Indian Journal of Agronomy **67** (1): 38–42 (March 2022)

Research Paper

Performance of maize and pigeonpea under different sowing dates and cropping systems

P. THIMME GOWDA[1] AND S.I. HALIKATTI[2]

Zonal Agricultural Research Station, V.C. Farm, Mandya, Karnataka 571 405

Received: June 2017; Revised accepted: December 2021

ABSTRACT

A field experiment was conducted during the rainy (*kharif*) and winter (*rabi*) seasons of 2010–11 and 2011–12 at Dharwad, Karnataka, to study the effect of sowing dates and cropping systems on growth and yield of maize (*Zea mays* L.) and pigeonpea [*Cajanus cajan* (L.) Millsp.] under rainfed condition. Pooled data over 2 years indicated that, maize and pigeonpea sown during the first fortnight of June revealed significantly higher grain/seed yield compared to subsequent sowing dates except sowing during the second fortnight of June (7.06 and 1.15 t/ha respectively). Among the cropping systems, sole maize and pigeonpea gave significantly higher grain/seed yield (7.48 and 1.42 t/ha respectively) than the intercropping systems. Among the intercropping systems, maize + piegonpea system in (4 : 2) row ratio recorded significantly higher maize grain-equivalent yield (9.04 t/ha) followed by maize + piegonpea in row (2 : 2) ratio (8.48 t/ha). The later treatment resulted in higher net returns and benefit: cost ratio (₹ 56,787/ha and 3.17, respectively) than rest of the cropping systems. Among the interaction effects, intercropping of maize + pigeonpea in 4 : 2 row ratio sown during the first fortnight of June recorded significantly higher maize-equivalent yield (10.23 t/ha), net returns (₹ 66,665/ha) and benefit: cost ratio (3.16) over other system.

***Key words*:** Economics, Intercropping, Maize-equivalent yield, Pigeonpea, Sowing date

Intercropping of legumes with cereals is a recognized practice for economizing the use of nitrogenous fertilizers and enhancing the productivity and profitability per unit area and time (Willey *et al.,* 1981). One of the main reasons for higher yields in intercropping is that component crops are able to use growth resources differently and make better overall use of natural resources than grown separately (Willey, 1979). A careful selection of crops having different growth habit can reduce the mutual competition to a considerable extent. Maize and pigeonpea are important crops of the Southern Transitional Zone of Karnataka. The area under maize cultivation in the region is showing the increasing trend because of low cost of cultivation and high demand for maize grain from poultry industry.

Pigeonpea is a deep-rooted and slow growing crop in its early growth stage, during that period more rapidly growing crops like maize can be conveniently intercropped to utilize the natural resources more efficiently (Lingaraju *et al*., 2008). Both, maize and pigeonpea can be sown in different dates to study the crop-weather relationship. In view of this, the present investigation was conducted to study the productivity and economics of intercropping of maize and pigeonpea at different row ratios under rainfed conditions.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) and winter (*rabi*) seasons of 2010–11 and 2011–12 at Main Agricultural Research Station, University of Agricultural Science, Dharwad, Karnataka. The soil was medium black, having *p*H 7.5. Available nitrogen, phosphorus and potassium contents of the soil were 223.8, 31.6 and 332.3 kg/ha, respectively. There were 4 cropping systems, comprising sole crop of maize (var. Kargil 900 M Gold) and 3 intercropping systems involving 2 : 1, 2 : 2 and 4 : 2 row proportion of maize and pigeonpea (var. 'Asha') and were sown in 4 dates, viz. I fortnight of June, II fortnight of June, I fortnight of July and II fortnight of July. These 20 treatments combinations were evaluated in randomized block design with factorial concept and replicated thrice in a gross plot size of 9.0 m × 4.2 m. The spacing adopted for intercropping was 60 cm × 20 cm for maize and 90 cm × 30 cm pigeonpea in sole crop, 45 cm/45 cm × 20 cm for maize and 90 cm × 20 cm for pigeonpea in maize + pigeonpea intercropping at 2:1 ratio, 90 cm/45 cm × 20 cm for maize and 90 cm/45 cm × 20 cm for pigeonpea in

[1]**Corresponding author's Email:** thimmegowdap@gmail.com
[1]Senior Farm Superintendent, ZARS, V.C. Farm, Mandya, Karnataka 571 405; [2]Professor (Agronomy), UAS, Dharwad, Karnataka 571 405

maize + pigeonpea intercropping at 2 : 2 ratio, for sole maize and 90 cm/45 cm × 20 cm for maize and 180 cm/45 cm × 20 cm for pigeonpea in maize + pigeonpea intercropping at 4 : 2 ratio. The recommended dose of fertilizers for maize (100 : 50 : 25 N, P : K kg/ha) and pigeonpea (25 : 50 N : P kg/ha) were applied basal in the form of urea, diammonium phosphate and muriate of potash independently as per plant population. For maize crop, N was applied in 2 splits–50% basal and remaining 50% at the time of tasseling immediately after rainfall. A rainfall of 890.8 and 709.5 mm was received during crop-growth period (June–February) of 2010–11 and 2011–12, respectively, compared with the normal rainfall of 645.2 mm. All other agronomic practices were followed as per the university package. Observations on growth and yield components of maize and pigeonpea, viz. total dry matter production (g/plant), number of rows per cob (maize) and number of pods per plant (pigeonpea) were recorded at harvesting. Maize-equivalent yield (MEY) was calculated by considering the prices of both the crops using following formulae.

$$\text{MEY (t/ha)} = \text{Maize yield (t/ha)} + \frac{\text{Pigeonpea yield (t/ha)} \times \text{Price of pigeonpea (₹/t)}}{\text{Price of maize (₹/t)}}$$

The data on growth and yield parameters of maize and pigeonpea were recorded at different stages and subjected to statistical analysis. The level of significance used in 'F' and 't' test was $P \leq 0.05$. Critical difference was calculated wherever 'F' test was significant.

RESULTS AND DISCUSSION

Effect of sowing date on growth and yield of maize and pigeonpea

The difference in grain yield of maize due to sowing date was significant (Table 1). Mean grain yield obtained with sowing in I fortnight of June (7.06 t/ha) and II fortnight of June (6.96 t/ha) was significantly higher than that of I fortnight of July (6.17 t/ha) and II fortnight of July (5.36 t/ha). The grain yield was higher by 12.7 and 24.1% with June I fortnight and 11.3 and 23.0% with June II fortnight compared to late sowing dates. It was attributed to better crop growth and yield attributes. The higher leaf-area index (Table 1) was recorded with I and II fortnight of June sowing dates (4.00 and 3.87 at flowering and fertilization, respectively) which might have resulted in higher radiation-use efficiency and higher synthesis of metabolites leading to higher total dry-matter production (Table 1) at maturity (315.52 and 305.36 g/plant, respectively) and in turn higher grain yield. The results are in line with the earlier findings of Khola *et al*. (1999) and Jayasree *et al*. (2008).

The difference in pigeonpea seed yield due to sowing dates was also significant (Table 1). Seed yield obtained with June I fortnight (1.15 t/ha) and June II fortnight (1.12 t/ha) sowing dates was significantly higher than that of July I fortnight (0.96 t/ha) and July II fortnight (0.73 t/ha). The higher seed yield in June I fortnight sowing was mainly attributed to better availability of resources like soil moisture and nutrients and this in turn enhanced the leaf-area index which resulted in higher radiation-use efficiency and higher synthesis of metabolites leading to higher total dry-matter production (Table 1) at physiological maturity (196.98 and 190.13 g/plant) and in turn higher seed yield. Our results confirm the findings of Kumar *et al*. (2008) and Rani and Raji Reddy (2010).

Effect of cropping systems on growth and yield of maize and pigeonpea

Maize grain yield differed significantly among the cropping systems (Table 1). Sole maize recorded significantly higher yield (7.48 t/ha) than intercropped maize under different row ratios. In intercropping systems, the maize yield was reduced from 5.34 to 6.51 t/ha and the extent of reduction was 13.0 to 28.7% as compared to sole maize. Reduced grain yield of maize under intercropping systems might be due to higher plant population per unit area resulting in increased competition for growth resources, especially for moisture, nutrients and light. Vyas *et al*. (1995), Barik (1997), Marer (2005) and Lingaraju *et al*. (2008) reported the reduction in seed yield of maize when intercropped with pigeonpea.

Seed yield of pigeonpea differed significantly among the cropping systems (Table 1). Among various cropping systems, sole pigeonpea gave significantly higher seed yield (1.42 t/ha) than intercropped pigeonpea under different row ratios. The seed yield of pigeonpea reduced from 0.58 to 1.10 t/ha in intercropping system and the extent of reduction was 22.5 to 58.8% as compared to sole pigeonpea. Reduced seed yield of pigeonpea under intercropping system might be attributed to increased plant population per unit area resulting in increased competition for growth resources, especially for moisture, nutrients and light. Singh and Pal (2003), Marer (2005) and Lingaraju *et al*. (2008) also reported similar reduction in seed yield of pigeonpea when intercropped with maize.

Interaction effect of sowing dates and cropping systems on growth and yield of pigeonpea

The interaction effect of date of sowing and cropping systems varied significantly (Table 1). Among the treatment combinations, significantly higher grain yield of maize and seed yield of pigeonpea was obtained when sole maize was sown in the fortnight of June (8.29 and 1.69 t/ha, respectively) and was at par with June II fortnight sown sole maize (8.11 and 1.62 t/ha, respectively) as compared to other treatment combinations.

Table 1. Effect of sowing dates and cropping systems on total dry matter production and leaf-area index of maize and pigeonpea (pooled data of 2 years)

Treatment	Total dry-matter production (g/plant) at physiological maturity		Leaf-area index		Yield attributes		Yield (t/ha)	
	Maize	Pigeonpea	Maize-flowering and fertilization	Pigeonpea-initiation of flower bud	Rows/cob (Maize)	Pods/plant (Pigeonpea)	Maize	Pigeonpea
Date of sowing (D)								
D_1, June I fortnight	315.5^{a}	197.0^{a}	4.0^{a}	2.1^{a}	14.8^{a}	116.3^{a}	7.1^{a}	1.1^{a}
D_2, June II fortnight	305.4^{a}	190.3^{a}	3.9^{b}	2.0^{a}	14.6^{a}	112.4^{a}	7.0^{a}	1.1^{a}
D_3, July I fortnight	280.2^{b}	177.7^{b}	3.7^{b}	1.4^{b}	13.0^{b}	94.0^{b}	6.2^{b}	1.0^{b}
D_4, July II fortnight	252.4^{c}	133.3^{c}	2.7^{c}	1.0^{c}	11.0^{c}	54.6^{c}	5.4^{c}	0.7^{c}
SEm±	2.94	1.84	0.04	0.03	0.23	1.7	0.08	0.02
Cropping system (C)								
C_1, 2:1 row ratio	282.4^{bc}	134.1^{d}	3.4^{c}	1.1^{c}	12.9^{bc}	66.3^{c}	6.2^{b}	0.6^{d}
C_2, 2:2 row ratio	272.3^{c}	174.5^{c}	2.7^{b}	1.0^{c}	12.5^{c}	91.2^{b}	5.3^{c}	1.1^{b}
C_3, 4:2 row ratio	289.8^{b}	186.6^{b}	3.6^{b}	2.0^{b}	13.6^{ab}	109.1^{a}	6.5^{b}	0.9^{c}
C_4, Sole maize/pigeonpea	308.9^{a}	203.1^{a}	4.7^{a}	2.4^{a}	14.3^{a}	110.7^{a}	7.5^{a}	1.4^{a}
SEm±	2.94	1.84	0.04	0.03	0.23	1.7	0.08	0.02
Date of sowing (D) × cropping system (C)								
D_1C_1	307.8^{b-d}	149.8^{f}	3.9^{cd}	1.4^{e}	14.3^{a-c}	80.3^{cd}	7.0^{b}	0.7^{f-h}
D_1C_2	294.7^{c-e}	192.9^{de}	3.0^{ef}	1.3^{e}	14.1^{a-c}	113.7^{b}	5.7^{c-e}	1.3^{bc}
D_1C_3	315.9^{bc}	212.2^{bc}	4.0^{c}	2.6^{b}	14.9^{ab}	135.9^{a}	7.3^{b}	1.0^{e}
D_1C_4	343.5^{a}	233.1^{a}	5.1^{a}	4.0^{a}	15.8^{a}	135.2^{a}	8.3^{a}	1.7^{a}
D_2C_1	298.6^{c-e}	144.2^{f}	3.7^{b}	1.3^{e}	14.3^{a-c}	74.0^{c-e}	6.8^{b}	0.6^{g-i}
D_2C_2	290.2^{d-f}	188.9^{e}	3.0^{f}	1.2^{f}	13.8^{a-d}	112.4^{b}	5.6^{c-e}	1.2^{bc}
D_2C_3	307.9^{b-d}	205.1^{cd}	3.9^{cd}	2.5^{b}	14.6^{a-c}	133.4^{a}	7.3^{b}	1.0^{de}
D_2C_4	324.7^{ab}	223.0^{ab}	4.9^{ab}	2.9^{a}	15.6^{ab}	129.9^{a}	8.1^{a}	1.6^{a}
D_3C_1	273.7^{e-g}	136.7^{f}	3.5^{b}	0.9^{fg}	12.5^{c-e}	66.9^{d-f}	5.9^{cd}	0.6^{hi}
D_3C_2	264.3^{f-h}	180.7^{e}	2.7^{f}	0.9^{fg}	11.9^{df}	87.9^{c}	5.3^{d-f}	1.1^{cd}
D_3C_3	282.2^{d-f}	188.8^{e}	3.7^{b}	1.8^{b}	13.5^{b-d}	109.6^{b}	6.1^{c}	0.9^{d-f}
D_3C_4	300.5^{b-d}	204.7^{cd}	4.7^{b}	2.1^{c}	14.1^{a-c}	111.6^{b}	7.3^{b}	1.3^{b}
D_4C_1	249.3^{g-h}	105.7^{f}	2.5^{ef}	0.6^{g}	10.5^{f}	44.0^{g}	5.2^{ef}	0.5^{i}
D_4C_2	240.1^{h}	135.6^{f}	2.2^{g}	0.7^{g}	10.3^{f}	50.7^{g}	4.7^{f}	0.8^{e-g}
D_4C_3	253.2^{gh}	140.2^{f}	2.8^{e}	1.3^{e}	11.4^{ef}	57.7^{fg}	5.4^{d-e}	0.6^{g-i}
D_4C_4	266.9^{fg}	151.5^{f}	3.9^{cd}	1.4^{e}	12.0^{b-f}	65.8^{ef}	6.2^{c}	1.0^{de}
SEm±	5.89	3.68	0.08	0.07	0.45	3.3	0.16	0.05

Means followed by the same lower case letter/s in a column do not differ significantly by Duncan's Multiple Range Test (DMRT) (P=0.05)

Effect of sowing dates on production efficiency and economics of maize and pigeonpea

Among the sowing dates, June I and II fortnight sowing recorded significantly higher maize-equivalent yield (MEY, 7.72 and 7.51 t/ha respectively) as compared to subsequent sowing dates (Table 2). However, the lowest maize-equivalent yield (MEY) was noticed in July II fortnight sowing (5.56 t/ha). The extent of reduction in MEY in July II fortnight sowing was 38.9 and 26.0% as compared to June I and II fortnight sowings, respectively. This reduction in MEY in delayed sowing condition was mainly due to decreased yield levels of both maize and pigeonpea. Similar findings were also reported by Khola *et al*. (1999) in maize and legumes intercropping systems.

Early-sown crop either June I or II fortnight recorded significantly higher net returns (₹53,951 and 52,483/ha respectively) and benefit: cost (B : C) ratio (3.03 and 2.97, respectively) compared to subsequent sowings (Table 2). Significantly higher net returns and B : C ratio in above-said treatments were owing to higher yield levels of both the crops under early-sown situation as compared to late-sown condition. Similarly, Khola *et al*. (1999) recorded the maximum net returns and B : C under normal time (25 June) of sowing of maize + cowpea, and Rani and Rajireddy (2010) in pigeonpea + soybean intercropping.

Effect of cropping systems on production efficiency and economics of maize and pigeonpea

Significant variations in mean-maize equivalent of intercropping systems than their respective sole stands of intercrops were recorded (Table 2). The present study indicated that, all the intercropping treatments recorded significantly higher MEY irrespective of row ratio (7.90 to 9.04 t MEY/ha) as compared to their respective sole stands (7.48 to 1.42 t MEY/ha, respectively in sole maize and sole pigeonpea). Among the intercropping systems, an intercropping of maize and pegeonpea in 4 : 2 row ratio exhibited higher MEY (9.04 t MEY/ha), followed by maize +

Table 2. Effect of sowing dates and cropping systems on maize-equivalent yield and economics of maize and pigeonpea (pooled data of 2 years)

Treatment	Maize equivalent yield (t/ha)	Net returns (× 10³₹/ha)	Benefit: cost
Date of sowing (D)			
D_1, June I fortnight	7.72[a]	53.95[a]	3.03[a]
D_2, June II fortnight	7.51[a]	52.48[a]	2.97[a]
D_3, July I fortnight	6.66[b]	43.14[b]	2.62[b]
D_4, July II fortnight	5.56[c]	31.77[c]	2.18[c]
SEm±	0.085	1.012	0.04
Cropping system (C)			
C_1, 2 : 1 row ratio	7.90[c]	45.55[c]	2.48[c]
C_2, 2 : 2 row ratio	8.48[b]	56.79[a]	3.17[a]
C_3, 4 : 2 row ratio	9.04[a]	56.12[a]	2.82[b]
C_4, Sole maize/pigeonpea	7.48[d]	45.84[b]	2.84[b]
SEm±	1.42[e]	22.39[c]	2.20[d]
C_1, 2 : 1 row ratio	0.085	1.012	0.04
Date of sowing (D) × cropping system (C)			
D_1C_1	8.92[c]	54.79[b-d]	2.78[c]
D_1C_2	9.48[b]	64.95[b]	3.48[a]
D_1C_3	10.23[a]	66.67[a]	3.16[b]
D_1C_4	8.29[de]	53.23[c-g]	3.14[b]
D_1C_5	1.69[i]	30.12[j]	2.61[cd]
D_2C_1	8.67[cd]	52.87[c-e]	2.71[cd]
D_2C_2	9.08[bc]	63.47[bc]	3.42[a]
D_2C_3	10.08[a]	66.16[a]	3.14[b]
D_2C_4	8.11[e]	51.62[fg]	3.08[b]
D_2C_5	1.62[i]	28.30[j]	2.51[de]
D_3C_1	7.53[f]	42.36[gh]	2.37[e]
D_3C_2	8.37[de]	56.02[d-f]	3.14[b]
D_3C_3	8.72[cd]	52.34[de]	2.70[cd]
D_3C_4	7.34[fg]	44.491[h]	2.79[c]
D_3C_5	1.35[ij]	20.48[k]	2.09[fg]
D_4C_1	6.46[h]	32.17[i]	2.04[g]
D_4C_2	7.00[g]	42.70[h]	2.63[cd]
D_4C_3	7.13[fg]	39.31[h]	2.28[ef]
D_4C_4	6.20[h]	34.01[i]	2.37[e]
D_4C_5	1.01[j]	10.67l	1.58[h]
SEm±	0.17	2.023	0.07

Means followed by the same lower case letter/s in a column do not differ significantly by Duncan's Multiple Range Test (DMRT) (P=0.05)

pigeonpea in 2 : 2 row ratio (8.48 t MEY/ha), while the lowest MEY was registered in sole pigeonpea (1.42 t MEY/ha). Higher MEY under intercropping than sole cropping of maize and or legumes was also reported by Sharma *et al*. (1998), Khola *et al*. (1999), Marer (2005) and Lingaraju *et al*. (2008).

Significant differences were observed with respect to net return and B : C among the cropping systems (Table 2). Among different cropping systems, the maximum net returns (₹ 56,787 /ha) and B : C (3.17) were observed with intercropping of maize + pigeonpea in 2 : 2 row ratio as compared to other treatments and it was followed by maize + pigeonpea 4:2 row ratio (₹ 56,118 /ha and 2.82 respectively). Patel *et al*. (1997), Mishra *et al*. (2001), Marer (2005) and Lingaraju *et al*. (2008) also reported similar results.

It can be concluded that, an intercropping of maize and pigeonpea in 4 : 2 or 2 : 2 row ratio sown during June I to II fortnight was more productive and remunerative than sole crop of maize or pigeonpea and other intercropping systems sown under delayed situations in rainfed areas of Northern Transitional Zone of Karnataka.

REFERENCES

Barik, K.C. 1997. Maize + legume intercropping for north central plateau off Orissa. *Legume Research* **20**(3/4): 218–220.

Jayasree, G., Linglab, D., Rajireddy, D. and Narasimha Rao, S.B.S. 2008. Assessment of moisture stress using water requirement satisfaction index in *kharif* maize. *Journal of Agrometeorology* **10**(2): 118–122.

Khola, O.P.S., Dube, R.K. and Sharma, N.K. 1999. Conservation

and production ability of maize (*Zea mays*) legume intercropping systems under varying dates of sowing. *Indian Journal of Agronomy* **44**(1): 40–46.

Kumar, N., Gopinath, K.A., Srivastva, Anil K. and Mahajan, Vinay. 2008. Performance of pigeonpea [*Cajanus cajan* (L.) Millsp.] at different sowing dates in the mid-hills of Indian Himlaya. *Archives of Agronomy and Soil Science* **54**(5): 507–514.

Lingaraju, B.S., Marer, S.B. and Chandrashekar, S.S. 2008. Studies on intercropping of maize and pigeonpea under rainfed conditions in northern transitional zone of Karnataka. *Karnataka Journal of Agricultural Sciences* **21**(1): 1–3.

Marer, S.B. 2005. Studies on intercropping of maize and pigeonpea under rainfed condition in northern transitional zone of Karnataka. M.Sc. (Agriculture) Thesis, University of Agricultural Sciences, Dharwad, Karnataka, (India).

Patel, G.T., Patel, G.N. and Arha, M.D. 1997. Intercropping in maize (*Zea mays*) with pigoenpea under different spacing and fertility levels. *Research Journal, Gujarat Agricultural University* **19**(2): 169–173.

Rani, B.P. and Raji Reddy, D. 2010. Performance of piegonpea in sole and intercropping system in Vertisols of Krishna-Godavari Zone in Andhra Pradesh. *Indian Journal of Agricultural Research* **44**(3): 225–228.

Sharma, P.B., Raghuwanshi, P.S. and Ambawatia, G.R. 1988. Intercropping sesame with pigeonpea under varying sowing dates. *Journal of Oilseeds Research* **15**(2): 58–63.

Singh, T. and Pal, M. 2003. Growth parameters, yield attributes and yield of pigeonpea as influenced by cropping systems and nitrogen + phosphorus levels. *Annals of Agricultural Research* **24**(4): 755–759.

Vyas, M.D., Billore, S.D., Mridula-Bargale and Bargale, M. 1995. Competition functions of maize + soyabean intercropping under various spatial arrangements. *Crop Research* **10**(2): 122–125.

Willey, R.W., Rao, M.R., and Natarajan, M. 1981. Traditional cropping systems with pigeonpea and their improvement. (In) *Proceedings of International Workshop on Pigeonpea*, vol. I, International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India.

Willey, R.W. 1979. Intercropping – Its importance and research needs. Part I competition and yield advantages. *Field Crops Abstract* **32**(1): 1–10.