



## Growth, phenology and yield of pigeonpea (*Cajanus cajan*) as affected by intercropping systems and application of nutrients level to intercrops

FATEHJEET SINGH SEKHON<sup>1</sup>, THAKAR SINGH<sup>1</sup> and SOMPAL SINGH<sup>2</sup>

*Punjab Agricultural University, Ludhiana 141 004*

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### ABSTRACT

An experiment was carried out during *kharif* season for the two consecutive years (2015 and 2016) at Students Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana to study the performance of pigeonpea [*Cajanus cajan* (L.) Millsp.] as influenced by intercropping systems and application of different nutrients levels to intercrops. Plant height, dry matter accumulation and seed yield of pigeonpea were not influenced by different intercropping systems and nutrients levels applied to intercrops. Pigeonpea equivalent yield was significantly affected by intercropping systems and nutrients levels applied to intercrops. Among the different intercropping systems and planting patterns, maximum pigeonpea equivalent yield of 18.4 and 19 q/ha was recorded with pigeonpea (50 × 25 cm) + maize fodder intercropping system during 2015 and 2016, respectively, which was statistically superior than all other intercropping systems with different planting patterns. The application of 100% recommended dose of nutrients to the intercrops resulted in the significantly higher pigeonpea equivalent yield (16.3 and 17.3 q/ha) than the 50% recommended dose (14.9 and 16 q/ha) and control (13.7 and 14.4 q/ha) during both the years.

**Key words:** Growth parameters, Intercropping system, Pigeonpea equivalent yield, Seed yield

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important pulse crop after chickpea in India which is cultivated on area of 3.9 m ha with production of 2.81 mt and productivity of 729 kg/ha (Anonymous 2016). It is predominantly grown during *kharif* season under wide range of agro-ecological situations. Growing of pigeonpea as a sole crop is not economically viable due to its low productivity and longer duration. Pigeonpea, a deep rooted crop and wide row planting with slow initial growth rate between 45-60 days after sowing is well suited for intercropping. The wide space left between the rows can be utilized effectively by growing short duration crops, which help in generating an additional income without reducing the yield of pigeonpea and soil properties. Intercropping of short duration cereals and pulses provides an opportunity to utilize available resources more efficiently with enhancement of productivity and profitability of the system. So, in modern agriculture, it can help increase in crop productivity particularly at small farms as it satisfies the diversified demands of the farm people (Imran *et al.* 2011). This may be due to some of the potential benefits for intercropping systems such as high productivity and profitability (Yildirim and Guvence 2005), reducing damage caused by pests, diseases and weeds (Sekamatte *et al.* 2003) and efficient use of environmental

resources (Knudsen *et al.* 2004 and Eskandari and Ghanbari 2009) through the complementary effects of two or more crops grown simultaneously on the same piece of land. The demand of fodder crops was increased in Punjab during last decade, due to increase in dairy units. Area and production of fodder crop is less and to meet this increase in demand of fodder, cultivation of fodder crops as intercrop with pigeonpea could help in achieving it. Among the different factors of production, inadequate fertilizer management has remained major constraint forever. Component crops in intercropping systems use the same resources in different forms (Szumigalski and Acker 2005). The greatest limitation of increasing the productivity of crops in intercropping system is inadequate supply of nutrients since most of the soils are poor in native fertility and continuous application of fertilizers even in balanced form may not sustain soil fertility and productivity. Thus, balanced fertilization along with sound crop husbandry offers a great scope for increasing productivity. However, when crops are intercropped by increasing the overall density, nutritional deficiency is likely to occur. The optimum dose of nutrients play an important role in increasing the productivity of these crops. The land holding of the farmers is shrinking day by day in Punjab. Hence, there is an urgent need to increase the productivity and profitability of the farmers per unit area per unit time, which is possible by raising short duration intercrops in between the wider rows of the main crop.

<sup>1</sup>Department of Agronomy (e mail: fatehjeetsingh@pau.edu, thakarsingh@pau.edu), <sup>3</sup>School of Climate Change and Agricultural Meteorology (e mail: sompal69@pau.edu).

## MATERIALS AND METHODS

A field experiment was carried out at the Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during *kharif* of 2015 and 2016 situated at 30° 54' N latitude and 75° 48' E longitude and at the height of 247 m above the mean sea level and characterized by sub-tropical and semi-arid type of climate with an average annual rainfall of 500-750 mm and mean annual evaporation of 850-1050 mm. The rainfall received during the crop growing period from May to November was 559 mm in 2015 and 546 mm in 2016. The soil texture was loamy sand with pH of 7.2, OC 0.31%, available nitrogen 196 kg/ha, available phosphorus 18.8 kg/ha and available potassium 213.2 kg/ha. The experiment was laid out in a split plot design with six treatments: Pigeonpea (50 cm × 25 cm) + cowpea fodder, pigeonpea (50 cm × 25 cm) + maize fodder, pigeonpea (50 cm × 25 cm) + groundnut, pigeonpea (100 cm × 12.5 cm) + cowpea fodder, pigeonpea (100 cm × 12.5 cm) + maize fodder and pigeonpea (100 cm × 12.5 cm) + groundnut in the main plot and three levels of recommended dose of nutrient (NPK) applied to intercrop (control, 50% and 100%) in sub-plots were replicated thrice.

Crops were grown as per cultural practices recommended in package of practices. Sowing of pigeonpea was done manually through pora method as per treatments with different row spacing and intercrops were sown in between of two row of pigeonpea. Sowing was done on 29 May, during crop season of 2015 and 26 May on during crop season of 2016. The varieties taken for sowing were PAU 881 of pigeonpea, SG 99 of groundnut, cowpea 88 of cowpea fodder and J 1006 of maize fodder. The recommended doses of fertilizers for pigeonpea (15 kg N, 40 kg P<sub>2</sub>O<sub>5</sub> and 30 kg K<sub>2</sub>O/ha) were applied at sowing. Fertilizer doses as per treatments were applied on area basis to all the intercrops. Nitrogen, phosphorus and potassium nutrients were applied in the form of urea, single super phosphate and muriate of potash, respectively. The harvesting of pigeonpea was done

manually on 3 November, 2015 and 26 October, 2016. The harvested crop was tied in labeled bundles and kept for sun drying. Then the threshing was carried out. Harvesting of cowpea fodder and maize fodder was done 45 days after sowing (DAS) for green fodder. The harvesting of groundnut was done on 2 October 2015 and 2016, respectively. Plant height and dry matter accumulation was recorded at 30 days intervals after sowing and at harvest and leaf area index and photosynthetic active radiation, plant height and dry matter accumulation was recorded at harvest during both the years. Pigeonpea equivalent yield (PEY) was calculated by using the formula

$$PEY = \frac{\text{Intercrop yield} \times \text{Price of intercrop}}{\text{Price of pigeonpea}} + \text{pigeonpea yield}$$

## RESULTS AND DISCUSSION

*Growth attributes of pigeonpea*

*Plant height:* Periodic plant height was recorded at 30, 60, 90, 120 DAS and at maturity (Table 1). There was a progressive increase in plant height with the advancement of crop age during the both years. A sharp increase in plant height was registered between 30 to 90 DAS. Further, there was decline in rate of increase in plant height from 120 DAS to maturity. At 30 DAS, significantly higher plant was recorded with pigeonpea (100 × 12.5 cm) + groundnut intercropping system as compared to pigeonpea (100 × 12.5 cm) + maize fodder and pigeonpea (50 × 25 cm) + maize fodder, however, it was statistically at par with pigeonpea (100 × 12.5 cm) + cowpea fodder, pigeonpea (50 × 25 cm) + groundnut and pigeonpea (50 × 25 cm) + cowpea fodder intercropping systems during both year of experimentation. Lowest plant height was recorded with pigeonpea (50 × 25 cm) + maize fodder during both the years. Similar trend was observed at 60 and 90 DAS during the both years. Lowest plant height of pigeonpea with maize as intercrop might be due to more competition

Table 1 Plant height of pigeonpea as influenced by different intercropping systems and levels of nutrients applied to intercrops

Intercropping system	Plant height (cm)									
	30 DAS		60 DAS		90 DAS		120 DAS		At harvest	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Pigeonpea (50 cm × 25 cm) + cowpea fodder	42.2	42.6	147.1	148.8	212.2	212.5	242.1	243.2	274.8	275.2
Pigeonpea (50 cm × 25 cm) + maize fodder	40.5	41.8	142.0	147.0	208.3	209.9	241.7	242.5	274.3	274.6
Pigeonpea (50 cm × 25 cm) + groundnut	42.3	42.7	147.9	148.9	213.7	212.4	242.2	243.9	274.9	275.6
Pigeonpea (100 cm × 12.5 cm) + cowpea fodder	42.4	42.8	148.4	149.0	213.4	212.2	242.9	243.6	274.5	274.7
Pigeonpea (100 cm × 12.5 cm) + maize fodder	40.7	42.1	144.1	147.3	210.5	210.9	242.3	243.2	274.4	274.8
Pigeonpea (100 cm × 12.5 cm) + groundnut	42.5	42.9	148.7	149.7	213.8	213.2	243.6	244.9	274.7	275.2
CD (P = 0.05)	0.9	0.6	1.7	1.2	1.4	1.4	NS	NS	NS	NS
<i>Nutrients levels applied to intercrops (% of recommended NPK)</i>										
0	40.8	41.6	143.8	146.6	209.9	209.2	241.6	242.2	274.1	274.5
50	41.6	42.4	146.5	148.5	211.7	211.3	242.8	243.9	274.4	274.9
100	42.7	43.4	148.9	150.5	214.3	214.6	243.0	244.5	275.3	275.6
CD (P = 0.05)	0.6	0.5	1.1	1.0	1.2	1.0	NS	NS	NS	NS

of component crops for growth resources early stages of plant growth. Plant height of pigeonpea was not affected significantly at 120 DAS and at maturity by the different intercropping systems. Kumar *et al.* (2013) also recorded that intercropping of mungbean with pigeonpea did not significantly influence the plant height at maturity of crop.

Plant height of pigeonpea was significantly influenced with different doses of NPK applied to intercrops at 30, 60, 90 DAS. Plant height of pigeonpea at 30 DAS was significantly reduced where no NPK was applied to intercrops and there was significant response to applied NPK up to 100% of recommended dose to intercrops during both the years. Similar observations were recorded at 60 and 90 DAS with different doses of NPK to intercrop on plant height of pigeonpea. At other growth stages, viz. 120 DAS and at maturity, plant height of pigeonpea was not significantly influenced by different doses of NPK applied to intercrops. The applied fertilizers were taken up by intercrops during initial stages and very negligible residual effect might have prevailed which failed to significantly influence the plant height at later stages of crop growth. Sharma *et al.* (2010) also observed that with increase in dose of fertilizer, plant height was not significantly influenced at maturity. Nagar *et al.* (2015) also reported similar findings when different doses of nutrients were applied.

*Dry matter accumulation (DMA):* Dry matter accumulation plays significant role in plant proliferation. Data was recorded on DMA at 30, 60, 90, 120 DAS and at maturity (Table 2). DMA increased continuously with the age of pigeonpea. It increased at the lowest rate at initial stage because of slow growth and development of pigeonpea at early stages and competition by intercrops. The increase in DMA was tremendous between 90 DAS to maturity in all the intercropping systems which was due to grand growth of pigeonpea during this period. All the intercropping systems did not show any significant effect

on DMA at all the growth stages of crop. This might be due to proper growth and development of pigeonpea crop after the harvest of fodder crops and groundnut being leguminous crop had no adverse effect on plant growth and development. Patel *et al.* (2013) and Reddy *et al.* (2012) also observed that different pigeonpea based intercropping systems and planting patterns did not show any significant effect on DMA of pigeonpea.

The application of different levels of recommended dose of nutrients to intercrops affected the DMA of pigeonpea significantly during both the years. At 30, 60 and 90 DAS, the 100% NPK applied to intercrops significantly increased DMA by pigeonpea over control and 50% NPK of recommended during both the years and thereafter, at 120 DAS and at maturity, application of different doses of recommended NPK failed to affect DMA of pigeonpea. This may be due to the fact that applied nutrient have been taken up by intercrops at early stages of pigeonpea and residual effect was found negligible at latter stages. Nagar *et al.* (2015) also observed that DMA of pigeonpea was not affected by different doses of nutrients.

*Growth attributes and yield of intercrops:* The results showed that plant height, DMA, LAI, PAR interception and yield of intercrops, viz. cowpea fodder (Fig 1), maize fodder and groundnut (Fig 2) were increased with the application of increased level of nutrients during 2015 and 2016. The increased dose of nutrients from 0 to 100% applied to intercrops on area basis, showed increase in growth parameters, PAR interception and yield of intercrops. The intercrops comprised two fodder crops and one oilseed crop. These crops were having different nature of growth habits, rooting pattern, canopy structure and days to maturity. Maize fodder and cowpea fodder were of short duration, possessed vigorous growth rate during the initial growth periods, whereas groundnut had slower growth rate during initial stages, shorter canopy structure

Table 2 Dry matter accumulation (DMA) of pigeonpea as influenced by different intercropping systems and levels of nutrients applied to intercrops

Intercropping system	DMA (g/plant)									
	30 DAS		60 DAS		90 DAS		120 DAS		At harvest	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Pigeonpea (50 cm × 25 cm) + cowpea fodder	8.7	9.6	28.2	29.0	97.7	98.4	148.5	148.4	223.1	224.0
Pigeonpea (50 cm × 25 cm) + maize fodder	8.5	9.5	28.1	28.9	97.1	98.4	148.1	148.3	222.6	223.0
Pigeonpea (50 cm × 25 cm) + groundnut	9.4	10.1	29.1	29.7	98.0	99.0	149.3	149.1	224.1	224.6
Pigeonpea (100 cm × 12.5 cm) + cowpea fodder	8.8	9.9	28.3	29.1	97.8	98.7	149.0	149.1	224.0	224.2
Pigeonpea (100 cm × 12.5 cm) + maize fodder	8.6	9.2	28.2	28.6	97.2	98.7	148.5	148.7	223.4	224.3
Pigeonpea (100 cm × 12.5 cm) + groundnut	9.6	10.3	29.2	29.9	98.1	99.2	149.6	149.5	224.4	224.8
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
<i>Nutrients levels applied to intercrops (% of recommended NPK)</i>										
0	8.5	9.4	27.4	28.7	96.3	97.3	148.2	148.0	222.7	223.3
50	8.9	9.7	28.4	29.1	97.9	98.8	148.8	148.6	223.4	224.0
100	9.6	10.1	29.4	29.8	98.8	100.1	149.6	149.8	224.7	225.3
CD (P = 0.05)	0.6	0.5	1.1	0.9	0.8	0.7	NS	NS	NS	NS

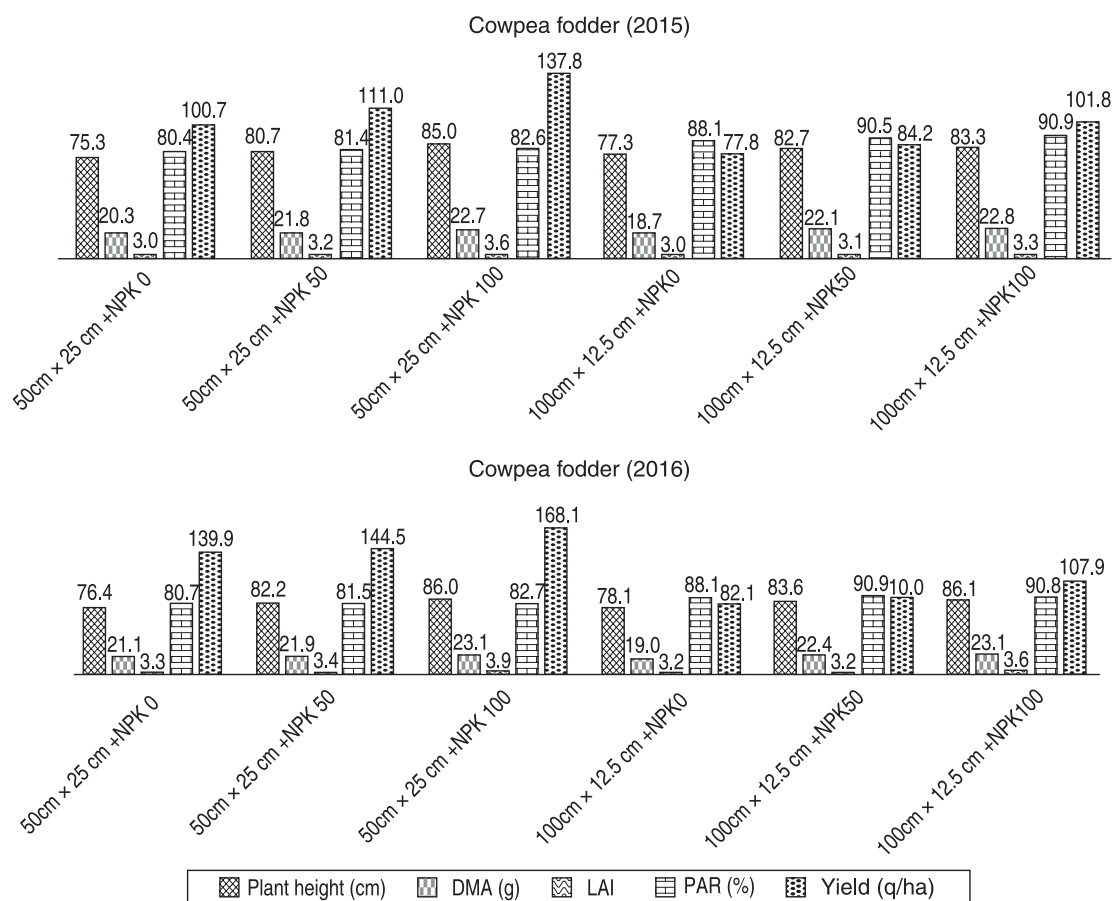


Fig 1 Growth parameters and yield of cowpea fodder as influenced by intercropping systems and nutrients applied to cowpea fodder during 2015 and 2016.

and long duration. The lower yield of cowpea fodder and maize fodder was observed in 2015 as compared to 2016. Both fodder crops recorded relatively higher yield during second year, which may be attributed to better agroclimatic conditions particularly rainfall distribution in the cropping season during second year. Cowpea fodder and maize fodder yield as intercrop in pigeonpea (50 × 25 cm) and pigeonpea (100 × 12.5 cm) with 1:1 was higher where 100% of recommended nutrients were applied during both the years. The groundnut yield varied largely during both the years. Higher groundnut yield was recorded in the first year as compared to second year with respect to all the treatments. However, there was increase in yield of intercrops with increase in levels of nutrients applied to intercrops on area basis in both the planting patterns of intercropping systems during both growing seasons.

**Seed yield of pigeonpea:** Economic yield can be expressed as a function of all the factors contributing towards yield. There was no significant effect of intercropping systems was observed on seed yield of pigeonpea during the both growing seasons (Table 3). However, higher seed yield was recorded with pigeonpea (100 × 12.5 cm) + groundnut intercropping system as compared to all other intercropping systems during both the years. Different levels of nutrients applied to intercrops did not significantly influence the seed

yield of pigeonpea. However, increasing trend was observed with increasing the levels of nutrients from zero to 100% of recommended dose, though the differences failed to reach the level of significance. This increase in seed yield may be attributed to positive effect of intercrops and higher nutrients level on DMA, pods/plant, grains/pod and 1000 seed weight of pigeonpea. Nagar *et al.* (2015) also reported similar effect of intercropping and different nutrient levels on seed yield of pigeonpea.

**Pigeonpea equivalent yield:** Among the different intercropping systems and planting patterns, maximum pigeonpea equivalent yield of 18.4 and 19.0 q/ha was recorded with pigeonpea (50 × 25 cm) + maize fodder intercropping system during 2015 and 2016, respectively, which was statistically superior than all other intercropping systems with different planting patterns (Table 6). Higher pigeonpea equivalent yield of intercropping system with maize was mainly due to a higher additional yield of maize fodder as compared to other crops. The lowest values of pigeonpea equivalent yield (1310 and 1367 kg/ha) were obtained from pigeonpea (100 × 12.5 cm) + groundnut intercropping system during both the years which may be attributed to lower yield of groundnut in these intercropping systems. The increase in dose of nutrients from 0 to 100% applied to intercrops on area basis, there was progressive

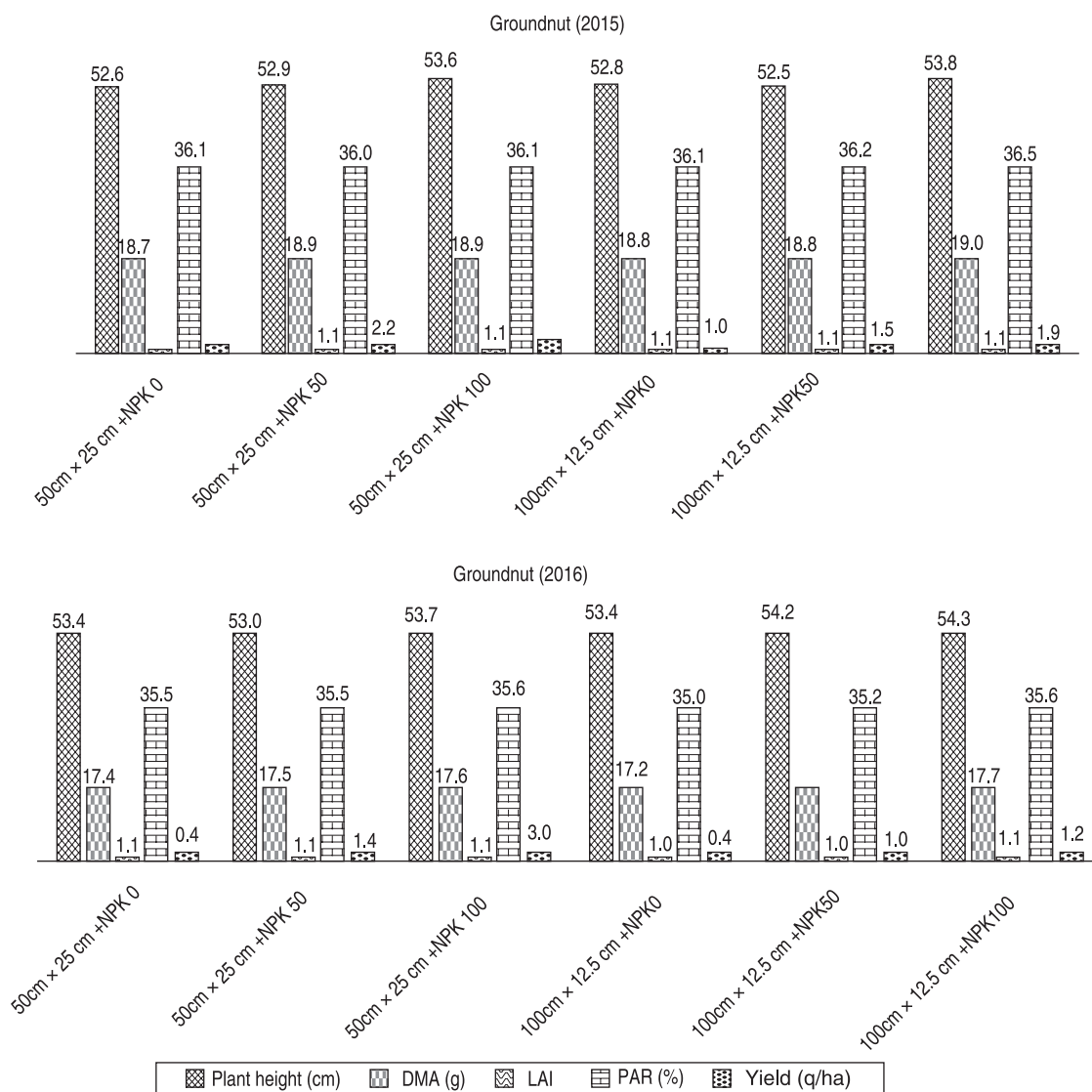


Fig 2 Growth parameters and yield of groundnut as influenced by intercropping systems and nutrients applied to groundnut during 2015 and 2016.

Table 3 Seed and biological yield of pigeonpea, intercrop yield and pigeonpea equivalent yield as influenced by different intercropping system and levels of nutrients applied to intercrops

Intercropping system	Seed yield (q/ha)		Intercrop yield (q/ha)		PEY (q/ha)	
	2015	2016	2015	2016	2015	2016
Pigeonpea (50 cm × 25 cm) + cowpea fodder	12.1	12.7	116.5	150.8	14.8	16.5
Pigeonpea (50 cm × 25 cm) + maize fodder	11.9	12.2	230.2	230.7	18.4	19.0
Pigeonpea (50 cm × 25 cm) + groundnut	12.2	13.0	2.2	1.6	13.6	14.3
Pigeonpea (100 cm × 12.5 cm) + cowpea fodder	12.1	12.9	87.9	93.3	14.5	15.2
Pigeonpea (100 cm × 12.5 cm) + maize fodder	11.7	12.7	131.7	136.8	15.3	16.7
Pigeonpea (100 cm × 12.5 cm) + groundnut	12.8	13.2	1.5	0.8	13.1	13.7
CD (P = 0.05)	NS	NS			1.8	1.7
<i>Nutrients levels applied to intercrops (% of recommended NPK)</i>						
0	11.6	12.1	73.9	81.4	13.7	14.4
50	12.0	12.8	92.0	100.5	14.9	16.0
100	12.8	13.3	119.1	125.3	16.3	17.3
CD (P = 0.05)	NS	NS			0.9	1.1

increase in pigeonpea equivalent yield. The application of 100% recommended dose of nutrients to the intercrops resulted in the significantly higher pigeonpea equivalent yield (16.3 and 17.3 q/ha) than the 50% recommended dose (14.9 and 16 q/ha) and control (13.7 and 14.4 q/ha) during both the years. This might be due to higher yield of intercrops with higher doses of nutrients applied to intercrops. These results are in conformity with those of Pandey *et al.* (2013) and Sharma *et al.* (2012) who reported that intercropping systems and increasing levels of nutrients helps in production of higher pigeonpea equivalent yield.

Different pigeonpea intercropping system and nutrient levels to intercrops at 30, 60 and 90 DAS show significant effect on plant height and dry matter accumulation but at latter stage, viz. 120 DAS and at harvest showed non-significant effects. Seed yield of pigeonpea was also not effected by different planting patterns and nutrients levels to intercrops. But pigeonpea intercropped with the maize fodder at planting pattern of 50 cm × 25 cm gave the highest pigeonpea equivalent yield with 100% of recommended NPK.

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