, phosphorus and potassium by pigeonpea as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

The interaction effect of strip cropping systems and fertility levels on potassium uptake by pigeonpea was significant during both the years and pooled mean. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (46.47 kg ha^{-1}) recorded significantly higher potassium uptake by pigeonpea over the treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (36.71 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (26.98 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (32.53 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (36.91 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (34.45 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (42.79 kg ha^{-1}), pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (41.79 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (38.93 kg ha^{-1}).

4.2.6 Available nutrients in the soil

4.2.6.1 Available nitrogen in the soil

The results of two years and pooled study indicated that the strip cropping systems and fertility levels had significant influence on the available nitrogen in soil after harvest, as presented in Table 53 and fig 19.

Influence of strip cropping systems and fertility levels on available nitrogen in the soil was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + pearl millet (2:4) (176.68 and 181.89 kg ha^{-1}, respectively) recorded significantly higher available nitrogen in the soil when compared to pigeonpea + sorghum (2:4) (138.75 and 144.47 kg ha^{-1}, respectively) and was found on par with pigeonpea + foxtail millet (2:4) (161.91 and 168.13 kg ha^{-1}, respectively). The significantly lower available nitrogen in the soil was recorded by pigeonpea + sorghum (2:4) over other two strip cropped treatments during both the years.

Table 53. Available nitrogen status of soil after harvest of crop as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Nitrogen (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	125.70	140.22	150.33	138.75	133.08	145.98	154.34	144.47	129.39	143.10	152.33	141.61
M_2	157.29	180.12	192.63	176.68	165.40	184.42	195.86	181.89	161.35	182.27	194.25	179.29
M_3	152.29	162.69	170.75	161.91	158.33	168.10	177.95	168.13	155.31	165.40	174.35	165.02
Mean	145.09	161.01	171.24		152.27	166.17	176.05		148.68	163.59	173.64	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	6.59		25.89		5.01		19.66		4.03		15.84	
Fertility levels (S)	5.19		16.01		4.31		13.28		3.39		10.46	
S at the same M level	13.11		NS		14.45		NS		13.56		NS	
M at the same or different S levels	15.16		NS		16.54		NS		14.23		NS	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Among the fertility levels, significantly higher available nitrogen in the soil was noticed with 100 % RDF to both component crops (171.24 and 176.05 kg ha^{-1}, respectively) when compared to 50 % RDF to both component crops (145.09 and 152.27 kg ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (161.01 and 166.17 kg ha^{-1}, respectively) during both the years.

Pooled data of two years revealed that pigeonpea with pearl millet (2:4) (179.29 kg ha^{-1}) recorded significantly higher available nitrogen in the soil when compared to strip cropped treatment of pigeonpea with sorghum (2:4) (141.61 kg ha^{-1}) and was found on par with pigeonpea with foxtail millet (2:4) (165.02 kg ha^{-1}). Application of 100 % RDF to both component crops (173.64 kg ha^{-1}) recorded significantly higher available nitrogen in the soil in comparison with 50 % RDF to both component crops (2:4) (148.68 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (163.59 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on available nitrogen in the soil was not significant during both the years and in pooled mean.

4.2.6.2 Available phosphorus in the soil

The results of two years and pooled study indicated that the strip cropping and fertility levels had significant influence on the available phosphorus in soil after harvest, as presented in Table 54 and fig 19.

Influence of strip cropping systems and fertility levels on available phosphorus in the soil was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + pearl millet (2:4) (14.46 and 15.61 kg ha^{-1}, respectively) recorded significantly higher available phosphorus in the soil when compared to pigeonpea + sorghum (2:4) (12.07 and 12.51 kg ha^{-1}, respectively) and was found on par with pigeonpea + foxtail millet (2:4) (13.29 and 14.15 kg ha^{-1}, respectively).

During both the years, among the fertility levels, significantly higher available phosphorus in the soil was noticed with 100 % RDF to both component crops (14.71 and 15.85 kg ha^{-1}, respectively) when compared to 50 % RDF to both component crops (11.53

Table 54. Available phosphorus status of soil after harvest of crop as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Phosphorus (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	10.43	12.42	13.37	12.07	10.11	12.92	14.48	12.51	10.27	12.67	13.93	12.29
M_2	12.09	14.85	16.45	14.46	13.60	15.89	17.34	15.61	12.84	15.37	16.89	15.04
M_3	12.06	13.50	14.32	13.29	12.89	13.82	15.74	14.15	12.48	13.66	15.03	13.72
Mean	11.53	13.59	14.71		12.20	14.21	15.85		11.86	13.90	15.28	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	1.41		1.60		0.32		1.24		0.33		1.30	
Fertility levels (S)	0.63		2.03		0.61		1.98		0.67		2.01	
S at the same M level	1.41		NS		1.18		NS		1.27		NS	
M at the same or different S levels	1.47		NS		1.22		NS		1.31		NS	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

and 12.20 kg ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (13.59 and 14.21 kg ha^{-1}, respectively).

Pooled data of two years revealed that pigeonpea with pearl millet (2:4) (15.04 kg ha^{-1}) recorded significantly higher available phosphorus in the soil when compared to strip cropped treatment of pigeonpea with foxtail millet (2:4) (13.72 kg ha^{-1}) and pigeonpea with sorghum (2:4) (12.29 kg ha^{-1}). Among fertility levels, application of 100 % RDF to both component crops (15.28 kg ha^{-1}) was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (13.90 kg ha^{-1}) and significantly higher over 50 % RDF to both component crops (2:4) (11.86 kg ha^{-1}) with respect to available phosphorus in soil.

The interaction effect of strip cropping systems and fertility levels on available phosphorus in the soil was not significant during both the years and pooled mean.

4.2.6.3 Available potassium in the soil

The results of two years and pooled study indicated that the strip cropping systems and fertility levels had significant influence on the available potassium in soil after harvest, as presented in Table 55 and fig 19.

Influence of strip cropping systems and fertility levels on available potassium in the soil was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + foxtail millet (2:4) (259.25 and 265.81 kg ha^{-1}, respectively) recorded significantly higher available potassium in the soil when compared to pigeonpea + sorghum (2:4) (220.62 and 231.31 kg ha^{-1}, respectively) and was found on par with pigeonpea + pearl millet (2:4) (240.92 and 245.48 kg ha^{-1}, respectively).

During both the years, among the fertility levels, significantly higher available potassium in the soil was noticed with 100 % RDF to both component crops (253.19 and 260.02 kg ha^{-1}, respectively) when compared to 50 % RDF to both component crops (226.03 and 235.18 kg ha^{-1}, respectively) and was found on par with 50% RDF through organic + 50 % RDF through inorganic to both component crops (241.59 and 247.40 kg ha^{-1}, respectively).

Table 55. Available potassium status of soil after harvest of crop as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Potassium (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	200.18	224.11	237.58	220.62	218.01	230.41	245.52	231.31	209.10	227.26	241.55	225.97
M_2	228.71	241.03	253.03	240.92	232.68	246.52	257.23	245.48	230.69	243.78	255.13	243.20
M_3	249.18	259.61	268.97	259.25	254.84	265.28	277.30	265.81	252.01	262.45	273.13	262.53
Mean	226.03	241.59	253.19		235.18	247.40	260.02		230.60	244.49	256.60	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	4.26		16.73		4.83		15.91		5.01		16.67	
Fertility levels (S)	4.98		15.35		3.65		11.74		4.72		12.54	
S at the same M level	16.76		NS		16.76		NS		18.24		NS	
M at the same or different S levels	18.98		NS		18.67		NS		17.76		NS	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

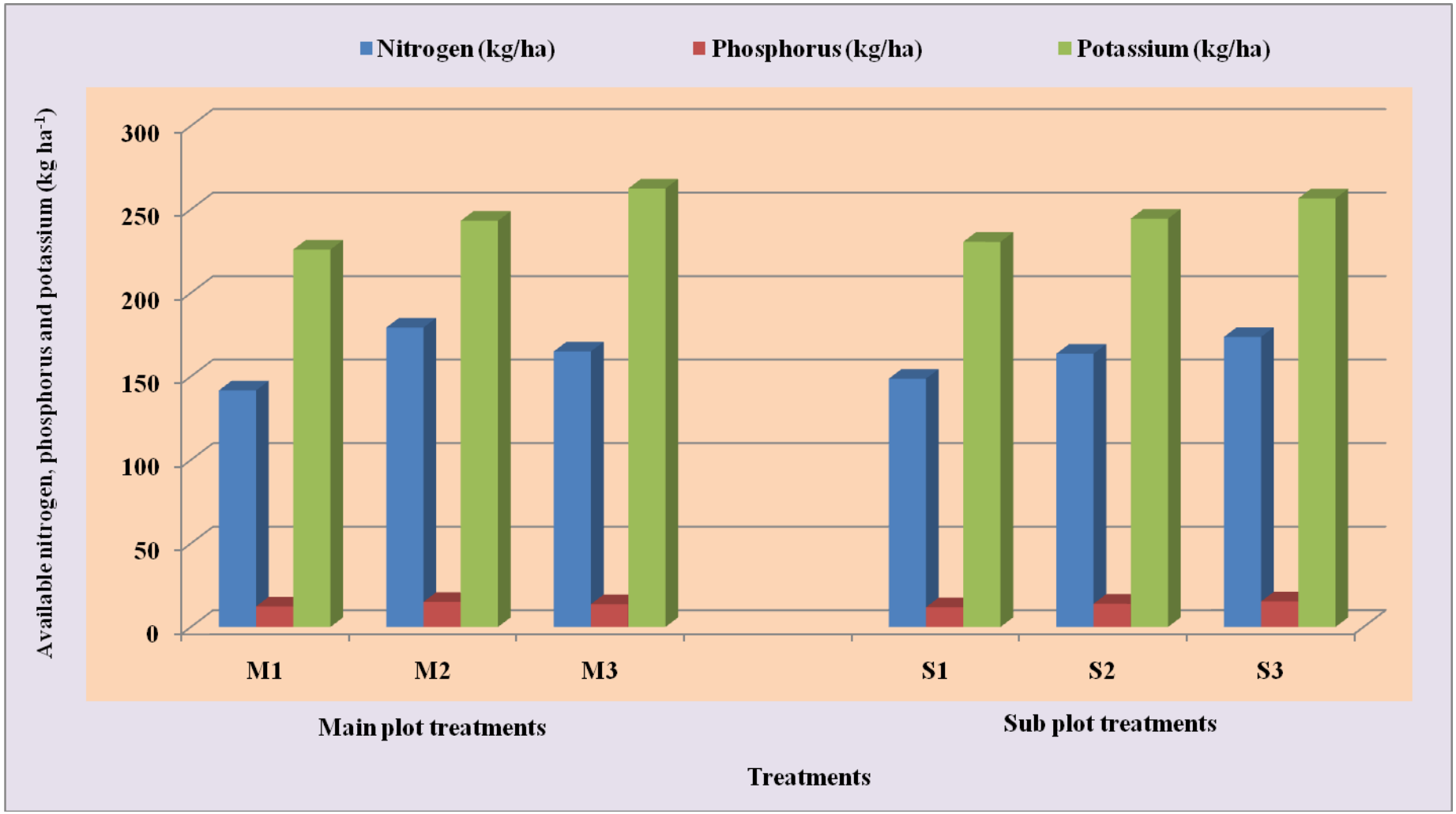

Fig. 19. Available nitrogen, phosphorus and potassium status of soil after harvest of crop as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Pooled data of two years revealed that pigeonpea with foxtail millet (2:4) (262.53 kg ha^{-1}) recorded significantly higher available potassium in the soil when compared to pigeonpea + sorghum (225.97 kg ha^{-1}) and was found on par with pigeonpea with pearl millet (2:4) (243.20 kg ha^{-1}). Among fertility levels application of 100 % RDF to both component crops (256.60 kg ha^{-1}) recorded significantly higher available potassium in the soil when compared to 50 % RDF to both component crops (2:4) (230.60 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (244.49 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on available potassium in the soil was not significant during both the years and pooled mean.

4.2.7 Pigeonpea equivalent yield

The results of two years and pooled study indicated that the strip cropping systems and fertility levels had significant influence on the pigeonpea equivalent yield as presented in Table 56 and fig 20.

Influence of strip cropping systems and fertility levels on pigeonpea equivalent yield was significant during both the years (2015 and 2016) and in pooled mean.

During both the years (2015 and 2016), among strip cropped treatments, pigeonpea + sorghum (2:4) (900 and 1042 kg ha^{-1}, respectively) recorded significantly higher pigeonpea equivalent yield when compared to pigeonpea + pearl millet (2:4) (749 and 871 kg ha^{-1}, respectively) and was found on par with pigeonpea + foxtail millet (2:4) (887 and 1018 kg ha^{-1}, respectively). The significantly lower pigeonpea equivalent yield was recorded by pigeonpea + pearl millet (2:4) over other two strip cropped treatments, during both the years. Among the fertility levels, significantly higher pigeonpea equivalent yield was noticed with 100 % RDF to both component crops (904 and 1036 kg ha^{-1}, respectively) when compared to 50 % RDF to both component crops (769 and 897 kg ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (863 and 997 kg ha^{-1}, respectively) during both the years. While, significantly lower pigeonpea equivalent yield was observed with 50 % RDF to both component crops over other two fertility levels during both the years.

Pooled data of two years revealed that pigeonpea with sorghum (2:4) (971 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield when compared to pigeonpea

Table 56. Pigeonpea equivalent yield (kg ha^{-1}) as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Pigeonpea equivalent yield (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	807	930	962	900	981	1073	1073	1042	894	1001	1017	971
M_2	704	758	786	749	816	882	916	871	760	820	851	810
M_3	796	901	964	887	895	1038	1120	1018	845	969	1042	952
Mean	769	863	904		897	997	1036		833	930	970	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	21		82		18		72		17		65	
Fertility levels (S)	21		64		21		65		18		56	
S at the same M level	36		111		37		113		32		97	
M at the same or different S levels	42		128		41		126		36		110	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

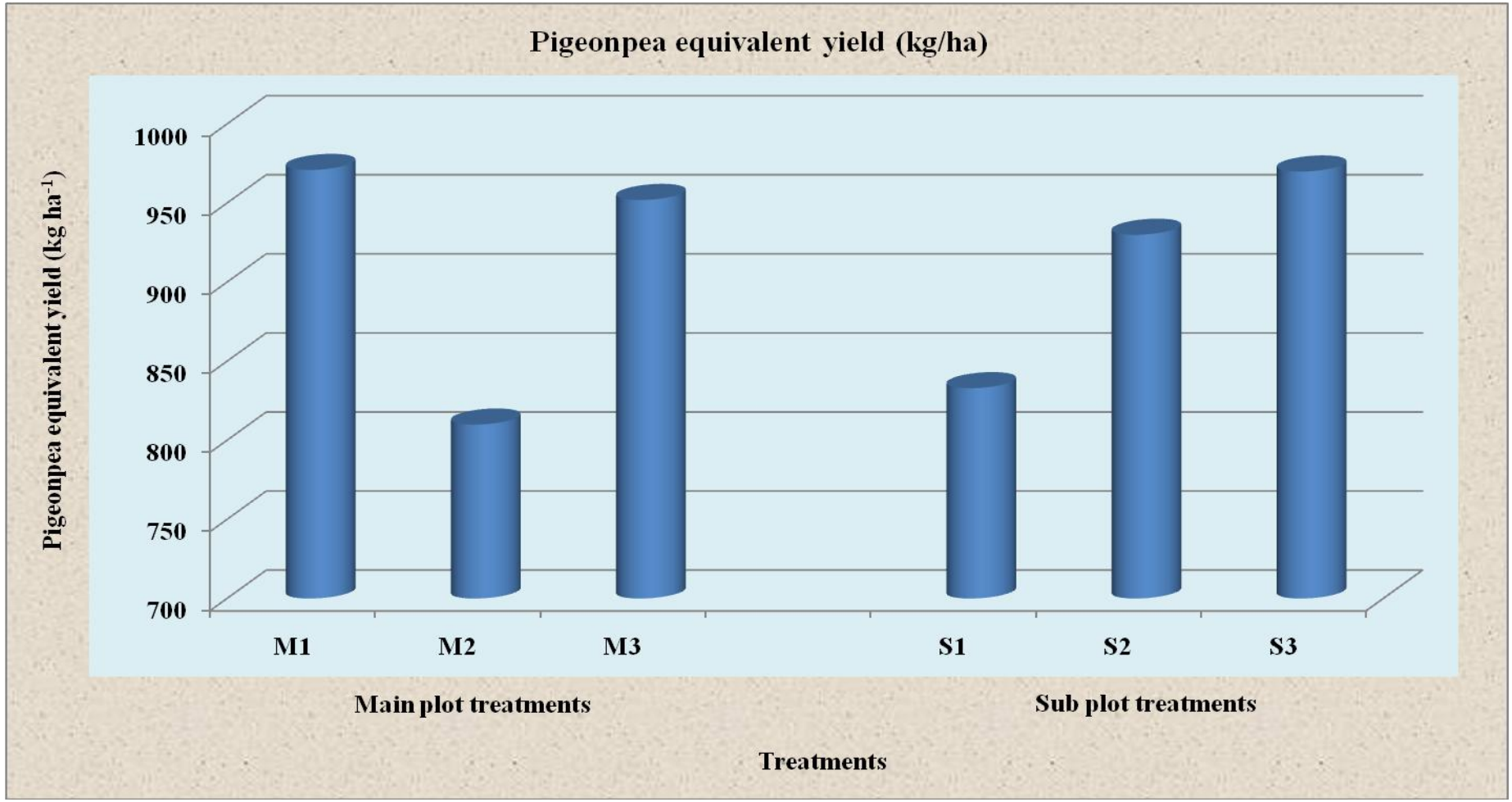

Fig. 20. Pigeonpea equivalent yield (kg ha^{-1}) as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

with pearl millet (2:4) (810 kg ha^{-1}) and was found on par with pigeonpea with fotail millet (2:4) (952 kg ha^{-1}). Among the fertility levels, application of 100 % RDF to both component crops (970 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield in comparison with 50 % RDF to both component crops (2:4) (833 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (930 kg ha^{-1}).

The interaction effect of strip cropping systems and fertility levels on pigeonpea equivalent yield was significant during both the years and in pooled mean. The pooled mean indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (1042 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield when compared to treatment interactions *viz.*, pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (845 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (760 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (820 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (851 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (894 kg ha^{-1}) and was found on par with pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (1017 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1001 kg ha^{-1}) and pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (969 kg ha^{-1}).

4.2.8 Economics

4.2.8.1 Cost of cultivation

The cost of cultivation as influenced by strip cropping systems and fertility levels is presented in Table 57.

Among strip cropping systems, pooled mean revealed that higher cost of cultivation was recorded with pigeonpea + foxtail millet (2:4) (Rs. 27330 ha^{-1}) followed by pigeonpea + sorghum (2:4) (Rs. 27130 ha^{-1}) and pigeonpea + pearl millet (2:4) (Rs. 26564 ha^{-1}). However among fertility levels pooled mean revealed that higher cost of cultivation was recorded under 50 % RDF through organic + 50 % RDF through

Table 57. Cost of cultivation (Rs.ha^{-1}) as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Cost of cultivation (Rs.ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	26203	27641	27005	26950	26563	28001	27365	27310	26383	27821	27185	27130
M_2	25637	27075	26439	26384	25997	27435	26799	26744	25817	27255	26619	26564
M_3	26475	27682	27292	27150	26835	28042	27652	27510	26655	27862	27472	27330
Mean	26105	27466	26912		26465	27826	27272		26285	27646	27092	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	-		-		-		-		-		-	
Fertility levels (S)	-		-		-		-		-		-	
S at the same M level	-		-		-		-		-		-	
M at the same or different S levels	-		-		-		-		-		-	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

inorganic to both component crops (Rs. 27646 ha^{-1}) over 100 % RDF to both component crops (Rs. 27092 ha^{-1}) and 50 % RDF to both component crops (Rs. 26285 ha^{-1}).

4.2.8.2 Gross returns

The gross returns recorded under strip cropping systems and fertility levels are presented in Table 58 and fig 21.

Among strip cropping systems, during both the years, higher gross returns was recorded with pigeonpea + sorghum (2:4) (Rs. 64236 and 53602 ha^{-1}, respectively) when compared to pigeonpea + pearl millet (2:4) (Rs. 52645 and 43831 ha^{-1}, respectively) and pigeonpea + foxtail millet (2:4) (Rs. 61835 and 51078 ha^{-1}). However among fertility levels, during both the years, higher gross returns was recorded under 100 % RDF to both component crops (Rs. 63630 and 52490 ha^{-1}, respectively) followed by 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs. 60818 and 50536 ha^{-1}, respectively) and 50 % RDF to both component crops (Rs. 54267 and 45484 ha^{-1}, respectively). Pooled mean also followed similar trend.

With respect to treatment combinations, the pooled mean indicated that pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (Rs. 61826 ha^{-1}) recorded higher gross returns followed by pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs. 60758 ha^{-1}), pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (Rs. 61720 ha^{-1}), pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs. 57446 ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (Rs. 54174 ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (Rs. 50635 ha^{-1}), pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (Rs. 50203 ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs. 48828 ha^{-1}) and pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (Rs. 45250 ha^{-1}).

4.2.8.3 Net returns

The net returns as influenced by strip cropping systems and fertility levels is presented in Table 59 and fig 21.

Table 58. Gross returns (Rs.ha^{-1}) as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Gross returns (Rs.ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	57827	66381	68501	64236	50521	55135	55150	53602	54174	60758	61826	58919
M_2	49463	53296	55175	52645	41036	44360	46096	43831	45250	48828	50635	48238
M_3	55510	62779	67214	61835	44896	52113	56225	51078	50203	57446	61720	56456
Mean	54267	60818	63630		45484	50536	52490		49876	55677	58060	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	-		-		-		-		-		-	
Fertility levels (S)	-		-		-		-		-		-	
S at the same M level	-		-		-		-		-		-	
M at the same or different S levels	-		-		-		-		-		-	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Table 59. Net returns (Rs.ha^{-1}) as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Net returns (Rs.ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	31624	38740	41496	37287	23958	27134	27785	26292	27791	32937	34641	31790
M_2	23826	26221	28736	26261	15039	16925	19297	17087	19433	21573	24016	21674
M_3	29035	35097	39922	34685	18061	24071	28573	23568	23548	29584	34248	29127
Mean	28162	33352	36718		19019	22710	25218		23591	28031	30968	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	1433		5626		887		3483		1000		3926	
Fertility levels (S)	1373		4232		990		3051		1051		3238	
S at the same M level	2379		7330		1827		5631		1878		5785	
M at the same or different S levels	2239		7557		2043		6295		2131		6567	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Among strip cropping systems, during both the years, significantly higher net returns was recorded with pigeonpea + sorghum (2:4) (Rs. 37287 and 26292 ha^{-1}, respectively) when compared to pigeonpea + pearl millet (2:4) (Rs. 26261 and 17087 ha^{-1}, respectively) and was found on par with pigeonpea + foxtail millet (2:4) (Rs. 34685 and 23568 ha^{-1}, respectively). However, among fertility levels, during both the years, significantly higher net returns was recorded by 100 % RDF to both component crops (Rs. 36718 and 25218 ha^{-1}, respectively) when compared to 50 % RDF to both component crops (Rs. 28162 and 19019 ha^{-1}, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs. 33352 and 22710 ha^{-1}, respectively). Pooled mean also followed similar trend.

The interaction effect of strip cropping systems and fertility levels on net returns was significant during both the years and in pooled mean. The pooled mean indicated that pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (Rs.34641 ha^{-1}) recorded significantly higher net returns when compared to treatment interactions *viz.*, pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (Rs. 27791 ha^{-1}), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (Rs. 24016 ha^{-1}), pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (Rs. 23548 ha^{-1}), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs. 21573 ha^{-1}) and pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (Rs. 19433 ha^{-1}) and was found on par with pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs.32937 ha^{-1}), pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (Rs.34248 ha^{-1}) and pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs.29584 ha^{-1}).

4.2.8.4 Benefit cost ratio

The benefit cost ratio as influenced by strip cropping systems and fertility levels is presented in Table 60 and fig 21.

Among strip cropping systems, during both the years, significantly higher benefit cost ratio was recorded with pigeonpea + sorghum (2:4) (2.38 and 1.96, respectively) when compared to pigeonpea + pearl millet (2:4) (1.99 and 1.64, respectively) and was

found on par with pigeonpea + foxtail millet (2:4) (2.28 and 1.85, respectively). However among fertility levels, during both the years, significantly higher benefit cost ratio was recorded by 100 % RDF to both component crops (2.36 and 1.92, respectively) when compared to 50 % RDF to both component crops (2.08 and 1.72, respectively) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (2.21 and 1.81, respectively). Pooled mean also followed similar trend.

The interaction effect of strip cropping systems and fertility levels on benefit cost ratio was significant during both the years and in pooled mean. The pooled mean indicated that pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (2.28) recorded significantly higher benefit cost ratio when compared to treatment interactions *viz.*, pigeonpea + sorghum (2:4) with 50 % RDF to both component crops (2.05), pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (1.90), pigeonpea + foxtail millet (2:4) with 50 % RDF to both component crops (1.88), pigeonpea + pearl millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1.79) and pigeonpea + pearl millet (2:4) with 50 % RDF to both component crops (1.75) and was found on par with pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (2.25), pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (2.19) and pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (2.06).

Table 60. Benefit cost ratio as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Benefit cost ratio											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	2.21	2.40	2.54	2.38	1.90	1.97	2.02	1.96	2.05	2.19	2.28	2.17
M_2	1.93	1.97	2.09	1.99	1.58	1.62	1.72	1.64	1.75	1.79	1.90	1.82
M_3	2.10	2.27	2.46	2.28	1.67	1.86	2.03	1.85	1.88	2.06	2.25	2.07
Mean	2.08	2.21	2.36		1.72	1.81	1.92		1.90	2.01	2.14	
	S.Em.±		CD at 5%		S.Em.±		CD at 5%		S.Em.±		CD at 5%	
Strip cropping (M)	0.05		0.18		0.03		0.13		0.04		0.13	
Fertility levels (S)	0.04		0.16		0.03		0.13		0.04		0.15	
S at the same M level	0.08		0.24		0.06		0.18		0.04		0.18	
M at the same or different S levels	0.09		0.28		0.06		0.20		0.05		0.22	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

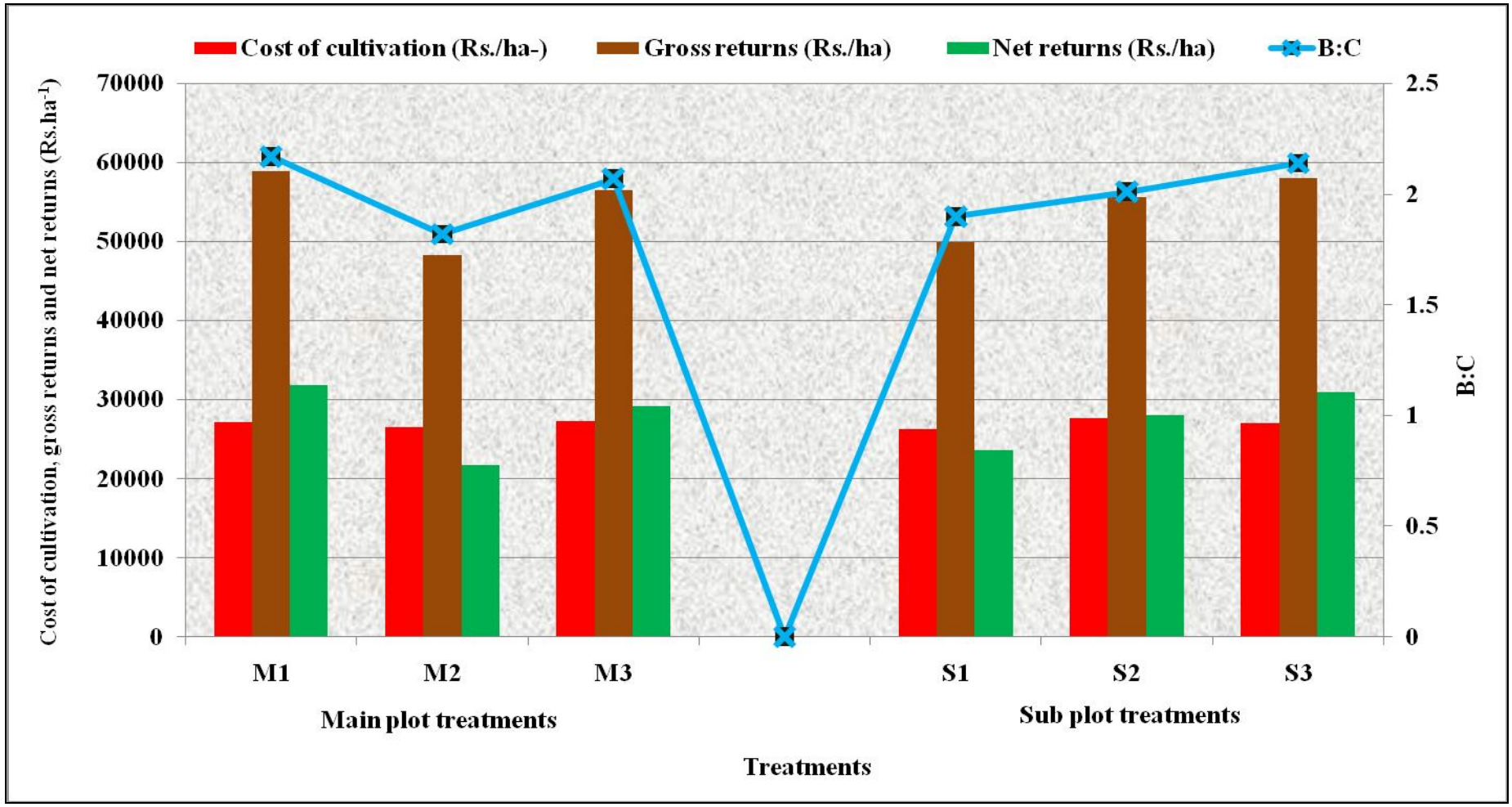

Fig. 21. Cost of cultivation, gross returns, net returns and B:C as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

DISCUSSION

V. DISCUSSION

The results of the investigation on "Production and nutritional quality enhancement of nutri-cereals through agronomic manipulations" conducted at Agricultural College Farm, Raichur, during *kharif*, 2015 and 2016 are discussed in this chapter.

5.1 Experiment-I: Performance of pigeonpea and nutri-cereals in traditional intercropping systems under rainfed condition

5.1.1 Weather conditions during growing season

Crop growth is mainly dependent on environmental factors soil and climate, the associated crops and the management. In that, the soil characteristics and weather conditions greatly influence the growth and development and yield potential of crops in general, and component crops in an intercropping system. In particular, the research station where the present investigation was carried out falls in North Eastern Dry Zone of Karnataka which is characterized by dry climate with uncertain and erratic rainfall and light red to deep black moisture retentive soils. The rainfall received during the first year of experimentation was 677.5 mm which was 7.73 per cent higher than the normal (628.9 mm) of past 85 years. However, during cropping season (15th July to 5th December, 2015) there was nearly 257 per cent improvement in the rainfall (479.6 mm of rainfall against the normal 134.3 mm). Crops were sown late by about two months due to delayed onset of south west monsoon. Rainfall was not well distributed during the cropping season also and consequently crop experienced partial moisture stress during later part of the season. There was delayed onset coupled with dry spell during first fortnight of August and a subsequent down pour during the month of September. About half (316.6 mm) of the annual rainfall was received only in September (Table 2.). Consequently, crop growth was adversely affected, firstly due to delayed sowing and secondly due to water inundation during growth phases. Excess moisture and fertile soils encouraged the growth of tillering crop like pearl millet and foxtail millet, partly pearl millet which suppressed pigeonpea while, sorghum which is adopted to dry situation was hindered due to excess moisture and humidity. There was incidence of early shoot fly in sorghum and fusarium wilt in pigeonpea which were, however, controlled through prophylactic measures.

The temperature and relative humidity were near normal during the first year of experimentation. Mean monthly maximum temperature ranged from 39.1°C (September

T_3-Pigeonpea + Foxtail millet (1:1) at 30 DAS

T_1-Pigeonpea + Sorghum (1:1) at 30 DAS

Plate 3. Intercropping systems in single row ratios under rainfed condition

and November) to 31.9°C (August). While, the mean minimum temperatures ranged from 16.2°C (September) to 25.3°C (February). The mean relative humidity was highest during the month of September (88%) and the lowest in February (62%).

Similarly during second year of experimentation, rainfall received during the crop growth period was 839.9 mm which was 33.55 percent higher than normal (628.9 mm) of past 85 years. The distribution of rainfall was uniform throughout the cropping period. Consequently crop did not show any moisture stress during the entire crop growth period and resulted in normal yield of component crops.

The temperature and relative humidity were near normal during the second year during growing period. Mean monthly maximum temperature ranged from 32.4°C (August and September) to 29.2°C (August). While, the mean minimum temperatures ranged from 16.1°C (November) to 23.5°C (July). The mean relative humidity was highest during the month of September (81.6%) and the lowest in December (58.1%).

5.1.2 Comparative performance of sole crop of pigeonpea and intercrops and their intercropping systems with varied row proportions

5.1.2.1 Performance of pigeonpea

It has been recognized that when two or more crops were grown as intercrops, their yields were generally reduced in intercropping system as compared to their sole crop yields. Although the combined yield may be higher than either of the sole crops, it is possible that the reduction in yield of component crops grown together could be minimized by selecting compatible crop species having different growth habits.

The results revealed that in the pooled analysis, the sole crop of pigeonpea gave significantly higher seed yield (1360 kg ha^{-1}) as compared to intercropped treatments which ranged between (734 to 991 kg ha^{-1}) (Table.17). The seed yield decreased in all the intercropped treatments to the extent of 27 to 46 per cent in comparison with sole crop of pigeonpea. The lower seed yield of pigeonpea under intercropping system may be attributed to increased plant population pressure of main to intercrops together resulting in increased competition for nutrients, water, space and light compared to their respective sole crops. Similar results of decreased pigeonpea yields were reported in pigeonpea with sesame/pearl millet intercropping systems (Arjun Sharma and Guled, 2011).

T_2-Pigeonpea + Pearl millet (1:1) at 30 DAS

T_6-Pigeonpea + Foxtail millet (1:2) at 30 DAS

Plate 4. Intercropping systems in single and double row ratios under rainfed condition

The higher yield in sole crop of pigeonpea over intercropped pigeonpea was due to superior growth parameters and yield attributing characters recorded in the sole crop. Among the most important growth characters, the leaf area at harvest (18.47 dm^2 $plant^{-1}$) and dry matter production at harvest (148.84 g $plant^{-1}$) (Table 10 and 15, respectively) were found to be significantly higher in sole crop of pigeonpea as compared to intercropped pigeonpea (8.71 to 12.60 dm^2 $plant^{-1}$ and 102.10 to 119.02 g $plant^{-1}$, respectively) in pooled anaysis. Similar results were obtained by Singh and Jadhav (2003) and Patil and Padmani (2007).

With respect to yield attributing characters of pigeonpea, number of pods per plant (103.48) and seed yield per plant (35.82 g) in pooled analysis were significantly higher in sole crop of pigeonpea compared to intercropped pigeonpea (78.43 to 89.18 and 21.28 to 26.76 g respectively) (Table 16). Similar reduction in the number of pods $plant^{-1}$ and seed yield $plant^{-1}$ of pigeonpea intercropped with cereals were reported by Prasad *et al.* (1991), Paslawar *et al.* (1997), Singh and Jadhav (2003) and Rani and Reddy (2010).

The yield components were directly responsible for higher seed yield and were known to have been determined by physiological characters both in the vegetative and reproductive phases of growth. Seed yield is the resultant product, which obviously depends upon the dry matter production at different stages of crop growth and its partitioning into reproductive parts at higher proportion.

The dry matter produced per plant of pigeonpea (at 30, 60, 90, 120 DAS and at harvest) was significantly reduced under intercropping system compared to sole cropped pigeonpea. The dry matter produced by pigeonpea under intercropping system was 4.69 to 6.53, 16.57 to 21.38, 48.38 to 57.86, 64.72 to 78.42 and 102.10 to 119.02 g $plant^{-1}$, respectively which was significantly lower than that of sole cropped pigeonpea (8.50, 26.43, 71.36, 102.26 and 148.84 g $plant^{-1}$) at 30, 60, 90,120 DAS and at harvest, respectively in the pooled analysis (Table 15). However, during all the crop growth stages higher dry matter accumulation in leaves, stem and reproductive parts and dry matter production was observed under intercropped systems of pigeonpea with intercrops *viz.*, foxtail millet, sorghum and pearl millet in single row ratios when compared to double row ratios. This clearly revealed that pigeonpea crop perceived lesser inter and intra species competition for moisture, nutrients and light, consequently resulting in high dry matter production in single row ratios then double row ratios. The dry matter production per

T_7-Sole Pigeonpea at 30 DAS

T_9-Sole Foxtail millet at 30 DAS

Plate 5. Sole cropping of component crops in intercropping systems under rainfed condition

plant was increased upto harvest irrespective of sole or intercrops. There was significantly higher dry matter production in sole pigeonpea over all the intercropped treatments at all the growth stages. Donald (1963) pointed out that during early stages of growth because of gradual growth and lower dry matter production of component crops, the growth resources did not become limiting factors and the difference in dry matter production between sole and intercropping was not marked. When growth advanced at an increasing rate, the competition for growth resources increased due to inter and intra species competition for moisture, nutrients and light, consequently resulting in low dry matter production under intercropped pigeonpea than in the sole cropped pigeonpea. Madhavan *et al.* (1986) reported similar reduction in the dry matter production in pigeonpea when intercropped with sorghum. Srinivasulu *et al.* (2000) reported reduction in dry matter production in pigeonpea when intercropped with blackgram and sesame. Goud and Andhalkar (2012) reported similar results in pigeonpea and soybean intercropping system.

Accumulation of dry matter in fruiting parts is the single most key factor contributing to the final seed yield. The data on dry matter accumulation in pigeonpea pods indicated that there was significant reduction in the dry matter accumulation in intercropped pigeonpea pods when compared to that of sole cropped pigeonpea at 90,120 DAS and at harvest. Sole pigeonpea recorded significantly higher dry matter in pods at 90, 120 DAS and harvest (6.50, 19.99 and 31.19 g plant^{-1}, respectively) when compared to intercropped pigeonpea (2.82 to 4.65, 13.50 to 16.70 and 21.84 to 26.50 g plant^{-1}, respectively) in pooled data (Table 14). The reduction in dry matter accumulation in pods of intercropped pigeonpea was mainly attributed to reduced dry matter producing ability of intercropped pigeonpea. Lower percentage of dry matter distribution in pods of intercropped pigeonpea was attributed to the stress, which reduced the source strength and photosynthetic ability, thereby reducing sink strength by decreased translocation (Ramamoorthy *et al.*, 2004).

The dry matter production and its accumulation in reproductive parts depend upon the photosynthetic capacity of the plant during vegetative and reproductive phases. The photosynthetic ability of plant at various stages of crop growth can be assessed through leaf area and dry matter accumulation in leaves which in turn affects the photosynthetic ability of plant and finally the yield of any crop.

T_9-Sole Pearl millet at 30 DAS

T_8-Sole Sorghum at 30 DAS

Plate 6. Sole cropping of component crops in intercropping systems under rainfed condition

The dry matter accumulation in pigeonpea leaves at all the growth stages of crop was significantly lower when intercropped with pearl millet, sorghum and foxtail millet irrespective of row proportions compared to sole cropped pigeonpea (Table 12). It clearly indicates that the intercrop competition was least at the early stages of growth. At advanced stages of crop growth, the dry matter accumulated in intercropped pigeonpea leaves was 4.10 to 5.84, 11.17 to 14.38, 8.32 to 11.44 and 3.94 to 6.38 g plant^{-1} when compared to that under sole cropped pigeonpea (7.35, 18.02 ,14.64 and 8.37 g plant^{-1}) at 60, 90, 120 DAS and at harvest, respectively, in pooled analysis (Table 10). The reduction in dry matter accumulation in leaves was related to the reduction in dry matter production and its accumulation in various plant parts at different stages of growth. This indicates that intercropped pigeonpea was considerably suppressed by intercrops competition resulting in lower dry matter production and its accumulation in leaves, which in turn reduced the photosynthetic ability of plant. Similar reasons can be quoted for reduction in dry matter accumulation in stem of pigeonpea when it was intercropped with pearl millet, sorghum and foxtail millet (Table 13).

The number of leaves which ultimately related to leaf area and its size *i.e.*, leaf area index (LAI) were the reflection of photosynthetic ability of crop plant. The leaf area per plant of pigeonpea also followed almost similar trend as that of dry matter accumulation in leaf. Sole cropped pigeonpea recorded higher leaf area than intercropped pigeonpea at all the stages of growth and the differences were significant at all the growth stages.

The leaf area increases upto 90 DAS in pigeonpea (Table 10) whereas in intercrops leaf area increases up to 60 DAS (Appendix III). This indicated that indeterminate growth habit and longer duration of pigeonpea when compared to intercrops resulted in obtaining both temporal and compensatory benefits from the intercropping system.

5.1.2.2 Performance of pigeonpea with intercrops

In present investigation different kinds of millets now called as nutri-cereals were intercropped with pigeonpea either in one or two rows between pigeonpea had significant influence on pigeonpea performance. Basith and Shaik Mohemmad (2012) attributed this variation to several cause and effect relations on their competitive growth influenced by the confounded interactive role of rainfall pattern, edaphic factor, crop duration, rooting

T_3-Pigeonpea + Foxtail millet (1:1) at 60 DAS

T_6-Pigeonpea + Foxtail millet (1:2) at 60 DAS

T_{10}-Sole foxtail millet at 60 DAS

Plate 7. Intercropping systems in different row ratios and sole stand under rainfed condition

pattern of the varieties, their morphological growth *etc*. Obviously pigeonpea seed yield under intercropping with different nutri-cereals was not similar to that of sole pigeonpea or in other words absolutely greater reduction in pigeonpea yield was visible as observed with all the intercropped systems.

Pigeonpea yield decreased drastically with all the intercrops as such reduction was of greater magnitude with pearl millet and sorghum than foxtail millet. The extent of reduction of pigeonpea seed yield was to the tune of 46 and 40, 40 and 33 and 38 and 27 per cent with pearl millet, sorghum and foxtail millet under 1:2 and 1:1, respectively over sole pigeonpea. However, similar reductions in pigeonpea yield due to intercropping with pearl millet was reported by Basith and Shaik Mohammad (2013) and Ansari *et al.* (2016) and intercropping with foxtail millet by Kalaghatagi and Guggari (2010). However, pearl millet, most aggressive intercrop found to inflict maximum damage to pigeopea crop as observed by Basith and Shaik Mohammad (2013) who attributed the inhibitive nature of pearl millet on pigeonpea to its fast growth right from the initial stage, tall growing nature, production of more leaf area and tillering habit. In the present investigation also pearl millet and sorghum were more aggressive as evidenced from data on growth components which could be attributed to two reasons, the soil was medium deep and fertile and the maximum rains received during september were further helpful in promoting the growth of sorghum, foxtail millet and pearl millet. Similar to pearl millet, sorghum and foxtail millet also suppressed the growth of pigeonpea and consequently reduced the yield of pigeonpea. The same attributes such as tillering nature and initial fast growth of foxtail millet could be attributed for poor performance of pigeonpea. Consequently, yield components (Table 16) of pigeonpea *viz*., number of pods per plant and seed weight per plant and also growth components of pigeopea *viz*., dry matter production and its distribution to plant parts, leaf area index, leaf area, number of primary and secondary branches and plant height were also reduced significantly when intercropped with pearl millet, sorghum and foxtail millet. The present findings were in conformity with those of Varshney *et al*. (2010), Pal *et al*. (2016) and Rathod *et al*. (2004).

Yield reduction under intercropping systems is also due to higher population load per unit area compared to pure stand. In the present investigation, it was observed that higher competition with intercrops due to the higher population load per unit area under 1:2 when compared to 1:1 row ratio of foxtail millet, sorghum and pearl millet.

T_1-Pigeonpea + Sorghum (1:1) at 60 DAS

T_4-Pigeonpea + Sorghum (1:2) at 60 DAS

T_7- Sole Sorghum at 60 DAS

Plate 8. Intercropping systems in different row ratios and sole stand under rainfed condition

Consequently, intercropping in 1:2 row proportions reduced more yield than that of 1:1 row proportion. Similarly, Shaik Mohammad *et al*. (1987) and Patel *et al*. (2002) also reported reduction in yield of pigeonpea particularly with two rows of the intercrop than with one row.

Among the intercrops, only foxtail millet proved to be little compatible intercrop with pigeonpea probably due to low canopy height, less vigour in comparison to sorghum and pearl millet. Besides, pigeonpea being legume it might have transferred part of the fixed N to respective intercrops, complementing the possible N competition that might have prevailed with other systems as evidenced from N uptake. Raghavulu and Ramarao (1994) found that N uptake was higher in intercropping system than sole crop and maximum N-uptake was observed when setaria was intercropped with pigeonpea. Varied performance in pigeonpea growth may be ultimately traced back to the nutrient utilization by crop from soil system. However, N, P and K uptake of sole pigeonpea was significantly higher over intercropped systems. Whereas, pigeonpea with sorghum irrespective of row proportions recorded significantly higher N, P and K uptake when compared to pigeonpea + pearl millet and pigeonpea + foxtail millet due to deep root system of sorghum which helps to pump the nutrient from soil. Similarly, pearl millet and foxtail millet intercropping with pigeonpea were less efficient in utilizing the nutrients. Maximum nitrogen uptake was observed when cereal and pulse crops were intercropped in 5:1 row ratio as reported by Raghavulu and Ramarao (1994).

The values in fact, indicated marginal improvement in the uptake probably because of complementarity in rhizosphere. There appears absolute absence of competition for nutrients in the root environment. Nutrient uptake with intercrops did not reveal any specific variation but more or less followed variation in yield trend. In general pigeonpea with sorghum indicated higher N, P and K uptake than with pearl millet and foxtail millet.

5.1.2.3 Performance of intercrops

An attempt was made in the present study to compare the productivity of intercrops on pigeonpea equivalent basis as productivity varied widely among the intercrops as they might have differential yielding ability (Table 56). Sorghum in single rows was most productive (1205 kg ha^{-1}) followed by double row (1160 kg ha^{-1}). The next higher productivity was observed in foxtail millet in 1:1 (1193 kg ha^{-1}) row

proportion followed by 1:2 (1087 kg ha^{-1}) row ratios in the pooled analysis. Lower pigeonpea equivalent yield was observed under pigeonpea + pearl millet system. Sorghum owing to its high market price fared better in achieving higher pigeonpea equivalent yield under intercropping system compared to foxtail millet and pearl millet. Among the row proportions pigeonpea equivalent yield was lower in 1:2 row proportion irrespective of intercrops as the higher population of intercrop under 1:2 might have affected adversely the yield of pigeonpea and finally ensuring lower pigeonpea equivalent yield in 1:2 row ratio as compared to 1:1 row ratio.

However, the yield differences were not exactly in tune with population levels. This indicated inter and intra crop interactions of differential magnitude. In general, intra crop competition appeared to be of higher magnitude than inter crop competition where probably a certain degree of complementaritiy might have also played a role because of changed microclimate, leguminous nature, vertical exploitation of light *etc*. which could be made out from the data on yield components and so also growth components of intercrops grown in different rows. Further, variation in growth and yield of intercrops may be finally attributed to uptake of nutrients by component crops. Sorghum among the intercrops recorded higher uptake of N, P and K (Appendix XIX). Pearl millet exhibited next higher uptake values and lower uptake was observed in foxtail millet irrespective of row proportions and sole stand.

5.1.3 Influence of agronomic manipulations on nutritional quality of nutri-cereals after harvesting and processing seeds

Zinc (Zn) and iron (Fe) content of seeds of pigeonpea and intercrops were analyzed before sowing and results indicated that, significantly higher Zn content was observed in foxtail millet (39.20 ppm) over the sorghum (10.83 ppm), pigeonpea (16.85 ppm) and pearl millet (21.80 ppm). However with regard to Fe content, significantly higher Fe content was recorded in pearl millet (624.31 ppm) over pigeonpea (66.21 ppm), sorghum (70.85 ppm) and foxtail millet (255.07 ppm). (Appendix XI).

Millets with their diversity in nutrient richness can be taken as component crops in pigeopea based intercropping systems to find out the nutrient content after agronomic manipulations. After harvesting of seeds, Zn and Fe content were analyzed for component crops and results yielded non significant difference found in pigeonpea and nutri-cereal crops while there was slight change with respect Zn and Fe content of component crops.

Sole pigeonpea seeds recorded numerically higher Zn and Fe content and increased to the extent of nine and three per cent over their initial status (Table 18). Among the intercropped treatments, pigeonpea + pearl millet (1:2) observed lower Zn and Fe content of pigeonpea seeds over sole pigeonpea.

However with regard to Zn and Fe content, nutri-cereals after harvesting/agronomic manipulations indicated that sole stand of nutri-cereal crops recorded numerically higher Zn and Fe content when compared to that under intercropping with pigeonpea in 1:2 and 1:1 row proportions. Higher Zn content was noticed by sole foxtail millet (40.76 ppm) over the initial status to the extent of four per cent. Similarly, Zn content of foxtail millet increased to the extent of three and three per cent over intercropping systems under 1:1 and 1:2 row proportions, respectively. However, numerically higher Fe content was recorded by sole pearl millet (629.43 ppm) and increased to the extent of 0.82 per cent over initial status (Table 18). After agronomic manipulations, Fe content of sole pearl millet increased to the extent of 0.30 and 0.38 per cent over the intercropped pearl millet under 1:2 and 1:1 row ratios, respectively.

Zn and Fe content of nutri-cereals were analysed after processing of seeds by dehusking process and results indicated sharp decline in Zn and Fe content of nutri-cereals and pigeonpea due to loss of nutrients present in husk during processing. However, Zn and Fe content of sole pigeonpea seeds decreased to the extent of 0.82 and 0.29 per cent over the agronomic manipulated pigeonpea seeds (Table 19). Similarly, Zn and Fe content of intercrops/nutri-cereal crop seeds decreased slightly after processing as compared to agronomic manipulated seeds. After processing, sole foxtail millet seeds recorded two per cent lesser Zn content over agronomic manipulated foxtail millet seeds. Whereas Zn content of sole foxtail millet seeds did not differ significantly when intercropped with pigeonpea irrespective of row proportions and similar trend was noticed with other intercrops. After processing, Fe content of pearl millet seeds did not differ significantly due to intercropping with pigeonpea.

5.1.4 Impact of row proportions on pigeonpea equivalent yield, land equivalent ratio (LER) and area time equivalent ratio (ATER) in companion cropping of pigeonpea and nutri-cereal crops

Generally, the production of a system depends not only on the efficiency of individual component crop of the system but also on how well these crops compliment

with each other in time and space (Willey *et al*., 1986). Therefore, the overall productivity of pigeonpea-based system depends partly on the efficiency of pigeonpea itself and partly on how well pigeonpea fits with other intercrops and vice versa. Since different types of crops are included as intercrops in intercropping systems, it becomes very difficult to compare the economic produce of one crop with the other. Hence, pigeonpea crop equivalent yield suggested for such studies was made use.

In present studies intercropping of pigeonpea with pearl millet and foxtail millet gave significantly lower pigeonpea equivalent yield over sole pigeonpea yield. However, pigeonpea equivalent yield obtained from pigeonpea + sorghum in both (1:1) and (1:2) row proportion in intercropping systems was numerically lower but statistically comparable to sole crop of pigeonpea. However, among intercropping systems pigeonpea + sorghum recorded significantly higher pigeonpea equivalent yield (1205 and 1160 kg ha^{-1}) with (1:1) and (1:2), respectively, in pooled analysis when compared to pigeonpea + pearl millet and pigeonpea + foxtail millet irrespective of row proportions, due to higher seed yield of the component crop owing to optimum nutrient availability coupled with higher market price which contributed to higher pigeonpea equivalent yield (Table 24). Similar results of higher pigeonpea equivalent yield were reported in pigeonpea and radish intercropping system (Behera *et al*., 1999) and pigeonpea with soybean intercropping system (Ved Prakash *et al*. 2004 and Arjun Sharma *et al*. 2012).

Among intercropped systems significantly lower pigeonpea equivalent yield was observed in pigeonpea + pearl millet (1:2) (998 kg ha^{-1}) as compared to single row ratio (1020 kg ha^{-1}). This might be due to lesser seed yield of component crops owing to improper nutrient availability coupled with lesser market price of pearl millet which contributed to lower pigeonpea equivalent yield.

Higher pigeonpea equivalent yield under sorghum and foxtail millet intercropping systems could be attributed due to yield advantage achieved in the intercropping systems. There was less inhibitory effect of sorghum and foxtail millet on pigeonpea performance. Further, sorghum and foxtail millet adopted well within the rows of pigeonpea and made best use of available resource such as light above ground and nutrient within rhizosphere. *This* could be evidenced from light transmission ratio and nutrient uptake. The light passing through the pigeonpea canopy was available to sorghum and foxtail millet which have less shading effect on pigeonpea at anytime. Light is one of the important growth factor influencing the growth and yield of crops. Unlike other sources, light was

instantaneously available and has to be instantaneously intercepted if it is to be used for photosynthesis (Donald, 1961)

However, during 60 and 90 DAS, light transmission ratio were higher under sole pigeonpea than intercropping systems, this could be due to shading of high canopy leaves in pigeonpea by all intercrops which ultimately responsible for lesser light transmission ratio in intercropping systems to the extent of 3.37 to 17.94 per cent when compared to sole pigeonpea at 90 DAS (Table 20). The higher leaf area per unit land area might be responsible for higher light transmission under sole pigeonpea than respective intercropping systems.

The land equivalent ratio reveals the merits and demerits of getting yield advantage under intercropping systems. In the present study, all the intercropped treatments showed significantly higher land equivalent ratio over sole crop of pigeonpea. Among intercropping systems pigeonpea + sorghum (1:2) recorded significantly higher land equivalent ratio (1.45) followed by pigeonpea + foxtail millet (1:2) (1.30), pigeonpea + sorghum (1:1) (1.40), pigeonpea + pearl millet (1:2) (1.40) and pigeonpea + foxtail millet (1:1) (1.30) and were on par with one another. Pigeonpea + pearl millet (1:1) (1.28) recorded significantly lower land equivalent ratio and was found on par with pigeonpea + sorghum (1:1) (1.40), pigeonpea + pearl millet (1:2) (1.40) (Table 24). However, the yield advantage to the extent of 28 to 45 per cent was obtained due to intercropping of pigeonpea with sorghum, foxtail millet and pearl millet over their respective sole stand crops (Table 24). This indicated that intercropping system was highly efficient in utilizing growth resource than sole cropping of component crops. Similar results of higher LER were reported in pigeonpea + greengram (1:3) row ratio (Udhaya and Kuzhanthaivel, 2015).

Similar to LER, ATER was significantly higher under intercropped systems of pigeonpea + sorghum (1:2) (1.25), pigeonpea + sorghum (1:1) (1.23) and pigeonpea + foxtail millet (1:1) (1.07) and were on par with one another. The higher ATER values indicated that the intercropping systems were highly efficient in utilizing resources in time and space than sole cropping of component crops (Table 24). Similar results of higher ATER was reported in pigeonpea with greengram intercropping systems (Arjun Sharma *et al*., 2012). The significantly lower ATER was observed in pigeonpea + pearl millet (1:1) (0.97) which was found on par with pigeonpea + foxtail millet (1:1) (1.07) and pigeonpea + pearl millet (1:2) (1.01).

5.1.5 Economics of intercropping system

In present study, comparative economics of pigeonpea based intercropping systems revealed that higher gross returns were recorded (Rs.81084 ha^{-1}) with sole pigeonpea over the intercropping systems. However under intercropping systems, pigeonpea + sorghum (1:1) (Rs.73680 ha^{-1}) recorded higher gross returns followed by pigeonpea + sorghum (1:2) (Rs.71383 ha^{-1}), pigeonpea + foxtail millet (1:1) (Rs.71491 ha^{-1}), pigeonpea + foxtail millet millet (1:2) (Rs.65394 ha^{-1}), pigeonpea + pearl millet (1:1) (Rs.61492 ha^{-1}) and pigeonpea + pearl millet (1:2) (Rs.60268 ha^{-1}) (Table 25). Even though pigeonpea + foxtail millet (1:1) recorded higher seed yield of pigeonpea, but due to less yielding ability and lower market price of foxtail millet, it realized lesser gross returns over pigeonpea + sorghum under both row ratios. Similarly, higher seed yield with higher market price of sorghum ensured the higher gross returns under pigeonpea + sorghum intercropping systems over other intercropping systems of pigeonpea + pearl millet and pigeonpea + foxtail millet irrespective of row proportions. Whereas, respective sole stand of all intercrops observed lesser gross returns over their respective intercropped systems.

Similarly significantly higher net returns was recorded in intercropping of pigeonpea with sorghum in (1:1) (Rs. 46597 ha^{-1}) and was found on par with sole pigeonpea (Rs.56507 ha^{-1}) (Table 25). Finally in terms of economic net returns pigeonpea + sorghum (1:1) and (1:2) accrued benefits higher to the extent of six and 17 per cent over pigeonpea + foxtail millet (1:1) and (1:2), respectively and 33 and 31 per cent increased benefits over pigeonpea + pearl millet (1:1) and (1:2), respectively. Similarly pigeonpea + foxtail millet (1:1) and (1:2) recorded increased net returns to the extent of 26 and 12 per cent over pigeonpea + pearl millet (1:1) and (1:2) row ratio, respectively. Similar results of higher net returns were reported with pigeonpea based intercropping systems by Tiwari *et al*. (2016) and Arjun Sharma and Guled (2011).

With respect to B:C ratio, the significantly higher benefit cost ratio was recorded with sole pigeonpea (3.33) (Table 25). Among the intercropped treatments, pigeonpea + sorghum (1:1) (2.74) recorded significantly higher net returns and was found on par with pigeonpea + foxtail millet (1:1) (2.61), pigeonpea + sorghum (1:2) (2.63) and pigeonpea + foxtail millet (1:2) (2.38). However significantly lower benefit cost ratio was recorded under sole foxtail millet (1.18), pearl millet (1.18) and sorghum (1.48) over their

respective intercropping systems. The higher B:C ratio under sole pigeonpea was due to higher market price of pigeonpea when compared to sorghum, foxtail millet and pearl millet. Similar results were reported by Pawar *et al.* (2013).

5.2 Experiment II: Performance of different nutri-cereals in strip cropping with pigeonpea under varied fertility levels

5.2.1 Effect of strip cropping systems on growth and yield of component crops

5.2.1.1 Performance of pigeonpea under strip cropping systems

Comparison of pigeonpea seed yield under strip cropping with sorghum, pearl millet and foxtail millet indicated that, they differed significantly and strip cropping systems had pronounced effect on seed yield of pigeonpea. The pooled analysis of pigeonpea + foxtail millet (2:4) produced significantly higher seed yield of pigeonpea (729 kg ha^{-1}) when compared to pigeonpea + pearl millet (2:4)(586 kg ha^{-1}) and was found on par with pigeonpea + sorghum (2:4)(679 kg ha^{-1}). However, seed yield of pigeonpea under pigeonpea + foxtail millet (2:4) increased to the extent of 24 and seven per cent over that under pigeonpea + pearl millet (2:4) and pigeonpea + sorghum (2:4) strip cropping systems, respectively (Table 40). The significantly higher seed yield of pigeonpea under pigeonpea + foxtail millet (2:4) was mainly due to significantly higher yield and growth components. Similar findings were reported by Kujur *et al*. (2010) in pigeonpea + finger millet (1:4) cropping system.

Among the yield components, number of pods per plant and seed weight per plant closely associate with the seed yield per hectare. The other factors which indirectly influence the seed yield are growth attributes such as number of leaves, number of primary branches, dry matter production and its distribution in various plant parts. The differences in seed yield of pigeonpea have been discussed in the light of observations made on various growth and yield attributes.

M_3S_3: Pigeonpea + Foxtail millet (2:4) with 100 % RDF to both component crops at 30 DAS

M_3S_2: Pigeonpea + Foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops at 30 DAS

Plate 9. Strip cropping systems with varied fertility levels

The higher yield of pigeonpea under pigeonpea + foxtail millet is the reflection of yield attributing characters. The significant increase in the seed yield of pigeonpea under pigeonpea + foxtail millet (2:4) can be traced back to significant increase in yield components like number of pods per plant and seed yield per plant as compared to pigeonpea + pearl millet (2:4) (Table 36 and 38). Similar differences in number of pods per plant and seed yield per plant of pigeonpea in different intercropping systems were observed by Anchal Dass and Sudhishri (2010).

Among the yield components, seed yield per plant had closer influence on the seed yield per hectare. However, pooled analysis revealed that significantly higher seed yield per plant of pigeonpea was recorded under pigeonpea + foxtail millet (2:4) (22.31 g) over pigeonpea + pearl millet (2:4) (19.64 g) and was found on par with pigeonpea + sorghum (2:4) (21.34 g). The seed yield per plant of pigeonpea under pigeonpea + foxtail millet (2:4) and pigeonpea + sorghum (2:4) increased to the extent of 14 and five per cent, respectively over the seed yield per plant of pigeonpea under pigeonpea + pearl millet (2:4) (Table 38). The significantly higher seed yield per plant was probably contributed by significantly higher number of pods per plant observed under pigeonpea + foxtail millet (2:4) (80.33) when compared to pigeonpea + pearl millet (2:4) (70.97) and was on par with pigeonpea + sorghum (2:4) (76.04).The number of pods per plant under pigeonpea + foxtail millet (2:4) and pigeonpea + sorghum (2:4) increased to the extent of 13 and seven per cent, respectively when compared to pigeonpea + pearl millet (2:4). Significantly higher number of pods per plant and seed yield per plant of pigeonpea observed in pigeonpea + foxtail millet (2:4) and pigeonpea + sorghum (2:4) strip cropping systems when compared to pigeonpea + pearl millet (2:4) strip cropping system is mainly attributed to higher efficiency in translocating the photosynthates to the reproductive parts.

M_1S_2: Pigeonpea + Sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops at 30 DAS

M_1S_3: Pigeonpea + Sorghum (2:4) with 100 % RDF to both component crops at 30 DAS

Plate 10. Strip cropping systems with varied fertility levels

Seed yield is an end product, which obviously depends on the total dry matter production and it's partitioning into reproductive parts, at different stages of crop growth. In the present study, the dry matter produced by pigeonpea when strip cropping with foxtail millet, sorghum and pearl millet at 60, 90, 120 DAS and at harvest, varied significantly. At 30 DAS the difference in dry matter production was not significant. But the competition was intensified as the growth advanced. At harvest, the dry matter produced per plant in pigeonpea (93.51 g plant^{-1}) under pigeonpea + foxtail millet (2:4) was 31 and 12 percent higher when compared to dry matter of pigeonpea produced in pigeonpea + pearl millet (2:4) and pigeonpea + sorghum (2:4) strip cropping systems, respectively (Tabel 35c). However, the dry matter produced per plant alone does not reflect on the efficiency, but it's greater partitioning into the reproductive parts is the real index of its effectiveness. When partitioning of dry matter in different plant parts was observed, it was apparent that at harvest, pigeonpea + foxtail millet (2:4) had accumulated significantly higher dry matter in reproductive parts of pigeonpea and it was 32 and 11 per cent higher when compared to pigeonpea + pearl millet (2:4) and pigeonpea + sorghum (2:4) strip cropping systems, respectively (34b).

The dry matter production and its accumulation in reproductive parts depend upon the photosynthetic capacity of the plant at various growth stages. Photosynthetic capacity of plant depends upon the accumulation of photosynthates in leaves, leaf number and leaf area. The pooled analysis indicated that pigeonpea + foxtail millet (2:4) recorded significantly higher dry matter in the leaves of pigeonpea at all the crop growth stages except at 30 DAS. At harvest, the dry matter accumulated in the leaves of pigeonpea under pigeonpea + foxtail millet (2:4) (3.83 g plant^{-1}) was significantly higher when compared to pigeonpea + pearl millet (2:4) (2.96 g plant^{-1}) and was found on par with pigeonpea + sorghum (2:4) (3.47 g plant^{-1}) (Table 32). In terms of percentage, the increase in dry matter accumulation in leaves of pigeonpea under pigeonpea + foxtail millet (2:4) was 29 and 10 per cent over pigeonpea + pearl millet (2:4) and pigeonpea + sorghum (2:4), respectively (Table 32). The higher dry matter accumulation in leaves of pigeonpea by pigeonpea + foxtail millet (2:4) may be due to higher number of branches per plant. This was attributed to higher leaf area which determines the photosynthetic ability, growth and dry matter production of a plant. It was further observed that strip cropping system recorded significantly higher leaf area at all the growth stages except at 30 DAS (Table 30).

The magnitude of photosynthetic ability of the crop is more meaningfully interpreted in terms of leaf area per plant and leaf area index (LAI). At 90 DAS, pooled mean indicated that significantly higher leaf area and leaf area index per plant of pigeonpea was produced by pigeonpea + foxtail millet (2:4) (23.95 dm^2 $plant^{-1}$ and 0.887, respectively) as compared to leaf area and leaf area index per plant of pigeonpea under pigeonpea + pearl millet (2:4) (20.36 dm^2 $plant^{-1}$ and 0.754, respectively) and was on par with pigeonpea + sorghum (2:4) (22.37 dm^2 $plant^{-1}$ and 0.829, respectively) (Table 30 and 31). However, due to higher leaf area and leaf area index, there was higher light transmission ratio during different growth stages of component crops (Table 48). This might be due to slow growing habit and temporal difference between the pigeonpea and nutria-cereal crops. The other components *viz.*, plant height, number of primary and secondary branches per plant also followed similar trend. Thus, it was evident that pigeonpea + foxtail millet (2:4) had higher leaf area and leaf area index of pigeonpea upto seed filling stage and these two properties enabled the pigeonpea crop to exhibit higher photosynthetic ability resulting in production of bolder seeds thereby higher productivity. These results are in agreement with the findings of Singh *et al*. (1998).

Stalk yield of pigeonpea differed significantly under strip cropping with nutri-cereal crops *viz.*, foxtail millet, sorghum and pearl millet. Pigeonpea + foxtail millet (2:4) produced significantly higher stalk yield of pigeonpea (1882 kg ha^{-1}) when compared to pigeonpea + pearl millet (2:4) (1597 kg ha^{-1}) and was on par with pigeonpea + sorghum (2:4) (1764 kg ha^{-1}) and increase in stalk yield under pigeonpea + foxtail millet (2:4) over pigeonpea + pearl millet (2:4) and pigeonpea + sorghum (2:4) was to an extent of 18 and seven per cent, respectively (Table 41).

5.2.1.2 Effect of strip cropping systems on nutritional quality of component crops

Pigeonpea seeds after agronomic manipulations did not record significant change with regard to zinc (Zn) and iron (Fe) content and pooled mean indicated that there was increase to the extent of two to five and one to two per cent in Zn and Fe content when compared to initial Zn and Fe content, respectively (Table 44). Pigeonpea did not differ significantly with respect to Zn and Fe content of seeds due to strip cropping systems as it is genetically determined. The pooled mean indicated that pigeonpea + foxtail millet (2:4) observed numerically higher Zn and Fe content of pigeonpea seeds (17.65 and 67.64 ppm, respectively) when compared to pigeonpea + sorghum (2:4) (17.47 and 67.38 ppm) and

pigeonpea + pearl millet (2:4) (17.26 and 67.15 ppm), respectively. Further, after harvesting, Zn and Fe content of pigeonpea seeds being analyzed after processing of seeds and pooled mean indicated that there was no significant difference among strip cropping systems and in general processing of pigeonpea seeds reduced the Zn and Fe content due to dehusking process. After processing, among strip cropping systems, numerically higher Zn and Fe content of pigeonpea seeds was recorded under pigeonpea + foxtail millet (2:4) (15.69 and 64.94 ppm, respectively) when compared to pigeonpea + pearl millet (2:4) and pigeonpea + sorghum (2:4) (Table 46). With respect to Zn and Fe content of nutri-cereal crops, strip cropping with pigeonpea non significantly influenced the zinc (Zn) and iron (Fe) content of nutria cereal crop *viz*., sorghum, foxtail millet and pearl millet as it is genetic character and remains unaffected (Table 45 and 47).

M_2S_3: Pigeonpea + Pearl millet (2:4) with 100 % RDF to both component crops at 30 DAS

M_1S_3: Pigeonpea + Sorghum (2:4) with 100 % RDF to both component crops at 60 DAS

Plate 11. Strip cropping systems with varied fertility levels

5.2.1.3 Effect of strip cropping systems on pigeonpea equivalent yield

The grain yield in strip cropping system is an outcome of interaction between the crop species grown in association. Yield advantage in intercropping occurs when component crop differ in their use of growth resources. Willey (1979) also opined that maximizing intercropping advantage is a matter of maximizing the degree of complementarity between the component crops and minimizing the intercrop competition. In the present studies, strip cropping of pigeonpea with sorghum (2:4) gave significantly higher pigeonpea equivalent yield (971 kg ha^{-1}) over pigeonpea + pearl millet (2:4) (810 kg ha^{-1}) and was found on par with pigeonpea with foxtail millet (2:4) (952 kg ha^{-1}) (Table 56). The strip cropping of pigeonpea + sorghum (2:4) recorded 20 per cent higher pigeonpea equivalent yield over pigeonpea + pearl millet (2:4). These results are similar to those reported by Anchal Dass and Sudhishri (2010).

5.2.1.4 Effect of strip cropping systems on economics

The strip cropping of pigeonpea with sorghum (2:4) recorded significantly higher gross returns (Rs.58,919 ha^{-1}), net returns (Rs.31,790 ha^{-1}) and BC ratio (2.17) over pigeonpea + pearl millet (2:4) (Rs.48,238 ha^{-1}, Rs.21,674 ha^{-1} and 1.82, respectively) and was found on par with pigeonpea with foxtail millet (2:4) (Rs.56,456 ha^{-1}, Rs.29,127 ha^{-1} and 2.07, respectively) (Table 58, 59 and 60). It is attributed to higher yield of sorghum with higher market price which ensured higher gross, net returns and BC ratio over other strip cropping systems but which was comparable with pigeonpea + foxtail millet (2:4) system. Even though higher pigeonpea yield was obtained under pigeonpea + foxtail millet (2:4) system but due to lower yielding ability and market price of foxtail millet resulted in lower gross returns, net returns and BC ratio over pigeonpea + sorghum (2:4) system. Hence it was well realized that strip cropping of pigeonpea with either sorghum or foxtail millet in (2:4) row ratio could be better in terms of economical profitability. The results are in conformity with findings of Koli *et al.* (2003) and Verma *et al.* (2005).

5.2.2 Effect of fertility levels on growth and yield of component crops

Fertility level is an important agronomic manipulation for attaining higher yields. The maximum yield for a particular crop and environment can be obtained at that plant density where competition between the plants is minimal. Optimum plant proportion between component crops helps to utilize the growth resources like soil, nutrients, moisture and solar radiation sufficiently and enable the crop to yield higher.

M_1S_2: Pigeonpea + Sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops at 60 DAS

M_3S_3: Pigeonpea + Foxtail millet (2:4) with 100 % RDF to both component crops at 60 DAS

Plate 12. Strip cropping systems with varied fertility levels

In the present investigation, 100 % RDF to both component crops recorded significantly higher seed yield (722 kg ha^{-1}) when compared to 50 % RDF to both component crops (598 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (674 kg ha^{-1}) (Table 40). The better availability of growth resources like water, nutrients, aeration due to difference in growth habit of intercrops and pigeonpea, however, intercrops like sorghum, foxtail millet and pearl millet are short duration crops and matures earlier then pigeonpea which helped the pigeonpea plants to exhibit their full potential at later stages of crop growth and produced higher yield with increased availability of nitrogen, phosphorus and potassium which had a boosting effect on the crop. Similar results were reported by Kumar and Rana (2007) and Bhanu Kumar Meena (2010).

The seed yield of pigeonpea was governed by yield components like number of pods per plant and seed yield per plant. Significantly higher number of pods per plant (79.76) was recorded by 100 % RDF to both component crops when compared to 50 % RDF to both component crops (70.87) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.70) (Table 36). Similarly 100 % RDF to both component crops (22.33 g) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (21.34 g) recorded on par seed yield per plant and significantly higher over 50 % RDF to both component crops (19.72 g) (Table 38). Significant increase in seed weight per plant was attributed to significantly higher number of pods per plant. These results are in accordance with the results obtained by Tejpal Singh and Mahendra Pal (2003) and Deshbhratar *et al*. (2010).

The better performance of pigeonpea with 100 per cent RDF to both component crops and 50 % RDF through organic + 50 % RDF through inorganic to both component crops may be attributed to non coincidence of peak nutrient demand of component crops and greater availability of growth resources *viz*., light and moisture due to change in rooting pattern and height of component crops and increased availability of nitrogen, phosphorus and potassium.

Significantly higher yield components obtained with 100 per cent RDF to both component crops was attributed to better plant development coupled with greater light interception, moisture utilization, nutrient and solar energy availability under lower degree of inter and intra plant competition and availability of additional amount of nutrients which favoured the development of root system, which might have improved the

M_3S_2: Pigeonpea + Foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops at 60 DAS

M_3S_3: Pigeonpea + Sorghum (2:4) with 100 % RDF to both component crops at 90 DAS

Plate 13. Strip cropping systems with varied fertility levels

rate of photosynthesis. These favourable conditions for growth caused significantly higher values of yield components under (2:4) row proportion with optimum nutrient level. Hence, strip cropping with higher nutrient level recorded significantly higher yield as compared to lesser nutrient level. The results are in conformity with those reported by Meena *et al*. (2011) and Saritha *et al*. (2012).

Significant differences in stalk yield of pigeonpea were noticed among various fertility levels (Table 41). The significantly higher stalk yield of pigeonpea was recorded with 100 % RDF to both component crops which was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops and significantly superior over 50 % RDF to both component crops. Higher stalk yield with 100 % RDF to both component crops was due to increased dry matter production per plant. Similar results were reported by Meena *et al*. (2011), Nagaraj (2008) and Kumar and Rana (2007).

The difference in various yield components which led to significant yield differences among different fertility levels could be traced to differences in dry matter production and its distribution in different plant parts. The dry matter production per plant (95.05 g plant^{-1}) at maturity under the fertility level of 100 per cent RDF to both component crops was significantly higher compared to the nutrient level *i e* 50 % RDF to both component crops (69.85 g plant^{-1}) and was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (83.48 g plant^{-1}) (Table 35c). The increase in dry matter production of pigeonpea recorded under 100 per cent RDF to both component crops was to an extent of 36 and 14 per cent, respectively over 50 % RDF to both component crops and 50 % RDF through organic + 50 % RDF through inorganic to both component crops.

At all the growth stages, leaf dry matter per plant decreased by lesser fertility levels. At harvest, the leaf dry matter per plant was decreased from 3.80 g plant^{-1} (100 % RDF to both component crops) to 2.96 g plant^{-1} under 50 % RDF to both component crops (Table 32). The increased leaf dry matter with 100 per cent RDF fertility level was associated with increased leaf area per plant which led to greater accumulation of photosynthates thereby improvement in yield components with the higher fertility level compared to lesser fertility level. Similarly, stem dry matter per plant decreased with decrease in fertility level. At harvest, decrease in dry matter accumulation in stem under 100 % RDF to both component crops was to an extent of 32 per cent when compared to

50 % RDF to both component crops (Table 33c). The increase in leaf and stem dry matter of pigeonpea at later stages was because of reduced inter plant competition as more space was available for growth of individual plant due to early harvesting of intercrops.

The dry matter accumulation in reproductive parts also decreased with decrease in fertility level. The extent of reduction in dry matter accumulation in reproductive parts due to decrease in fertility level from 100 % RDF to both component crops (22.33 g plant^{-1}) to 50 % RDF to both component crops (14.37 g plant^{-1}) was 55 per cent (Table 34b). Higher dry matter accumulation in different plant parts (leaf, stem and reproductive parts) with strip cropping systems with higher fertility levels resulted in higher total dry matter per plant at all the growth stages. Similarly, Saritha *et al*. (2012) and Meena *et al*. (2011) obtained higher dry matter in pigeonpea with higher nutrient level.

Further, at higher fertility level (100 % RDF to both component crops), plant produced higher number of primary branches (13.08) at harvest (Table 28). It was also seen that the early harvesting of intercrops tended to develop more number of secondary branches per plant of pigeonpea (Table 29) due to greater availability of space per plant and application of higher dose of fertilizer helps in increased biological nitrogen fixation and nutrient uptake. On the contrary lesser fertility level decreased the production of secondary branches due to decreased availability of nutrients in root zone which leads to lower nutrient uptake.

Leaf area is an important attribute of plant which determines the active photosynthetic ability, growth, dry matter production and in turn the yield of any crop. Leaf area index which depends on the leaf area per plant can be widely changed by manipulating cultural practices. The main objective of nutrient management is to have an optimum leaf area index for maximum production. In the present investigation, leaf area index was higher with higher dose of nutrient level *i.e.*, 100 per cent RDF to both component crops compared to 50 per cent RDF to both component crops and 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (Table 31). This increase in LAI may be attributed to early harvesting of intercrops which provided more solar radiation during later stages of crop growth which increased the photosynthetic ability of crop leading to greater biomass production and higher nitrogen availability, nitrogen being a constituent of polynucleotide, helped in cell division and expansion of cell resulting in higher leaf area and application of higher phosphorus

caused intensive root development and better nodulation which helped in higher uptake of nutrients and water to growing plants, in turn resulted in development of more number of leaves and leaf area and increased leaf area index. Saritha *et al*. (2012) and Meena *et al*. (2011) also recorded significantly higher leaf area index with application of higher level of P_2O_5 ha^{-1} as compared to lesser level of P_2O_5 ha^{-1}.

Zinc (Zn) and iron (Fe) content of seeds of pigeonpea and nutri-cereal crops after agronomic manipulations or processing of seeds, did not differ significantly due to fertility levels. However, pooled analysis indicated that higher Zn and Fe content of pigeonpea was observed (17.59 and 67.78 ppm and 15.75 and 64.98 ppm, respectively) with 100 per cent RDF to both component crops after agronomic manipulations and processing, respectively. Lower Zn and Fe content of pigeonpea seeds was observed (17.20 and 67.15 ppm and 15.25 and 64.46 ppm) with 50 per cent RDF to both component crops after agronomic manipulations and processing, respectively (Table 44 and 45). However, processing of both component crop seeds (pigeonpea and nutri cereal crops) indicated that there was change with slight decrease in Zn and Fe content due to processing as dehusking process could removed nutrient content in husk. The decrease in Zn and Fe content of pigeonpea seeds after processing was to extent of 10 to 12 per cent and 4 to 5 per cent, respectively over after harvesting of seeds (Table 45). Further, decrease in Zn and Fe content of sorghum, pearl millet and foxtail millet seeds after processing was to an extent of seven and four, nine and one and five and three per cent, respectively over after harvesting of seeds (Table 47).

The pigeonpea equivalent yield varied significantly with fertility levels. Among fertility levels, pooled analysis revealed that 100 per cent RDF to both component crops (970 kg ha^{-1}) and 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (930 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield over 50 per cent RDF to both component crops (833 kg ha^{-1}) which were on par with each other. Higher yield of nutri cereal crops under higher fertility level (100 per cent RDF to both component crops) resulted in higher pigeonpea equivalent yield (Table 56). Similar results were reported by Singh and Agrawal (2004) and Arjun Sharma *et al.* (2012).

At harvest, uptake of nitrogen, phosphorus and potassium varied significantly with fertility levels. In 100 per cent RDF to both component crops and 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops, uptake of

N, P and K was significantly higher over other nutrient levels because of higher availability of nutrient in the root zone, compared to lower fertility level (50 % RDF to both component crops) (Table 50, 51 and 52)

Available nitrogen, phosphorus and potassium in soil after the harvest of pigeonpea and intercrops varied significantly among fertility levels. In 100 per cent RDF to both component crops and 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops recorded significantly higher available N, P and K over other fertility levels because of higher nutrient availability (Table 53, 54 and 55).

The fertility level *i.e.* 100 per cent RDF to both component crops recorded significantly higher gross returns (Rs. 58, 060 ha^{-1}), net returns (Rs.30968, ha^{-1}) and B: C ratio (2.14) than 50 per cent RDF to both component crops (Rs. 49876 ha^{-1}, Rs. 23591 ha^{-1} and 1.90, respectively) and was found on par with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (Rs. 55,677 ha^{-1} Rs. 28,031 ha^{-1} and 2.01, respectively) (Table 58, 59 and 60). However, higher cost of cultivation incurred in organic source nutrient which reduced the net returns and B:C ratio in 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops. The results are in conformity with findings of Suresh (2005).

5.2.3 Interaction effect of strip cropping systems and fertility levels

The individual effects of strip cropping systems and fertility have been discussed earlier in detail. However, the picture would not be clear unless the interaction effects of the above factors are discussed.

The seed yield of pigeonpea produced under strip cropping system of pigeonpea + foxtail millet (2:4) with 100 per cent RDF to component crops (805 kg ha^{-1}) was found to be significantly higher when compared to pigeonpea + pearl millet (2:4) with 50 per cent RDF to component crops (549 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (580 kg ha^{-1}), pigeonpea + pearl millet (2:4) with 100 per cent RDF to component crops (628 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 per cent RDF to component crops (606 kg ha^{-1}), pigeonpea + foxtail millet (2:4) with 50 per cent RDF to component crops (638 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 per cent RDF through organic + 50 per cent

RDF through inorganic to both component crops (697 kg ha^{-1}) and was found on par with pigeonpea + sorghum (2:4) with 100 per cent RDF to component crops (733 kg ha^{-1}) and pigeonpea + foxtail millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (744 kg ha^{-1}). Yield increase in pigeonpea was to an the extent of 47 per cent under pigeonpea + foxtail millet (2:4) with 100 per cent RDF to component crops over pigeonpea + pearl millet (2:4) with 50 per cent RDF to component crops (Table 40). The results are in conformity with those of Kujur *et al*. (2010) in pigeonpea and finger millet strip cropping system.

Among the yield components, seed yield of pigeonpea is mainly influenced by number of pods per plant and seed yield per plant. Pigeonpea + foxtail millet (2:4) with 100 per cent RDF to component crops recorded significantly higher number of pods per plant (85.20) and seed yield per plant (23.68 g) and was higher by 34 and 31 per cent, respectively when compared to pigeonpea + pearl millet (2:4) with 50 per cent RDF to component crops (63.69 and 18.09 g, respectively) (Table 36 and 38). This attributed to the significant increase in seed yield under pigeonpea + foxtail millet (2:4) with 100 per cent RDF to component crops when compared pigeonpea + pearl millet (2:4) with 50 per cent RDF to component crops.

The seed yield is an end product which obviously depends upon the dry matter production at different stages of crop growth and its partitioning into fruiting parts for higher production. The dry matter production at harvest was significantly higher in pigeonpea + foxtail millet (2:4) (106.28 g $plant^{-1}$) with 100 per cent RDF to both component crops when compared to pigeonpea + pearl millet (2:4) (60.94 g $plant^{-1}$) with 50 per cent RDF to component crops, pigeonpea + pearl millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (69.48 g $plant^{-1}$), pigeonpea + pearl millet (2:4) with 100 per cent RDF to component crops (83.10 g $plant^{-1}$), pigeonpea + sorghum (2:4) with 50 per cent RDF to component crops (69.73 g $plant^{-1}$), pigeonpea + foxtail millet (2:4) with 50 per cent RDF to component crops (78.89 g $plant^{-1}$) and pigeonpea + sorghum (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (85.62 g $plant^{-1}$) and was found on par with pigeonpea + foxtail millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (95.35 g $plant^{-1}$) and pigeonpea + sorghum (2:4) with 100 per cent RDF to both component crops (95.76 g $plant^{-1}$) (Table 35c).

The partitioning of dry matter in fruiting parts is a single most important factor contributing to the final yield. The data on dry matter accumulation in pods of pigeonpea at harvest indicated that pigeonpea + foxtail millet (2:4) with 100 per cent RDF to both component crops with (25.06 g plant^{-1}) accumulated significantly higher dry matter in pods than pigeonpea + pearl millet (2:4) with100 per cent RDF to both component crops (18.53 g plant^{-1}) and was on par with pigeonpea + sorghum (2:4) with 100 per cent RDF to both component crops (23.40 g plant^{-1}) and pigeonpea + foxtail millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (22.22 g plant^{-1}).

Higher seed yield, yield components and dry matter accumulation per plant at harvest was mainly attributed to the higher uptake of N, P and K by pigeonpea under pigeonpea + foxtail millet (2:4) strip cropped system with 100 per cent RDF to both component crops (137.53, 16.84 and 46.47 kg ha^{-1}) when compared to that under pigeonpea + pearl millet (2:4) with 100 per cent RDF to both component crops (118.38, 13.70 and 36.71 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (2:4) (132.43, 15.65 and 42.79 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 100 per cent RDF to both component crops (129.71, 15.17 and 41.79 kg ha^{-1}) and pigeonpea + sorghum (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (126.39, 13.75 and 38.93 kg ha^{-1}), respectively (Table 50, 51 and 52).

Pigeonpea + cereal intercropping systems are very common in traditional pigeonpea based cropping systems. The short and early maturing cereals such as sorghum, maize and millets accumulated dry matter and utilized resources during the initial slow growth period of pigeonpea. As the reproductive growth of these intercrops does not coincide with pigeonpea, the yield of cereals is not affected adversely. After harvest of cereals, pigeonpea growth is compensated and additional pigeonpea yield is obtained. However, due to taller height of pearl millet variety which inhibited the growth of pigeonpea in all the stages finally adversely affecting the yield of pigeonpea due to shading effect as revealed in the yield data (Table 48).

The results of the investigations indicated that pigeonpea + sorghum (2:4) with 100 per cent RDF to both component crops recorded significantly higher net returns and BC ratio (Rs.34,641 ha^{-1} and 2.28, respectively) over pigeonpea + pearl millet (2:4) with

100 % RDF to both component crops (Rs.24,016 ha^{-1} and 1.90, respectively). However, it was found on par with pigeonpea + foxtail millet (2:4) with 100 per cent RDF to both component crops (Rs.34,248 ha^{-1} and 2.25), pigeonpea + sorghum (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (Rs.32,937 ha^{-1} and 2.19, respectively) and pigeonpea + foxtail millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (Rs.29,584 ha^{-1} and 2.06, respectively). High yielding ability of sorghum under high fertility level coupled with higher market price accounted for the higher net returns and BC ratio under pigeonpea + sorghum (2:4) with 100 per cent RDF to both component crops. Similar results were reported by Mittoliya *et al*. (2015).

SUMMARY AND CONCLUSIONS

VI. SUMMARY AND CONCLUSIONS

The field experiments on "Production and nutritional quality enhancement of nutri-cereals through agronomic manipulations" were conducted during *kharif* season of 2015 and 2016 to evaluate performance of pigeonpea based cropping systems with nutri cereal crops under different row proportions and strip cropping systems with varied fertility levels. The important findings of two experiments were summarized below.

6.1 Experiment-I: Performance of pigeonpea and nutri-cereals in traditional intercropping systems under rainfed condition

The sole crop of pigeonpea produced significantly higher seed and stalk yield (1360 and 2838 kg ha^{-1}, respectively) as compared to that under intercropping systems in pooled analysis. Among the intercropping systems, pigeonpea + foxtail millet (1:1) (991 and 2541 kg ha^{-1}), pigeonpea + sorghum (1:1) (909 and 2430 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (847 and 2327 kg ha^{-1}) and pigeonpea + pearl millet (1:1) (813 and 2285 kg ha^{-1}) recorded significantly higher seed and stalk yield of pigeonpea over other treatments and were on par with one another in pooled analysis.

Pigeonpea yield components differed significantly when intercropped with nutri cereal crops in varied row proportions. Sole pigeonpea recorded significantly higher number of pods per $plant^{-1}$ and seed yield $plant^{-1}$ (103.48 and 35.82 g) when compared to pigeonpea + foxtail millet (1:1) (89.18 and 26.76 g), pigeonpea + sorghum (1:1) (86.41 and 24.59 g), pigeonpea + foxtail millet (1:2) (84.38 and 23.20 g), pigeonpea + sorghum (1:2) (80.74 and 21.28 g), pigeonpea + pearl millet (1:1) (82.27 and 21.86 g) and pigeonpea + pearl millet (1:2) (78.43 and 20.05 g), respectively. Among intercropped treatments, pigeonpea + foxtail millet (1:1) (89.18 and 26.76 g) recorded significantly higher number of pods per $plant^{-1}$ and seed yield $plant^{-1}$, respectively when compared to pigeonpea + pearl millet (1:2) (78.43 and 20.05 g) and pigeonpea + sorghum (1:2) (80.74 and 21.28 g), respectively and was found on par with pigeonpea + sorghum (1:1) (86.41 and

24.59 g), pigeonpea + foxtail millet (1:2) (84.38 and 23.20 g) and pigeonpea + pearl millet (1:1) (82.27 and 21.86 g), respectively.

Sole pigeonpea produced significantly higher dry matter production over all intercropping systems at all the growth stages. At harvest, among the intercropping treatments, pigeonpea + foxtail millet (1:1) (119.02 g plant^{-1}) recorded significantly higher dry matter production which was on par with pigeonpea + sorghum (1:1) (115.97 g plant^{-1}), pigeonpea + foxtail millet (1:2) (114.11 g plant^{-1}) and pigeonpea + pearl millet (1:1) (112.07 g plant^{-1}). Similar trend was observed in dry matter accumulation in reproductive parts and other growth components *viz.*, number of leaves, number of primary and secondary branches, leaf area per plant and leaf area index (LAI).

Pigeonpea + sorghum based intercropping system in both single and double row ratios recorded significantly higher N, P and K uptake, followed by pigeonpea + foxtail millet and pigeonpea + pearl millet intercropping systems. However, sole stand of component crops observed lower N, P and K uptake when compared to their respective intercropping systems.

Zinc (Zn) and iron (Fe) content of pigeonpea seeds did not differ significantly due to intercropping with nutri cereal crops in different row proportions after harvesting and processing of seeds. However, with respect to zinc (Zn) and iron (Fe) content of nutri cereal crops, foxtail millet and pearl millet observed higher zinc (Zn) and Iron (Fe) content, respectively when compared to respective intercropping systems after harvesting and processing of seeds.

With respect to system productivity (PEY), pigeonpea + sorghum and pigeonpea + foxtail millet intercropping system recorded significantly higher pigeonpea equivalent yield (1205 and 1193 kg ha^{-1}) with single row ratio when compared to pigeonpea + pearl millet and pigeonpea + foxtail millet irrespective

of row proportions and was statistically on par with sole pigeonpea. Pearl millet was least productive irrespective of row proportions.

Among intercropping systems, pigeonpea + sorghum recorded significantly higher land equivalent ratio and area time equivalent ratio followed by pigeonpea + foxtail millet irrespective of row proportions. The yield advantage obtained in the intercropped treatments was to the extent of 28 to 45 per cent over sole crop of pigeonpea.

The sole crop of pigeonpea recorded significantly higher net returns and B:C (Rs.56,507 ha^{-1} and 3.33, respectively) and was on par with pigeonpea + sorghum (1:1) (Rs. 46597 ha^{-1} and 2.74). Among the intercropping systems, pigeonpea + sorghum recorded significantly higher net returns and B:C in both (1:1) (Rs. 46597 ha^{-1} and 2.74) and (1:2) (Rs.44257 ha^{-1} and 2.63) and pigeonpea + foxtail millet (1:1) (Rs.44068 ha^{-1} and 2.61) and (1:2) (Rs.37928 ha^{-1} and 2.38), respectively and were found on par with each other.

6.2 Experiment II: Performance of different nutri-cereals in strip cropping with pigeonpea under varied fertility levels

6.2.1 Performance of component crops under strip cropping systems

The differences in the yield potentiality of pigeonpea differed significantly under foxtail millet, sorghum and pearl millet strip cropped systems. Significantly higher seed yield of pigeonpea was observed under pigeonpea + foxtail millet (2:4) (729 kg ha^{-1}) when compared to pigeonpea + pearl millet (2:4) (586 kg ha^{-1}) and was found on par with pigeonpea + sorghum (2:4) (679 kg ha^{-1}).

Significantly higher stalk yield of pigeonpea was recorded by pigeonpea + foxtail millet (2:4) (1882 kg ha^{-1}) and pigeonpea + sorghum (2:4) (1764 kg ha^{-1}) over pigeonpea + pearl millet (2:4) (1597 kg ha^{-1}).

Pigeonpea yield components differed significantly when strip cropping with foxtail millet, sorghum and pearl millet. Pigeonpea + foxtail millet (2:4) recorded significantly higher number of pods per plant (80.33) and seed yield per plant (22.31 g)

when compared to pigeonpea + pearl millet (2:4) (70.97 and 19.64 g, respectively) and was on par with pigeonpea + sorghum (2:4) (76.04 and 21.34 g, respectively).

Pigeonpea performance differed significantly with respect to dry matter production and its distribution into various plant parts. The strip cropped system of pigeonpea + foxtail millet (2:4) (93.51 g plant^{-1}) recorded significantly higher dry matter production at harvest when compared to pigeonpea + pearl millet (2:4) (71.17 g plant^{-1}) and was on par with pigeonpea + sorghum (2:4) (83.70 g plant^{-1}). Similar trend was observed in dry matter accumulation in reproductive parts and other growth components *viz*., number of leaves, number of primary and secondary branches, leaf area per plant and leaf area index (LAI).

Pigeonpea seeds did not differ significantly with respect to Zn and Fe content. Similarly Zn and Fe content of nutri-cereal crop seeds cannot be compared with each other due to difference with respect genetic makeup of seeds even though these crops are grouped as nutri-cereal due to higher minerals and micronutrients content.

With respect to pigeonpea equivalent yield, among strip cropping systems, pigeonpea + sorghum (2:4) (971 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield when compared to pigeonpea + pearl millet (810 kg ha^{-1}) and was found on par with pigeonpea + foxtail millet (952 kg ha^{-1}).

At harvest, uptake of nitrogen, phosphorous and potassium varied significantly among strip cropping systems. Significantly higher N, P and K uptake by pigeonpea was recorded under pigeonpea + foxtail millet (2:4) when compared to pigeonpea + pearl millet (2:4) and was on par with pigeonpea + sorghum (2:4).

Available nitrogen, phosphorus and potassium in soil after the harvest of component crops varied significantly among strip cropping systems. Pigeonpea + pearl millet (2:4) recorded significantly higher available N and P (179.29 and 15.04 kg ha^{-1},) over pigeonpea + sorghum (2:4) (141.61 and 12.29 kg ha^{-1}) and were on par with pigeonpea + foxtail millet (2:4) (165.02 and 13.72 kg ha^{-1}), respectively. However, significantly higher potassium availability was recorded under pigeonpea + foxtail millet (262.53 kg ha^{-1}) over pigeonpea + sorghum (225.97 kg ha^{-1}) and was found on par with pigeonpea + pearl millet (243.20 kg ha^{-1}).

6.2.2 Effect of fertility levels on component crops

The differences in the seed yield of pigeonpea under strip cropping systems differed significantly due to varied fertility levels. The yield of pigeonpea with 100 % RDF to both component crops recorded significantly higher seed and stalk yield (722 and 2020 kg ha^{-1}) when compared to 50 % RDF to both component crops (598 and 1636 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (674 and 1755 kg ha^{-1}).

The higher seed yield recorded at 100 % RDF to both component crops may be attributed to significantly higher values of yield components *viz*. number of pods per plant (79.76) and seed yield per plant (22.33 g) which was on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (76.70) and (21.24 g) respectively.

The differences in the total dry matter production per plant and its distribution into various plant parts differed significantly among the fertility levels at all the growth stages except 30 DAS. At harvest, total dry matter production of pigeonpea was significantly higher at 100 % RDF to both component crops (95.05 g $plant^{-1}$) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (83.48 g $plant^{-1}$) over 50 % RDF to both component crops (69.85 g $plant^{-1}$) and were on par with each other. Similar trend was observed in other growth components *viz*., plant height, number of primary and secondary branches per plant, leaf area and leaf area index (LAI).

At harvest, uptake of nitrogen, phosphorus and potassium varied significantly among fertility levels. At 100 % RDF to both component crops, it recorded significantly higher N, P and K uptake by pigeonpea (128.54, 15.24 and 41.72 kg ha^{-1}) over 50 % RDF to both component crops (116.21, 11.61 and 32.71 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (124.06, 13.74 and 38.08 kg ha^{-1}), respectively.

Among the fertility levels, 100 % RDF to both component crops (970 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield over 50 % RDF to both component crops (833 kg ha^{-1}) and was found on par with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (930 kg ha^{-1}).

Available nitrogen, phosphorus and potassium in soil after the harvest of component crops varied significantly at varied fertility levels. Among the fertility levels, 100 % RDF to both component crops (173.64, 15.28 and 256.60 kg ha^{-1}) and 50 % RDF through organic + 50 % RDF through inorganic to both component crops (163.59, 13.90 and 244.49 kg ha^{-1}), recorded significantly higher available N, P and K, respectively over 50 % RDF to both component crops (148.68, 11.86 and 230.60 kg ha^{-1}).

6.2.3 Economics

The strip cropping of pigeonpea with sorghum (2:4) with 100 % RDF to both component crops recorded significantly higher net returns (Rs. 34,641 ha^{-1}) and benefit cost ratio (2.28) when compared to pigeonpea + pearl millet (2:4) with 100 % RDF to both component crops (Rs.24,016 ha^{-1} and 1.90, respectively) and was found on par with pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (Rs.34,248 ha^{-1} and 2.25, respectively), pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs.32,937 ha^{-1} and 2.19) and pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (Rs.29,584 ha^{-1} and 2.06), respectively.

Practical utility of results

1 Intercropping of pigeonpea with foxtail millet and sorghum irrespective of row proportion was more useful in utilizing natural resource both in time and space which ultimately ensured better system productivity.

2 Instead of sole cropping of pigeonpea, intercropping of pigeonpea with sorghum or foxtail millet in both (1:1) and (1:2) row ratio could be viable and feasible pigeonpea based cropping systems which ensured higher economical profitability.

3 Strip cropping of pigeonpea with either sorghum or foxtail millet performed better in terms of higher productivity and profitability and including nutri-cereals as intercrop is helpful in achieving higher nutritional security and system productivity.

4 Application of 100 % RDF to both component crops and 50 % RDF through organic + 50 % RDF through inorganic to both component crops ensured higher system productivity.

Future line of work

1. There is need to study the influence of growth regulators and foliar nutrition in pigeonpea millet intercropping systems.
2. Studies are needed on the performance of pigeonpea based cropping systems involving millets as intercrop under different shading situation either in open shade or in partial shade.
3. Studies are needed to evaluate different millet varieties under pigeonpea based cropping systems.

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APPENDICES

Appendix I. Plant height of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Plant height (cm)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	46.6	48.5	47.5	180.9	183.3	182.1	198.7	203.4	201.0	233.7	231.4	232.6
T_2 -Pigeonpea + pearl millet (1:1)	54.5	58.7	56.6	191.7	193.8	192.7	-	-	-	242.5	244.3	243.4
T_3-Pigeonpea + foxtail millet (1:1)	38.3	42.1	40.2	91.9	96.3	94.1	-	-	-	115.5	117.1	116.3
T_4 -Pigeonpea + sorghum (1:2)	47.8	49.6	48.7	182.7	185.3	184.0	200.4	205.5	203.0	236.8	235.2	236.0
T_5-Pigeonpea + pearl millet (1:2)	56.3	60.3	58.3	194.3	196.7	195.5	-	-	-	246.6	249.2	247.9
T_6-Pigeonpea + foxtail millet (1:2)	40.3	43.6	42.0	94.4	100.5	97.5	-	-	-	117.3	119.7	118.5
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	53.4	55.3	54.4	188.4	191.5	189.9	204.6	208.7	206.6	240.1	242.9	241.5
T_9-Sole pearl millet (45 cm × 15 cm)	59.3	63.3	61.3	200.7	205.5	203.1	-	-	-	250.4	247.2	248.8
T_{10}-Sole foxtail millet (30 cm × 10 cm)	43.4	48.2	45.8	96.9	103.7	100.3	-	-	-	126.4	129.4	127.9

Appendix II. Number of leaves per plant of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Number of leaves plant^{-1}											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	5.80	6.20	6.00	11.53	11.80	11.67	6.20	6.93	6.57	4.27	4.60	4.43
T_2 -Pigeonpea + pearl millet (1:1)	5.37	5.90	5.63	9.60	9.93	9.77	-	-	-	5.13	5.57	5.35
T_3-Pigeonpea + foxtail millet (1:1)	4.13	4.67	4.40	9.31	9.60	9.45	-	-	-	4.23	4.53	4.38
T_4 -Pigeonpea + sorghum (1:2)	6.10	6.53	6.32	12.67	13.07	12.87	6.87	6.77	6.83	5.20	5.37	5.28
T_5-Pigeonpea + pearl millet (1:2)	5.70	6.30	6.00	10.50	10.90	10.70	-	-	-	6.30	6.77	6.53
T_6-Pigeonpea + foxtail millet (1:2)	4.93	5.17	5.05	10.77	10.90	10.83	-	-	-	4.80	5.07	4.93
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	6.57	7.10	6.83	13.73	13.17	13.45	8.60	9.33	8.97	7.40	7.07	7.23
T_9-Sole pearl millet (45 cm × 15 cm)	6.37	6.53	6.45	12.10	12.20	12.15	-	-	-	6.43	6.83	6.65
T_{10}-Sole foxtail millet (30 cm × 10 cm)	5.37	6.10	5.73	11.47	11.77	11.63	-	-	-	5.57	5.90	5.73

Appendix III. Leaf area of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Leaf area (dm^2 $plant^{-1}$)											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	7.66	8.26	7.96	26.97	27.34	27.15	19.64	19.95	19.80	14.89	15.44	15.17
T_2 -Pigeonpea + pearl millet (1:1)	6.83	7.32	6.98	25.89	26.03	25.96	-	-	-	12.14	12.73	12.44
T_3-Pigeonpea + foxtail millet (1:1)	6.35	6.41	6.36	23.96	24.22	24.09	-	-	-	9.37	9.44	9.41
T_4 -Pigeonpea + sorghum (1:2)	7.92	8.93	8.42	27.61	27.85	27.73	21.41	21.67	21.54	15.86	15.94	15.90
T_5-Pigeonpea + pearl millet (1:2)	7.09	7.42	7.26	26.04	26.47	26.26	-	-	-	13.54	13.84	13.69
T_6-Pigeonpea + foxtail millet (1:2)	6.56	6.61	6.58	25.28	25.73	25.51	-	-	-	10.27	10.55	10.41
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	8.46	9.28	8.87	28.57	29.71	29.14	23.33	25.38	24.41	17.14	17.26	17.20
T_9-Sole pearl millet (45 cm × 15 cm)	7.61	8.10	7.76	26.56	27.07	26.81	-	-	-	14.49	14.95	14.72
T_{10}-Sole foxtail millet (30 cm × 10 cm)	7.15	7.37	7.26	25.85	26.59	26.22	-	-	-	12.77	12.89	12.83

Appendix IV. Leaf area index of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Leaf area index											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	2.65	2.73	2.69	7.51	7.58	7.54	5.69	5.84	5.81	3.95	3.96	3.96
T_2 -Pigeonpea + pearl millet (1:1)	2.47	2.53	2.50	7.19	7.21	7.20	-	-	-	3.47	3.50	3.49
T_3-Pigeonpea + foxtail millet (1:1)	2.24	2.29	2.26	6.19	6.24	6.22	-	-	-	2.86	2.89	2.87
T_4 -Pigeonpea + sorghum (1:2)	2.71	2.83	2.77	7.72	7.76	7.74	5.77	5.97	5.83	4.12	4.21	4.17
T_5-Pigeonpea + pearl millet (1:2)	2.54	2.58	2.56	7.24	7.28	7.26	-	-	-	3.54	3.85	3.69
T_6-Pigeonpea + foxtail millet (1:2)	2.27	2.36	2.31	6.25	6.38	6.31	-	-	-	2.94	2.93	2.94
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	2.88	2.94	2.91	8.04	8.29	8.16	6.18	6.23	6.21	4.32	4.41	4.37
T_9-Sole pearl millet (45 cm × 15 cm)	2.65	2.69	2.67	7.45	7.66	7.55	-	-	-	3.69	3.87	3.78
T_{10}-Sole foxtail millet (30 cm × 10 cm)	2.47	2.47	2.47	6.49	6.53	6.51	-	-	-	3.09	3.12	3.10

Appendix V. Dry matter accumulation in leaves of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter accumulation in leaves (g plant^{-1})											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	1.78	1.89	1.83	7.74	7.92	7.83	9.46	9.78	9.62	8.13	8.09	8.11
T_2 -Pigeonpea + pearl millet (1:1)	1.55	1.67	1.61	6.98	6.74	6.68	-	-	-	6.66	6.69	6.67
T_3-Pigeonpea + foxtail millet (1:1)	0.24	0.29	0.26	2.03	2.06	2.05	-	-	-	1.49	1.52	1.51
T_4 -Pigeonpea + sorghum (1:2)	1.89	2.12	2.01	8.05	8.26	8.16	10.03	10.15	10.09	8.64	8.69	8.33
T_5-Pigeonpea + pearl millet (1:2)	1.62	1.76	1.69	6.61	7.13	7.06	-	-	-	7.01	7.12	7.07
T_6-Pigeonpea + foxtail millet (1:2)	0.28	0.34	0.31	2.08	2.17	2.13	-	-	-	1.62	1.66	1.64
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	2.34	2.52	2.43	8.58	8.95	8.76	11.17	11.33	11.25	10.04	10.15	10.09
T_9-Sole pearl millet (45 cm × 15 cm)	1.84	2.01	1.92	7.32	7.46	7.39	-	-	-	7.89	7.90	7.89
T_{10}-Sole foxtail millet (30 cm × 10 cm)	0.41	0.54	0.48	2.33	2.39	2.36	-	-	-	2.01	2.11	2.06

Appendix VI. Dry matter accumulation in stem of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter accumulation in stem (g plant^{-1})											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	1.54	1.77	1.66	41.64	45.95	43.80	43.63	44.95	44.29	52.76	53.76	53.26
T_2 -Pigeonpea + pearl millet (1:1)	1.49	1.73	1.61	36.29	38.96	37.63	-	-	-	46.02	47.96	46.99
T_3-Pigeonpea + foxtail millet (1:1)	0.31	0.41	0.36	5.59	6.17	5.88	-	-	-	5.95	6.92	6.44
T_4 -Pigeonpea + sorghum (1:2)	1.68	1.92	1.80	42.73	47.12	44.92	47.16	48.21	47.69	54.65	55.48	55.07
T_5-Pigeonpea + pearl millet (1:2)	1.61	1.86	1.74	38.55	41.35	39.95	-	-	-	47.04	49.62	48.33
T_6-Pigeonpea + foxtail millet (1:2)	0.34	0.49	0.42	5.88	6.36	6.12	-	-	-	6.13	7.25	6.69
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	2.04	2.44	2.24	47.52	50.28	48.90	48.92	50.65	49.79	56.17	57.75	56.96
T_9-Sole pearl millet (45 cm × 15 cm)	1.93	2.25	2.09	45.97	47.29	46.63	-	-	-	50.05	52.71	51.38
T_{10}-Sole foxtail millet (30 cm × 10 cm)	0.52	0.76	0.64	6.15	6.44	6.29	-	-	-	6.65	7.38	7.02

Appendix VII. Dry matter accumulation in reproductive plant parts of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter accumulation in reproductive plant parts (g plant^{-1})								
	60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	6.53	6.84	6.69	40.65	41.52	41.09	63.73	64.48	64.10
T_2 -Pigeonpea + pearl millet (1:1)	5.81	6.04	5.93	-	-	-	58.51	59.22	58.86
T_3-Pigeonpea + foxtail millet (1:1)	3.39	3.69	3.54	-	-	-	9.52	10.18	9.85
T_4 -Pigeonpea + sorghum (1:2)	6.86	7.13	7.00	42.37	43.52	42.94	67.52	68.03	67.77
T_5-Pigeonpea + pearl millet (1:2)	6.04	6.18	6.11	-	-	-	60.41	61.18	60.80
T_6-Pigeonpea + foxtail millet (1:2)	3.45	3.79	3.62	-	-	-	9.67	10.41	10.04
T_7 -Sole pigeonpea (90 cm × 30 cm)	0.00	0.00	0.00	-	-	-	0.00	0.00	0.00
T_8 -Sole sorghum (45 cm × 15 cm)	7.46	7.75	7.61	46.56	47.25	46.91	69.29	70.07	69.68
T_9-Sole pearl millet (45 cm × 15 cm)	6.63	6.81	6.72	-	-	-	61.48	63.30	62.39
T_{10}-Sole foxtail millet (30 cm × 10 cm)	4.76	5.28	5.02	-	-	-	10.59	11.41	11.00

Appendix VIII. Dry matter production of intercrops at different stages of crop growth as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Dry matter production (g plant^{-1})											
	30 DAS			60 DAS			90 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	3.57	4.04	3.49	55.91	60.71	58.31	93.74	96.25	95.00	124.61	126.33	125.47
T_2 -Pigeonpea + pearl millet (1:1)	3.03	3.41	3.22	48.70	51.75	50.23	-	-	-	111.18	113.87	112.53
T_3-Pigeonpea + foxtail millet (1:1)	0.55	0.70	0.62	11.02	11.92	11.47	-	-	-	16.96	18.63	17.79
T_4 -Pigeonpea + sorghum (1:2)	3.32	3.66	3.81	59.65	62.52	61.08	99.56	101.88	100.72	130.81	132.20	131.50
T_5-Pigeonpea + pearl millet (1:2)	3.23	3.62	3.42	51.56	54.66	53.11	-	-	-	114.46	117.93	116.19
T_6-Pigeonpea + foxtail millet (1:2)	0.62	0.82	0.72	11.41	12.32	11.87	-	-	-	17.42	19.31	18.37
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	4.39	4.96	4.67	63.56	66.98	65.27	106.65	109.23	107.94	135.50	137.96	136.73
T_9-Sole pearl millet (45 cm × 15 cm)	3.77	4.26	4.01	54.92	58.56	56.74	-	-	-	119.42	123.91	121.67
T_{10}-Sole foxtail millet (30 cm × 10 cm)	0.93	1.29	1.11	13.24	14.11	13.68	-	-	-	19.26	20.90	20.08

Appendix IX. Number of effective tillers per plant, length of earhead, grain weight per earhead and 1000 grain weight (g) of intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	No of effective tillers plant^{-1}			Length of earhead (cm)			Grain weight earhead^{-1} (g)			1000-grain weight (g)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	2.00	2.20	1.95	18.62	19.16	18.89	20.67	21.14	20.91	26. 82	26. 95	26.89
T_2 -Pigeonpea + pearl millet (1:1)	2.20	2.10	2.00	14.59	15.85	15.22	12.78	13.37	13.08	13.45	14.04	13.74
T_3-Pigeonpea + foxtail millet (1:1)	2.40	2.30	2.35	15.11	16.01	15.56	4.93	5.34	5.14	2.93	2.97	2.95
T_4 -Pigeonpea + sorghum (1:2)	1.80	2.10	2.10	21.15	22.06	21.61	21.38	22.18	21.78	27.05	27.17	27.11
T_5-Pigeonpea + pearl millet (1:2)	1.90	2.10	2.15	15.51	16.47	15.99	13.24	13.96	13.60	13.81	14.09	13.95
T_6-Pigeonpea + foxtail millet (1:2)	2.40	2.60	2.50	15.31	16.65	15.98	5.54	5.93	5.74	2.97	3.07	3.02
T_7 -Sole pigeonpea (90 cm × 30 cm)	-	-	-	-	-	-	-	-	-	-	-	-
T_8 -Sole sorghum (45 cm × 15 cm)	2.40	2.50	2.45	22.10	22.33	22.22	22.28	22.59	22.44	27.11	27.29	27.22
T_9-Sole pearl millet (45 cm × 15 cm)	2.30	2.50	2.40	17.06	17.85	17.45	13.67	14.37	14.02	13.89	14.13	14.01
T_{10}-Sole foxtail millet (30 cm × 10 cm)	2.90	3.00	2.95	17.01	17.56	17.28	6.07	6.40	6.23	3.04	3.09	3.06

Appendix X. Grain yield, Stover yield and harvest index of intercrops as influenced by varying row proportion in intercropping systems under rainfed condition

Treatments	Grain yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1 -Pigeonpea + sorghum (1:1)	987	1125	1056	4262	4495	4379	0.19	0.20	0.19
T_2 -Pigeonpea + pearl millet (1:1)	854	1002	928	1769	1983	1876	0.33	0.34	0.33
T_3-Pigeonpea + foxtail millet (1:1)	619	660	639	938	1053	996	0.40	0.39	0.39
T_4 -Pigeonpea + sorghum (1:2)	1114	1373	1244	5685	6027	5856	0.16	0.19	0.17
T_5-Pigeonpea + pearl millet (1:2)	1066	1274	1170	2103	2403	2253	0.34	0.35	0.34
T_6-Pigeonpea + foxtail millet (1:2)	741	774	758	1348	1402	1375	0.36	0.36	0.36
T_7 -Sole pigeonpea (90 cm × 30 cm)	0	0	0	0	0	0	0.00	0.00	0.00
T_8 -Sole sorghum (45 cm × 15 cm)	1380	1524	1452	6969	7246	7108	0.17	0.17	0.17
T_9-Sole pearl millet (45 cm × 15 cm)	1319	1405	1362	5893	6233	6063	0.18	0.18	0.18
T_{10}-Sole foxtail millet (30 cm × 10 cm)	1109	1157	1133	1815	1905	1860	0.38	0.38	0.38

Appendix XI. Estimated Zn and Fe concentration of pigeonpea and intercrops before sowing of seeds

Treatments	Pigeonpea			Sorghum			Pearl millet			Foxtail millet		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Fe (ppm)	64.90	67.51	66.21	69.51	72.19	70.85	621.05	627.56	624.31	253.97	256.17	255.07
Ca (ppm)	238.96	241.18	240.07	24.85	26.28	25.57	742.20	748.24	745.22	80.35	83.26	81.81
Zn (ppm)	16.49	17.21	16.85	10.20	11.45	10.83	20.15	23.45	21.80	38.21	40.19	39.20
K (ppm)	15070.78	15064.18	15067.48	5484.85	5495.17	5490.01	4782.90	4789.78	4786.34	5046.38	5051.18	5048.78
Mg (ppm)	1708.04	1705.45	1706.75	2737.48	2745.71	2741.60	1611.48	1616.35	1613.92	2789.01	2796.08	2792.55

Appendix XII. Plant height (cm) of intercrops at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Plant height at 30 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	42.53	44.69	46.84	44.69	43.27	46.48	47.67	45.81	42.90	45.59	47.26	45.25
M_2	50.70	52.12	54.78	52.54	51.18	52.86	56.30	53.45	50.94	52.49	55.54	52.99
M_3	37.27	38.31	41.27	38.95	37.90	38.87	42.19	39.65	37.59	38.59	41.73	39.30
Mean	43.50	45.04	47.63		44.12	46.07	48.72		43.81	45.56	48.18	
Treatments	Plant height at 60 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	180.94	182.08	185.27	182.76	181.67	183.49	187.01	184.06	181.31	182.79	186.14	183.41
M_2	188.31	192.01	196.41	192.24	188.80	193.71	198.63	193.72	188.56	192.86	197.52	192.98
M_3	91.27	92.78	96.41	93.49	91.97	93.82	98.34	94.71	91.62	93.30	97.38	94.10
Mean	153.51	155.62	159.37		154.15	157.01	161.33		153.83	156.32	160.35	
Treatments	Plant height at 90 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	194.34	197.00	202.05	197.80	195.41	198.84	203.49	199.24	194.87	197.92	202.77	198.52
M_2	-	-	-	-	-	-	-	-	-	-	-	-
M_3	-	-	-	-	-	-	-	-	-	-	-	-
Mean	194.34	197.00	202.05		195.41	198.84	203.49		194.87	197.92	202.77	
Treatments	Plant height at harvest											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	228.39	232.43	238.69	233.17	230.25	234.77	241.46	235.49	229.32	233.60	240.07	234.33
M_2	235.89	238.81	245.74	240.15	237.19	241.20	248.11	242.17	236.54	240.01	246.93	241.16
M_3	109.78	112.82	118.86	113.82	111.45	114.49	120.86	115.60	110.62	113.65	119.86	114.71
Mean	191.36	194.69	201.09		192.96	196.82	203.47		192.16	195.75	202.28	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XIII. Number of green leaves plant^{-1} of intercrops at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Number of green leaves plant^{-1} at 30 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	4.51	4.80	5.12	4.81	4.42	4.93	5.38	4.91	4.46	4.87	5.25	4.86
M_2	4.69	5.32	6.15	5.39	4.85	5.40	6.33	5.53	4.77	5.36	6.24	5.46
M_3	4.67	4.85	5.08	4.87	4.73	4.90	5.32	4.98	4.70	4.88	5.20	4.92
Mean	4.62	4.99	5.45		4.67	5.08	5.68		4.64	5.03	5.57	
Treatments	Number of green leaves plant^{-1} at 60 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	9.49	10.70	11.54	10.57	9.57	10.90	11.97	10.81	9.53	10.80	11.76	10.69
M_2	11.43	12.43	13.75	12.53	11.56	12.55	14.04	12.72	11.49	12.49	13.90	12.63
M_3	9.75	10.80	11.74	10.76	9.86	10.86	12.00	10.90	9.81	10.83	11.87	10.83
Mean	10.22	11.31	12.34	11.29	10.33	11.43	12.67	11.48	10.28	11.37	12.51	11.38
Treatments	Number of green leaves plant^{-1} at 90 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	6.50	6.60	7.33	6.81	6.56	6.68	7.49	6.91	6.53	6.64	7.41	6.86
M_2	-	-	-	-	-	-	-	-	-	-	-	-
M_3	-	-	-	-	-	-	-	-	-	-	-	-
Mean	6.50	6.60	7.33	6.81	6.56	6.68	7.49	6.91	6.53	6.64	7.41	6.86
Treatments	Number of green leaves plant^{-1} at At harvest											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	4.71	4.97	5.70	5.13	4.82	5.08	5.80	5.24	4.77	5.03	5.75	5.18
M_2	5.26	5.64	6.85	5.92	5.33	5.75	7.02	6.04	5.30	5.70	6.94	5.98
M_3	4.50	4.86	5.31	4.89	4.58	4.94	5.60	5.04	4.54	4.90	5.46	4.96
Mean	4.82	5.15	5.96		4.91	5.26	6.14		4.87	5.21	6.05	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XIV. Leaf area of intercrops at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Leaf area (dm² plant⁻¹) at 30 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	6.43	6.99	8.92	7.45	6.54	7.07	9.11	7.57	6.49	7.03	9.01	7.51
M_2	6.78	6.55	7.78	7.04	6.87	6.63	7.97	7.16	6.83	6.59	7.88	7.10
M_3	5.31	5.80	6.79	5.97	5.32	5.89	7.05	6.09	5.32	5.85	6.92	6.03
Mean	6.17	6.45	7.83	6.82	6.24	6.53	8.04	6.94	6.21	6.49	7.94	6.88
Treatments	Leaf area (dm² plant⁻¹) at 60 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	24.85	25.44	26.89	25.73	24.91	25.59	27.14	25.88	24.88	25.52	27.02	25.80
M_2	23.60	24.23	25.91	24.58	23.68	24.35	26.07	24.70	23.64	24.29	25.99	24.64
M_3	22.90	23.71	25.43	24.01	22.97	23.83	25.56	24.12	22.94	23.77	25.50	24.07
Mean	23.78	24.46	26.08		23.85	24.59	26.26		23.82	24.52	26.17	
Treatments	Leaf area (dm² plant⁻¹) at 90 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	18.72	20.43	22.15	20.43	18.80	20.50	22.37	20.55	18.76	20.47	22.26	20.50
M_2	-	-	-	-	-	-	-	-	-	-	-	-
M_3	-	-	-	-	-	-	-	-	-	-	-	-
Mean	18.72	20.43	22.15	20.43	18.80	20.50	22.37	20.55	18.76	20.47	22.26	20.50
Treatments	Leaf area (dm² plant⁻¹) at harvest											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	13.96	14.19	16.19	14.78	14.08	14.33	16.43	14.95	14.02	14.26	16.31	14.86
M_2	12.10	12.90	14.06	13.02	12.18	13.01	14.27	13.15	12.14	12.95	14.12	13.09
M_3	9.40	10.12	10.84	10.12	9.55	10.21	11.12	10.29	9.47	10.17	10.98	10.21
Mean	11.82	12.40	13.70		11.94	12.52	13.94		11.88	12.46	13.82	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XV. Leaf area index of intercrops at different stages of crop growth as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Leaf area index at 30 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	2.19	2.45	3.03	2.55	2.27	2.54	3.22	2.68	2.23	2.49	3.12	2.62
M_2	2.06	2.29	2.86	2.41	2.13	2.35	3.05	2.51	2.09	2.32	2.96	2.46
M_3	1.94	2.19	2.70	2.28	1.97	2.26	2.74	2.32	1.96	2.23	2.72	2.30
Mean	2.06	2.31	2.86	2.41	2.12	2.38	3.00	2.50	2.09	2.35	2.93	2.46
Treatments	**Leaf area index at 60 DAS**											
	2015				**2016**				**Pooled**			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	6.45	6.94	8.98	7.46	6.57	7.09	9.17	7.61	6.51	7.02	9.07	7.53
M_2	6.14	6.82	8.36	7.11	6.24	6.97	8.62	7.27	6.19	6.89	8.49	7.19
M_3	5.11	5.94	7.49	6.18	5.18	6.11	7.54	6.28	5.15	6.02	7.51	6.23
Mean	5.90	6.57	8.27	6.91	6.00	6.72	8.44	7.05	5.95	6.64	8.36	6.98
Treatments	**Leaf area index at 90 DAS**											
	2015				**2016**				**Pooled**			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	5.07	5.36	6.40	5.61	5.15	5.48	6.61	5.75	5.11	5.42	6.51	5.68
M_2	-	-	-	-	-	-	-	-	-	-	-	-
M_3	-	-	-	-	-	-	-	-	-	-	-	-
Mean	5.07	5.36	6.40	5.61	5.15	5.48	6.61	5.75	5.11	5.42	6.51	5.68
Treatments	**Leaf area index at harvest**											
	2015				**2016**				**Pooled**			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	3.48	4.13	4.64	4.09	3.57	4.24	4.85	4.22	3.53	4.19	4.75	4.15
M_2	2.84	3.29	3.94	3.36	2.92	3.33	4.00	3.42	2.88	3.31	3.97	3.39
M_3	2.18	2.50	3.04	2.58	2.23	2.57	3.18	2.66	2.21	2.54	3.11	2.62
Mean	2.84	3.31	3.87	3.34	2.91	3.38	4.01	3.43	2.87	3.34	3.94	3.39

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XVI. Dry matter production of intercrops at different stages of crop growth as influenced by strip cropping and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Dry matter production (g plant^{-1}) at 30 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	3.42	3.65	4.27	3.78	3.56	3.90	4.44	3.97	3.49	3.78	4.36	3.87
M_2	3.03	3.29	4.04	3.45	3.12	3.44	4.22	3.59	3.08	3.37	4.13	3.52
M_3	0.54	0.62	0.81	0.66	0.60	0.68	1.00	0.76	0.57	0.65	0.91	0.71
Mean	2.33	2.52	3.04		2.43	2.67	3.22		2.38	2.60	3.13	
Treatments	Dry matter production (g plant^{-1}) at 60 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	83.89	91.23	99.73	91.61	85.78	92.88	102.32	93.66	84.83	92.06	101.03	92.64
M_2	42.47	44.57	48.25	45.09	43.19	45.15	49.64	45.99	42.83	44.86	48.95	45.54
M_3	6.82	7.98	9.35	8.05	7.03	8.53	9.97	8.51	6.92	8.26	9.66	8.28
Mean	44.39	47.93	52.44		45.33	48.85	53.98		44.86	48.39	53.21	
Treatments	Dry matter production (g plant^{-1}) at 90 DAS											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	92.43	94.93	96.65	94.67	95.76	98.56	101.54	98.62	94.09	96.74	99.09	96.64
M_2	-	-	-	-	-	-	-	-	-	-	-	-
M_3	-	-	-	-	-	-	-	-	-	-	-	-
Mean	92.43	94.93	96.65	94.67	95.76	98.56	101.54	98.62	94.09	96.74	99.09	96.64
Treatments	Dry matter production (g plant^{-1}) at harvest											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	116.68	126.48	138.05	127.07	119.25	128.86	140.94	129.69	117.97	127.67	139.50	128.38
M_2	105.67	112.01	119.07	112.25	107.10	113.73	121.96	114.26	106.39	112.87	120.52	113.26
M_3	15.28	16.90	21.02	17.73	16.58	18.09	22.43	19.03	15.93	17.49	21.73	18.38
Mean	79.21	85.13	92.71		80.98	86.89	95.11		80.09	86.01	93.91	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XVII. Number of effective tillers plant^{-1}, length of earhead (cm), grain weight earhead^{-1} (g) and 1000-grain weight (g) of intercrops as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutri cereals (2:4) intercropping system

Treatments	Number of effective tillers plant^{-1}											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1.65	1.87	2.00	1.84	1.76	1.98	2.12	1.95	1.71	1.93	2.06	1.90
M_2	1.87	1.90	1.96	1.91	1.93	2.01	2.11	2.02	1.90	1.96	2.04	1.96
M_3	1.93	2.00	2.00	1.98	1.93	2.17	2.22	2.11	1.93	2.08	2.11	2.04
Mean	1.82	1.92	1.99		1.88	2.05	2.15		1.85	1.99	2.07	
Treatments	Length of earhead (cm)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	19.09	19.66	20.61	19.78	19.17	19.74	20.69	19.86	19.13	19.70	20.65	19.82
M_2	14.19	14.78	15.32	14.76	14.22	14.83	15.50	14.85	14.20	14.81	15.41	14.81
M_3	14.11	14.36	14.68	14.39	14.15	14.39	14.87	14.47	14.13	14.38	14.78	14.43
Mean	15.80	16.27	16.87		15.85	16.32	17.02		15.82	16.29	16.95	
Treatments	Grain weight earhead^{-1} (g)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	19.01	20.68	20.89	20.19	19.06	20.73	21.04	20.28	19.04	20.71	20.96	20.24
M_2	11.18	11.61	13.91	12.24	11.26	11.71	14.08	12.35	11.22	11.66	14.00	12.29
M_3	4.93	5.78	5.85	5.52	4.97	5.83	5.88	5.56	4.95	5.81	5.87	5.54
Mean	11.71	12.69	13.55		11.76	12.76	13.67		11.74	12.73	13.61	
Treatments	1000-grain weight (g)											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	24.99	26.29	28.02	26.43	24.95	26.31	28.21	26.49	24.97	26.30	28.12	26.46
M_2	11.71	12.38	13.54	12.54	11.80	12.46	13.69	12.65	11.75	12.42	13.62	12.60
M_3	2.85	2.91	2.94	2.90	2.89	2.95	2.98	2.94	2.87	2.93	2.96	2.92
Mean	13.18	13.86	14.83		13.21	13.90	14.96		13.19	13.88	14.90	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XVIII. Seed yield (kg ha^{-1}), Stover yield (kg ha^{-1}) and harvest index of intercrops as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

	Seed yield (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	997	1007	1056	1020	1004	1038	1093	1045	1001	1041	1031	1033
M_2	894	947	1003	948	919	977	1055	984	907	962	1029	966
M_3	639	697	729	688	669	724	764	719	654	711	747	704
Mean	843	884	929		864	913	971		854	905	936	

Treatments	Stover yield (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	4227	4304	4428	4320	4282	4372	4451	4368	4254	4338	4440	4344
M_2	1798	1878	2029	1902	1845	1982	2099	1975	1822	1930	2064	1938
M_3	1123	1256	1372	1250	1174	1317	1434	1308	1149	1287	1403	1279
Mean	2382	2479	2609		2433	2557	2661		2408	2518	2636	

Treatments	Harvest index											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	0.19	0.19	0.19	0.19	0.20	0.19	0.20	0.19	0.19	0.19	0.19	0.19
M_2	0.33	0.34	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
M_3	0.36	0.36	0.35	0.36	0.36	0.35	0.35	0.36	0.36	0.36	0.36	0.36
Mean	0.30	0.30	0.29		0.30	0.29	0.29		0.30	0.30	0.29	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XIX. Uptake of nitrogen, phosphorus and potassium of intercrops as influenced by strip cropping systems and varied fertility levels in pigeonpea and nutricereals (2:4) intercropping system

Treatments	Nitrogen (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	66.82	70.32	74.23	70.46	71.60	74.54	78.08	74.74	69.21	72.43	76.16	72.60
M_2	29.28	33.00	36.97	33.08	31.66	36.36	40.78	36.27	30.47	34.68	38.88	34.68
M_3	20.45	24.34	27.56	24.12	23.30	25.74	30.40	26.48	21.88	25.04	28.98	25.30
Mean	38.85	42.55	46.25		42.19	45.55	49.75		40.52	44.05	48.00	

Treatments	Phosphorus (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	25.44	29.07	31.41	28.64	27.56	30.56	34.00	30.71	26.50	29.82	32.70	29.67
M_2	12.15	14.04	17.15	14.45	13.34	15.56	18.70	15.87	12.75	14.80	17.93	15.16
M_3	6.18	6.93	8.22	7.11	6.78	8.11	9.71	8.20	6.48	7.52	8.96	7.66
Mean	14.59	16.68	18.93		15.89	18.08	20.80		15.24	17.38	19.87	

Treatments	Potash (kg ha^{-1})											
	2015				2016				Pooled			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	43.15	46.35	50.73	46.74	46.79	49.79	55.14	50.57	44.97	48.07	52.94	48.66
M_2	34.62	37.43	41.18	37.74	36.50	39.25	44.20	39.98	35.56	38.34	42.69	38.86
M_3	14.11	15.17	16.89	15.39	15.04	16.74	19.46	17.08	14.58	15.96	18.17	16.24
Mean	30.63	32.98	36.27		32.78	35.26	39.60		31.70	34.12	37.93	

Main plot:
M_1- Pigeonpea + Sorghum (2:4)
M_2- Pigeonpea + Pearl millet (2:4)
M_3- Pigeonpea + Foxtail millet (2:4)

Sub plot
S_1-50 % RDF to both component crops
S_2-50 % RDF through organic + 50 % RDF through inorganic to both component crops
S_3-100 % RDF to both component crops

Appendix XX. Mean weekly standard meteorological data for the year 2015 at Main Agricultural Research Station, Raichur

2015 /week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
1	Jan 01-07	29.9	16.7	10	1	89	50
2	Jan 08-14	29.2	10.8	0	0	78	29
3	Jan 15-21	29.8	15.8	0	0	70	38
4	Jan 22-28	29.8	17.0	0	0	80	38
5	Jan 29-Feb 04	30.8	18.2	0	0	87	36
6	Feb 05-11	31.7	17.0	0	0	73	24
7	Feb 12-18	33.7	17.8	0	0	65	20
8	Feb 19-25	34.5	19.4	0	0	54	21
9	Feb 26-Mar 04	33.7	20.0	0	0	63	32
10	Mar 05-11	33.7	21.9	24.9	1	79	36
11	Mar 12-18	35.7	22.1	0	0	64	25
12	Mar 19-25	38.0	23.1	0	0	53	19
13	Mar 26-Apr 01	37.7	25.1	0	0	65	26
14	Apr 02-08	39.9	25.4	0	0	47	21
15	Apr 09-15	35.0	22.9	52.4	3	79	40
16	Apr 16-22	36.8	25.1	0	0	71	28
17	Apr 23-29	37.5	23.8	61.8	1	74	32

Contd….

2015 /week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
18	Apr 30- May 06	39.0	26.3	16	1	67	26
19	May 07-13	38.8	26.9	0	0	58	29
20	May 14-20	38.2	25.8	2.7	0	77	31
21	May 21-27	42.3	27.9	0	0	68	23
22	May 28-June 03	40.9	26.0	4.4	1	69	27
23	June 04-10	38.4	25.9	2.6	0	74	35
24	June 11-17	35.7	24.8	21.1	3	77	44
25	June 18-24	33.3	24.2	10.6	2	80	43
26	June 25-July 01	36.5	25.2	0	0	74	36
27	July 02-08	37.0	25.3	0.5	0	71	32
28	July 09-15	36.9	25.3	23	1	77	42
29	July 16-22	35.4	24.5	2.2	0	79	36
30	July 23-29	35.5	23.9	14.3	2	81	37
31	July 30-Aug 05	35.9	24.0	4.2	0	77	43
32	Aug 06-12	35.3	24.4	7.2	1	78	48
33	Aug 13-19	34.1	24.5	8	1	78	42
34	Aug 20-26	34.2	24.2	23	2	84	54

Contd….

2015 /week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
35	Aug 27-Sept 02	34.0	23.9	11	2	83	44
36	Sept 03-09	33.6	23.7	132.6	4	87	56
37	Sept 10-16	30.3	23.0	148	5	94	72
38	Sept 17-23	32.1	23.1	7.8	1	87	53
39	Sept 24-Oct 30	61.7	23.8	28.2	1	86	54
40	Oct 01-07	31.9	23.5	66	3	92	59
41	Oct 08-14	33.2	23.3	0	0	83	46
42	Oct 15-21	34.7	23.5	0	0	75	34
43	Oct 22-28	34.0	21.6	0	0	69	34
44	Oct 29-Nov 04	32.9	23.4	1.2	0	79	42
45	Nov 05-11	32.9	21.8	0	0	76	35
46	Nov 12-18	30.9	19.2	0	0	76	42
47	Nov 19-25	31.3	21.8	2	0	82	49
48	Nov 26-Dec 02	31.8	20.3	0	0	86	48
49	Dec 03-09	30.9	18.5	2.2	0	90	37
50	Dec 10-16	33.1	18.9	0	0	88	38
51	Dec 17-23	32.9	20.1	0	0	83	38
52	Dec 24-31	31.3	15.6	0	0	72	26

Appendix XXI. Mean weekly standard meteorological data for the year 2016 at Main Agricultural Research Station, Raichur

2016 /week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
1	Jan 01-07	31.6	16.8	0	0	78	27
2	Jan 08-14	30.9	15.3	0	0	67	22
3	Jan 15-21	29.6	18.6	1.4	0	78	44
4	Jan 22-28	31.5	20.0	0	0	78	36
5	Jan 29-Feb 04	35.1	18.1	0	0	62	19
6	Feb 05-11	34.2	21.0	0	0	70	30
7	Feb 12-18	34.8	21.8	0	0	59	24
8	Feb 19-25	36.9	22.3	0	0	55	21
9	Feb 26-Mar 04	34.9	24.2	0	0	72	35
10	Mar 05-11	36.6	22.9	0	0	60	23
11	Mar 12-18	38.5	23.9	0	0	57	21
12	Mar 19-25	40.9	25.3	0	0	39	16
13	Mar 26-Apr 01	39.7	26.4	0	0	52	19
14	Apr 02-08	40.5	26.6	0	0	54	18
15	Apr 09-15	41.3	28.2	0	0	46	23
16	Apr 16-22	42.2	29.5	0	0	53	17
17	Apr 23-29	43.2	28.7	0	0	37	12

Contd….

2016 /week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
18	Apr 30- May 06	41.7	27.6	14	1	56	23
19	May 07-13	38.5	25.3	16	1	65	29
20	May 14-20	39.8	27.6	5.2	1	66	31
21	May 21-27	39.0	26.2	37	1	72	30
22	May 28-June 03	39.8	26.4	27	2	74	34
23	June 04-10	33.6	24.3	45.6	1	84	50
24	June 11-17	35.3	24.8	0.5	0	79	45
25	June 18-24	32.8	23.6	111.8	4	88	61
26	June 25-July 01	31.8	23.7	24.2	1	86	58
27	July 02-08	33.0	24.3	5.4	1	83	49
28	July 09-15	32.3	23.8	8.4	1	81	62
29	July 16-22	33.3	23.4	32.4	3	84	55
30	July 23-29	30.3	23.0	26.8	4	92	68
31	July 30-Aug 05	28.6	22.7	84.6	4	91	76
32	Aug 06-12	32.3	22.8	2.4	0	87	51
33	Aug 13-19	33.4	22.9	2	0	84	47
34	Aug 20-26	33.9	22.8	12	1	86	45

Contd….

2016 /week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
35	Aug 27-Sept 02	31.2	23.8	47.2	2	88	51
36	Sept 03-09	30.9	22.3	16.5	2	87	57
37	Sept 10-16	28.6	22.8	136.2	5	93	79
38	Sept 17-23	28.5	22.2	79	4	92	63
39	Sept 24-Oct 30	28.9	22.8	60.8	4	95	77
40	Oct 01-07	30.4	22.4	5.2	1	90	62
41	Oct 08-14	31.2	22.2	34	1	90	58
42	Oct 15-21	31.6	18.1	0	0	80	41
43	Oct 22-28	31.4	16.6	0	0	77	38
44	Oct 29-Nov 04	31.6	20.2	0	0	86	48
45	Nov 05-11	31.2	15.6	0	0	81	34
46	Nov 12-18	30.9	18.1	0	0	88	43
47	Nov 19-25	30.4	14.8	0	0	85	33
48	Nov 26-Dec 02	31.4	13.5	0	0	76	30
49	Dec 03-09	31.2	16.7	0	0	82	38
50	Dec 10-16	29.7	16.7	8.2	0	75	44
51	Dec 17-23	30.5	13.4	0	0	84	27
52	Dec 24-31	30.1	13.8	0	0	84	28

Appendix XXII. Mean weekly standard meteorological data for the year 2017 at Main Agricultural Research Station, Raichur

2017/ Week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
1	Jan 01-07	30.4	14.6	0	0	74	26
2	Jan 08-14	30.4	14.7	0	0	76	37
3	Jan 15-21	29.9	16.4	0	0	78	26
4	Jan 22-28	31.0	17.9	0	0	78	32
5	Jan29- Feb 04	32.6	18.7	0	0	71	24
6	Feb 05-11	33.1	19.7	0	0	56	24
7	Feb12-18	31.9	19.0	0	0	67	27
8	Feb19-25	36.5	20.0	0	0	57	14
9	Feb26-Mar04	35.7	19.1	0	0	54	14
10	Mar 05-11	37.1	21.9	0	0	41	17
11	Mar 12-18	34.9	22.5	30	1	63	29
12	Mar 19-25	37.4	23.2	0	0	53	17
13	Mar26- Apr 01	39.5	24.9	0	0	44	16
14	Apr 02-08	40.4	26.1	0	0	44	18
15	Apr 09- 15	40.8	25.3	0	0	58	26
16	Apr 16- 22	41.4	27.2	0	0	68	28
17	Apr 23-29	40.9	25.7	7.2	1	41	22

Contd….

2017/ Week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
18	Apr30-may6	39.6	26.7	0	0	49	22
19	May 7-13	39.9	27.0	0	0	59	25
20	May14-20	39.4	27.0	8.1	1	71	26
21	May21-27	42.3	29.5	0	0	59	20
22	May28-Jun3	39.6	27.3	0	0	68	29
23	Jun 4-10	36.7	24.7	58.4	2	83	42
24	Jun 11-17	32.6	24.2	42.5	3	85	62
25	Jun 18-24	33.3	23.8	57.8	3	86	52
26	Jun 25- July 01	34.9	24.5	3.1	0	78	40
27	July 02- 08	35.0	24.6	6.2	1	78	39
28	July 09-15	32.8	24.0	3	0	77	55
29	July 16- 22	33.4	23.7	0	0	80	48
30	July 23- 29	35.2	24.0	3	1	77	41
31	July 30- Aug 05	34.8	23.9	4.1	0	81	44
32	Aug 06-12	33.5	20.9	81.6	4	86	56
33	Aug 13-19	31.6	23.9	3.8	1	88	62
34	Aug 20-26	31.1	22.8	27.1	4	87	64

Contd….

2017/ Week	Date	Maximum Temp. (°c)	Minimum Temp. (°c)	Rainfall (mm)	Rainy Day	Relative humidity maximum (%)	Relative humidity maximum (%)
35	Aug 27-Sept 02	30.9	23.3	82	5	89	66
36	Sep 03- 09	30.9	23.7	74.4	3	92	69
37	Sep10-16	32.5	24.3	35.3	2	89	64
38	Sep 17- 23	29.4	22.5	50.5	1	89	76
39	Sep 24-30	31.0	22.5	88.2	5	97	82
40	Oct01-07	30.2	23.5	42.5	2	96	75
41	Oct 08 -14	30.4	22.9	130.8	5	96	72
42	Oct 15-21	31.0	21.5	20.2	1	91	68
43	Oct 22-28	31.1	22.1	0	0	91	63
44	Oct 29-Nov 04	30.5	19.0	0	0	82	51
45	Nov 05-11	30.3	19.6	0	0	85	53
46	Nov 12-18	31.2	19.1	0	0	82	45
47	Nov 19-25	31.8	21.8	0	0	85	47
48	Nov 26-Dec 02	30.3	17.7	0	0	78	49
49	Dec 03-09	29.8	18.8	0	0	82	52
50	Dec 10-16	31.3	16.6	0	0	87	39
51	Dec 17-23	28.7	14.0	0	0	89	49

Appendix XXIII. Price of inputs and outputs for 2015-16 and 2016-2017

Sl. No.	Particulars	Unit	Price (Rs.) 2015	Price (Rs.) 2016
A. Inputs				
I	**Seeds**			
1	Pigeonpea	kg	85	115
2	Sorghum	kg	51	55
3	Foxtail millet	kg	35	35
4	Pearl millet	kg	80	84
II	**Fertilizers**			
	1) Urea	kg	7	6.8
	2) DAP	kg	22.1	22.80
	3) Muriate of potash	kg	16.00	16.90
	4) FYM	t	500	500
III	**Labour wages**			
	1. Men	Day	236	260
	2. Women	Day	236	260
	3. Bullock pair	Per day	500	500
	4. Irrigation	Per hectare	320	325
	5. Tractor	Per hour	500	550
IV	**Plant protection chemicals**			
	1. Dichloravas(DDVP)	litre	750	750
	2. Chloropyriphos	litre	350	350
	3. Coragen	litre	13,500	13,500
	4. Fipronil	litre	1280	1280
	5. Thimmet 10G	5 kg bag	1000	1000
	6. Bavistin	kg	600	600
V	**Miscellaneous**			
	Marketing and handling charges	3 % of the gross value of the produce		
B. Outputs				
	Pigeonpea	q	6890	5050
	Sorghum	q	1590	1650
	Foxtail millet	q	1275	1330
	Pearl millet	q	1800	1895
	Straw	t	500	500

PRODUCTION AND NUTRITIONAL QUALITY ENHANCEMENT OF NUTRI-CEREALS THROUGH AGRONOMIC MANIPULATIONS

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ABSTRACT

Field experiments were conducted at, UAS, Raichur farm, during *kharif* season of 2015-16 and 2016-17 to study production and nutritional quality enhancement of nutri-cereals through agronomic manipulations.

In an experiment with respect to performance of pigeonpea and nutri-cereals in intercropping systems, intercropping of pigeonpea with foxtail millet (1:1) (991 kg ha^{-1}) recorded significantly higher seed yield of pigeonpea and was on par with pigeonpea + sorghum (1:1) (909 kg ha^{-1}), pigeonpea + foxtail millet (1:2) (847 kg ha^{-1}) and pigeonpea + pearl millet (813 kg ha^{-1}). However, pigeonpea + sorghum (1:1) (1205 kg ha^{-1}) and pigeonpea + foxtail millet (1:1) (1193 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield and found at par with sole pigeonpea (1360 kg ha^{-1}). Land equivalent ratio indicated yield advantage, to the extent of 28 to 45 per cent obtained due to intercropping with sorghum, foxtail millet and pearl millet. Sole pigeonpea recorded significantly higher net returns (56,507 Rs. ha^{-1}) and BC ratio (3.33) over intercropping systems and was found on par with pigeopea + sorghum (1:1) (46,597 Rs. ha^{-1} and 2.74), respectively. The results of experiment on the performance of different nutri-cereals in strip cropping with pigeonpea under varied fertility levels indicated that pigeonpea + foxtail millet (2:4) with 100 % RDF to both component crops (1042 kg ha^{-1}) recorded significantly higher pigeonpea equivalent yield and was found to be on par with pigeonpea + sorghum (2:4) with 100 % RDF to both component crops (1017 kg ha^{-1}), pigeonpea + sorghum (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (1001 kg ha^{-1}) and pigeonpea + foxtail millet (2:4) with 50 % RDF through organic + 50 % RDF through inorganic to both component crops (969 kg ha^{-1}). However, pigeonpea + sorghum (2:4) with 100 per cent RDF to both component crops recorded significantly higher net returns and BC ratio (Rs.34,641 ha^{-1} and 2.28), respectively. However, it was found on par with pigeonpea + foxtail millet (2:4) with 100 per cent RDF to both component crops (Rs.34,248 ha^{-1} and 2.25), pigeonpea + sorghum (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (Rs.32,937 ha^{-1} and 2.19) and pigeonpea + foxtail millet (2:4) with 50 per cent RDF through organic + 50 per cent RDF through inorganic to both component crops (Rs.29,584 ha^{-1} and 2.06), respectively.