E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(7): 1841-1843
Received: 25-04-2025
Accepted: 27-05-2025

BM Mane
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, College of Agriculture, Badnapur, Maharashtra, India

KT Jadhav
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, College of Agriculture, Badnapur, Maharashtra, India

PA Pagar
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, College of Agriculture, Badnapur, Maharashtra, India

PS Magar
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, College of Agriculture, Badnapur, Maharashtra, India

Corresponding Author:
BM Mane
Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, College of Agriculture, Badnapur, Maharashtra, India

Effect of different spacing, land configuration and intercropping on economics of pigeonpea (*Cajanus cajan* L. Mill)

BM Mane, KT Jadhav, PA Pagar and PS Magar

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i7w.3459

Abstract
A field experiment was conducted during *Kharif* 2024 at ARS, Badnapur, on clayey soil. Pigeonpea variety BDN 2013-41 (Godavari) was sown with eight treatments *viz*., four sole pigeonpea spacings 90×20 cm (T_1), 120×30 cm (T_2), 150×30 cm on ridges and furrow (T_3) and 180×30 cm on ridges and furrow (T_4), two paired row planting on BBF 60-120×30 cm (T_5) and 90-150×30 cm (T_6) and pigeonpea + soybean intercropping systems with two ratios 1:4 (T_7) and 2:4 (T_8), respectively. The trial was laid out in RBD with three replications. Sowing was done by dibbling on 11 July 2024. Wider spacing of 180 × 30 cm on ridges and furrow (T_4) recorded highest benefit cost ratio (3.1). However, significantly highest pigeonpea equivalent yield (PEY) (2262 kg ha^{-1}), gross monetary return (GMR) (₹1,76,436 ha^{-1}) and net monetary return (NMR) (₹1,09,309 ha^{-1}) was recorded under 2:4 pigeonpea + soybean (T_8) and was at par with 1:4 pigeonpea + soybean (T_7) (PEY: 2195 kg ha^{-1}), (GMR: ₹1,71,189 ha^{-1}) and (NMR: ₹1,04,298 ha^{-1}), moreover, both intercropping systems recorded significantly more PEY, GMR and NMR over rest of the treatments.

Keywords: Pigeonpea, spacing, broad bed and furrow, intercropping, pigeonpea equivalent yield, GMR, NMR.

Introduction

Pigeonpea (*Cajanus cajan* L. Mill.) is an important legume crop predominantly grown in rainfed and semi-arid regions of India due to its resilience to drought and adaptability to low-input farming systems. It significantly contributes to dietary protein and micronutrient intake, especially among vegetarian populations. Improved spacing facilitates better canopy architecture and resource utilization, while land configurations like Broad Bed and Furrow (BBF) and ridges and furrow are effective in managing soil moisture and aeration, particularly in black soils susceptible to water stagnation. Intercropping pigeonpea with early-maturing crops offers benefits such as improved system productivity and greater land use efficiency. In addition, better resilience due to climate vagaries where intercropping system provides cushioning in the case of failure of any one crop. Considering these the present study was carried out during *kharif* 2024 at ARS, Badnapur to assess the impact of agronomic interventions on pigeonpea performance under rainfed conditions.

Materials and Methods

The field experiment was conducted during the Kharif season of 2024-2025 at the Agricultural Research Station, Badnapur, Jalna (Maharashtra), VNMKV, Parbhani. The soil was alkaline in reaction with a pH of 7.83 and characterized by a clayey texture. The chemical properties of the soil showed medium organic carbon content (0.59%), low available nitrogen (149.0 kg ha^{-1}), medium phosphorus and very high potassium. A total rainfall of 596.3 mm was received over 30 rainy days between July and December 2024.

The experiment was laid out in a Randomized Block Design (RBD) with three replications and eight treatments four sole pigeonpea spacings (T_1) 90×20 cm, (T_2) 120×30 cm), (T_3) 150×30 cm (on ridges and furrow) and (T_4) 180×30 cm (on ridges and furrow), two paired row planting on BBF (T_5) 60-120×30 cm and (T_6) 90-150×30 cm, (T_7) 1:4 pigeonpea + soybean and (T_8) 2:4

pigeonpea + soybean intercropping systems, respectively. The crop was sown by dibbling method on 11 July 2024. The recommended dose of fertilizers (RDF) was 25:50:25 NPK kg ha⁻¹ through urea, SSP and MOP. The pigeonpea variety BDN 2013-41 (Godavari) were used.

Results and Discussion

Effect of various treatment on pigeonpea equivalent yield (PEY) and percent yield reduction over the best treatment.

The data on pigeonpea equivalent yield (PEY) and percent yield reduction over the best treatment, presented in Table 1, revealed significant influence of planting geometries and intercropping systems. The highest PEY (2262 kg ha^{-1}) was obtained under pigeonpea + soybean (2:4) (T_8) intercropping, and was at par with pigeonpea + soybean (1:4) (2195 kg ha^{-1}). In contrast, the lowest PEY (1543 kg ha^{-1}) was recorded under sole pigeonpea at 90 × 20 cm spacing (T_1), which was statistically at par with other sole cropping treatments such as 120 × 30 cm (T_2), 150 × 30 cm on ridges and furrow (T_3), 60-120 × 30 cm (T_5), and 90-150 × 30 cm (T_6). The superior performance of soybean-based intercropping systems was attributed to the combined yield advantage from both crops, efficient use of spatial and soil resources, and complementary canopy structures that enhanced light interception and moisture retention. Although soybean has a comparatively lower market value than pigeonpea, its inclusion improved total system productivity. The lowest percent yield reduction in pigeonpea (2.89%) was observed in pigeonpea + soybean (1:4) over pigeonpea + soybean (2:4), while the highest yield reduction (31.79%) occurred in the sole 90 × 20 cm pigeonpea crop. The general trend of declining PEY with closer spacing indicated the positive influence of wider row geometry on growth and yield attributes, especially in the Godavari variety. These outcomes emphasized the importance of strategic intercropping and wider spacing for maximizing economic returns and sustainability under rainfed conditions. These results were well supported by Araj *et al.*, (2024) [1] and Singh *et al*., (2017) [4], whose findings highlight the benefits of soybean intercropping and wider spacing in enhancing pigeonpea system productivity.

Table 1: Effect of various treatment on pigeonpea equivalent yield (PEY) and percent yield reduction over the best treatment.

Tr. No.	Treatment	Pigeonpea yield (kg ha^{-1})	Soybean yield (kg ha^{-1})	PEY (kg ha^{-1})	(%) yield reduction over best treatment
T_1	90×20 cm (sole pigeonpea) 55,555 plants ha^{-1}	1543	_	1543	31.79%
T_2	120×30 cm (sole pigeonpea on riges & furrow) 27,777 plants ha^{-1}	1609	_	1609	28.87%
T_3	150×30 cm (sole pigeonpea on riges & furrow) 22,222 plants ha^{-1}	1720	_	1720	23.97%
T_4	180×30 cm (sole pigeonpea) 18,518 plants ha^{-1}	1840	_	1840	18.66%
T_5	60-120×30 cm, (pigeonpea paired row on BBF) 37,037 plants ha^{-1}	1620	_	1620	28.39%
T_6	90-150×30 cm, (pigeonpea paired row on BBF) 27,777 plants ha^{-1}	1725	_	1725	23.77%
T_7	Pigeonpea +Soybean (1:4) 14,812 plants ha^{-1}	1385	1404	2195	2.98%
T_8	Pigeonpea +Soybean (2:4) 27,777 plants ha^{-1}	1579	1184	2262	31.79%
	SE (m) ±	61.72	_	70.26	_
	C.D. at 5%	187.23	_	213.14	_
	General Mean	1628.63	1294	1814.25	_

Gross monetary returns (GMR) (₹ ha^{-1})

The data on gross monetary return (GMR), presented in Table 2, indicated that the pigeonpea + soybean (2:4) intercropping system (T_8) recorded the highest GMR (₹1,76,436 ha^{-1}), which was statistically at par with pigeonpea + soybean (1:4) (T_7) (₹1,71,189 ha^{-1}). Among sole cropping systems, wider spacing of 180 × 30 cm on ridges and furrow (T_4) (₹143520 ha^{-1}) achieved significantly higher GMR compared to narrower spacings like 90 × 20 cm (T_1) and 120 × 30 cm (T_2), and was at par with 150 × 30 cm on ridges and furrow (T_3) (₹1,34,160 ha^{-1}) and 90-150 × 30 cm (T_6) (₹1,34,550 ha^{-1}). The increased returns in intercropping treatments were due to the additional contribution of soybean yield, which improved the overall pigeonpea equivalent yield (PEY) and gross income despite relatively higher input costs. In contrast, sole cropping lacked this additive benefit, which resulted in lower GMR. The lowest GMR was observed under 90 × 20 cm spacing (T_1) (₹1,20,354 ha^{-1}). Enhanced economic returns in intercropping systems were also linked to better utilization of light, nutrients, and moisture due to complementary growth patterns of the component crops. These findings were in conformity with Garud *et al.*, (2018) [2], who reported similar advantages of soybean-based intercropping in improving gross monetary returns through better spatial efficiency and system intensification.

Table 2: Gross monetary return (₹ ha^{-1}), Net momentary return (₹ ha^{-1}) and B:C ratio of pigeonpea influenced by various treatments

Tr. No.	Treatment	Cost of cultivation (₹ ha^{-1})	Gross momentary return (₹ ha^{-1})	Net momentary return (₹ ha^{-1})	B:C ratio
T_1	90×20 cm (sole pigeonpea) 55,555 plants ha^{-1}	46007	120354	74347	2.6
T_2	120×30 cm (sole pigeonpea on riges & furrow) 27,777 plants ha^{-1}	46062	125502	79440	2.7
T_3	150×30 cm (sole pigeonpea on riges & furrow) 22,222 plants ha^{-1}	46217	134160	87943	2.9
T_4	180×30 cm (sole pigeonpea) 18,518 plants ha^{-1}	46435	143520	97085	3.1
T_5	60-120×30 cm, (pigeonpea paired row on BBF) 37,037 plants ha^{-1}	46293	126360	80067	2.7
T_6	90-150×30 cm, (pigeonpea paired row on BBF) 27,777 plants ha^{-1}	46392	134550	88158	2.9
T_7	Pigeonpea +Soybean (1:4) 14,812 plants ha^{-1}	66891	171189	104298	2.6
T_8	Pigeonpea +Soybean (2:4) 27,777 plants ha^{-1}	67127	176436	109309	2.6
	SE (m) ±	-	5485.48	5485.48	0.10
	C.D. at 5%	-	16640.13	16561.78	0.32
	General Mean	51428	141508.81	90080.85	2.76

Net monetary returns (₹ ha^{-1})

Pigeonpea + soybean (2:4) intercropping system (T_8) achieved the highest NMR (₹1,09,309 ha^{-1}), which was statistically at par with pigeonpea + soybean (1:4) (T_7) (₹1,04,298 ha^{-1}) and sole pigeonpea at 180 × 30 cm on ridges and furrow (T_4) (₹97,085 ha^{-1}). Among sole cropping treatments, wider spacing in 180 × 30 cm on ridges and furrow (T_4) recorded significantly higher NMR than narrow spacings such as 90 × 20 cm (T_1) and 120 × 30 cm (T_2), and was at par with 150 × 30 cm on ridges and furrow (T_3) (₹87,943 ha^{-1}) and 90-150 × 30 cm (T_6) (₹88,158 ha^{-1}). The increased NMR in these treatments could be attributed to reduced input costs particularly lower seed rates and labour and improved harvest efficiency under wider spacing. Conversely, the lowest NMR (₹74,347 ha^{-1}) was observed under narrow spacing 90 × 20 cm (T_1). These results highlight the economic advantage of intercropping and wider planting geometry through improved returns and cost-effective resource use, which are in line with the findings of Lomte *et al*., (2006) [3], who reported that wider spacing and legume-based intercropping systems significantly enhance net returns due to better input utilization and higher productivity. Intercropping involved the highest cultivation cost due to greater input demands and labuor intensive operations; however, this was compensated by enhanced gross and net returns from the additional soybean yield.

Benefit cost ratio (B:C)

The data presented in Table 2. revealed that the highest benefit cost (B:C) ratio (3.1) was observed with 180 × 30 cm sole pigeonpea on ridges and furrow (T_4), which was statistically at par with 150 × 30 cm on ridges and furrow (T_3) and 90-150 × 30 cm on BBF (T_6) (2.9 each). On the other hand, the lowest B:C ratio (2.6) was recorded due to 90 × 20 cm (T_1), pigeonpea + soybean 1:4 (T_7) and pigeonpea + soybean 2:4 (T_8) (2.6 each), which were at par with treatments 120 × 30 cm (T_2), BBF 60-120 × 30 cm (T_5) (2.7 each), 90-150 × 30 cm (T_6) and 150 × 30 cm on ridges and furrow (T_3) (2.9 each).

The superior B:C ratio under wider sole planting systems such as 180 × 30 cm on ridges and furrow (T_4) was attributed to optimized resource utilization, relatively lower cultivation costs and higher per unit benefit, contributing to more efficient economic returns. In contrast, 90 × 20 cm (T_1), pigeonpea + soybean 1:4 (T_7) and pigeonpea + soybean 2:4 (T_8) reported significantly lower B:C ratios, which might be due to high input cost from intercropping and reduced yield under narrow spacing in 90 × 20 cm (T_1).

Conclusion

The study revealed that pigeonpea + soybean (2:4) intercropping recorded the highest pigeonpea equivalent yield and economic returns, followed by the 1:4 pigeonpea + soybean system. Among sole crops, 180 × 30 cm spacing on ridges and furrow proved most effective in enhancing gross and net monetary returns as well as B:C ratio. Wider spacing and intercropping strategies significantly improved productivity and profitability under rainfed conditions for medium duration Godavari variety.

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