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Original Research Article

Evaluation of Pigeonpea (*Cajanus cajan* L.) based Cropping Systems for Different Dates of Sowing in Marathwada Region of Maharashtra under *Rainfed* Condition

G.R. Pawar[1*], D.N. Gokhale[2] and P.N. Karanjikar[3]

[1]Department of Agronomy, Lokmangal College of Agriculture, Wadala, India
[2]College of Agriculture, Parbhani, India
[3]Department of Agronomy, College of Agriculture, Ambajogai, India

**Corresponding author*

A B S T R A C T

A field experiment entitled, Evaluation of pigeonpea (*Cajanus cajan* L.) based cropping systems for different dates of sowing in Marathwada Region of Maharashtra under *Rainfed* Condition was conducted at Department of Agronomy, VNMKV., Parbhani during *kharif* 2016-2017 and 2017-2018. The soil of experimental plot was deep black (vertisol) with good drainage. The experiment was laid out in split plot design with two replications. In main plot treatment four sowing dates (D_1- sowing within a week period after regular commencement of monsoon, D_2- sowing 15 days after D_1, D_3- sowing 15 days after D_2 and D_4- sowing 15 days after D_3) and in sub plot treatments seven cropping system i.e. I_1- pigeonpea+soybean (2:3), I_2- pigeon pea+ pearlmillet (2:1), I_3-pigeonpea+niger (2:3), I_4- sole pigeon pea, I_5- sole soybean, I_6- sole pearlmillet and I_7- sole niger. The net plot size is 5.4 m x 4.8 m for each treatment. The results revealed that sowing date D_1 recorded maximum pigeon pea equivalent yield, gross monetary return, net monetary return as well as B: C ratio over date D_3 and D_4 but which was on par with D_2. Among seven cropping systems pigeonpea + soybean was recorded highest pigeonpea equivalent yield over all other cropping systems. In case of GMR pigeonpea + soybean (I_1) cropping system was found significantly greater over pigeonpea + pearlmillet (I_2), Sole soybean (I_5), sole pearlmillet (I_6) and sole niger (I_7) cropping systems but on par with pigeonpea + niger (I_3) and sole pigeonpea (I_4). During pooled result on system net monetary returns confirmed that pigeonpea + soybean (I_1) cropping system was found significantly superior over cropping systems pigeonpea + pearlmillet (I_2), sole pigeonpea (I_4), Sole soybean (I_5), sole pearlmillet (I_6) and sole niger (D_1I_7), but on par with pigeonpea + niger (I_3). Cropping systems Pigeonpea + niger (I_3) and Pigeonpea + soybean (I_1) confirmed maximum B:C ratio (3.10 and 2.95) during pooled results.

Keywords

Cropping systems, Dates of sowing, Pigeonpea

Introduction

Climate is the basis for crop adaption. The farmer selects a crop that is adapted to the area where it will be grown. However, it is weather in the locality that will eventually determine the crop growth, development and productivity. Unless the crop and cultivars are well adapted to the area where they are grown, there cultivation in that area is uneconomical. Knowledge of agro-meteorology is necessary for crop production as it is concern with interaction between meteorological and hydrological factor on

one hand and crop production on the other. Weather during the crop season strongly influence crop growth and development and it accounts for 2/3 (67 %) of variation in productivity while other factors including soil and nutrient management account for 1/3 (33%). of the productivity. Importance of weather assumes greater importance in dryland agriculture where soil moisture during crop season is highly variable and strongly dependent on the quantum and distribution of rainfall.

Indian agriculture, to large extent, depends on the South-West monsoon activity and associated weather condition. The agro-climatic conditions control the choice and productivity of crop and sustainability of production. Annual rainfall of the country is about 4 x 10^3 km^3 (400 M ha m) out of 5 x 10^5 km^3 received globally (Lal, 1994). India's share thus is about one per cent of global precipitation. Major contribution from South West monsoon (74 %) compared with 10 per cent during North East monsoon. The average annual rainfall of the country is 1200 mm (400 M ham). However distribution across the country varies from less than 100 mm in Western Rajasthan to greater than 3600 mm in North Eastern states and 1000 mm from East Coast to 2500- 3000 mm in West Coast.

Over Indian continent, monsoon sets in either by the end of May or early June along Malabar Coast. Normal onset of monsoon over India is first June with heavy rains over Kerala and Coastal Karnataka. The earliest and most delayed one during last 100 years differ by 46 days (7 May and 22 June, respectively). In general the active phase of monsoon in India is July to September. Prolonged break in monsoon have tendency to occur during August- September break period of 6 to 8 weeks is not uncommon. Nearly 16 per cent of geographical area in the country is chronically drought affected due to prolonged breaks on monsoon.

Dryland agriculture has distinct place in Indian agriculture, occupying around 67 percent of cultivated area, containing to nearly 44 per cent of food grains and supporting 40 per cent of human and 60 per cent of livestock population. Most (80 to 90 per cent) of the pulses, oilseeds and millets are confined to dryland ecosystem. It is characterized by resource poor, small and marginal farmers, poor infrastructure and low investment in technology and inputs. The mismatch between rainfall distribution and the crop water needs is the major cause of instability of certain crops in some dryland area. Most dryland areas of India are either mono-cropped or intercropped. Traditional dryland cropping systems are not necessarily the most suitable ones to the agro-climatic conditions as they are mostly subsistence systems.

In agriculture management practices are usually formulated for individual crops. However, farmers are cultivating different crops in different season, domestic needs and profitability. A cropping system refers to a set of crop systems, making up the cropping activities of farm system. Cropping system comprises all the components required for production of a particular crop and the interrelationships between them and environment (TAC, CGIAR 1978). In other words, a cropping system usually refers to a combination of crop in time and space. Combination in time occurs when crops occupy different growing period and combinations in space occur when crops are inter-planted.

Intercropping includes alley cropping, strip cropping, counter cropping, paired raw cropping, skip cropping, parallel cropping, companion cropping, multi-story cropping and synergetic cropping (additive series and

replacement series). Cereals with pigeonpea intercropping systems are popular in India (Aiyer, 1949). Amount of rainfall determines the cereal crop associated with pigeonpea, rice with 1000 to 1500 mm, maize with 750 to 1000 mm, sorghum with 500 to 750 mm and millets with 400 t0 600 mm rainfall. Most cereals, depending on their growth duration and height, reduce the growth of pigeonpea and can be ranked for competitiveness: maize > sorghum > pearlmillet > setaria (Rao and Willey, 1980). At IARI (New Delhi), pearlmillet and pigeonpea in 2:1 (40/80 cm paired row planting) as additive series resulted in highest yield and economic advantage during rainy season (Ramulu *et al.,* 1998).

Paired raw planting can accommodate full population of base crop and leave adequate inter space to accommodate two or more raw of intercrop. In this technique two adjacent rows of the base crop are paired reducing the inter-row spacing in the pair, narrow enough to create some inter-space between pairs of base crop rows but wide enough to minimize competition among plants of the base crop. In the inter-space of 60 cm, one raw of pigeonpea or two or more rows of other short statured intercrop can be planted. In other words, two rows of base crop and three rows of intercrop can be accommodated in 90 cm space instead of two rows of base crop alone with usual planting method. This is often referred to as 30/60 cm paired row planting. In dryland agriculture, intercropping is practiced to minimize the risk of total crop failure due to rainfall vagaries than for yield and economic advantage over sole cropping.

All India coordinated research project on cropping systems indicated several intercropping systems in different region of the country in the recent past (Hegde, 1992, Singh *et al.,* 1994, Yadav and Prasad, 1997).

Pigeonpea is a highly drought resistant crop. It can successfully grown in areas receiving only 65 cm annual rainfall, as the crop matures fast and pest damage is low. It is mostly photoperiodic sensitive and short days result in reduced vegetative phase and onset of flowering. Pigeonpea can be cultivated on variety of soils from sand to heavy clay loams. However, well drained medium heavy loams are best suited. The inbuilt mechanism of biological nitrogen fixation enables pulse crops to meet 30 to 90 % of their N requirements, hence a small dose of 15- 25 kg N/ha applied at sowing is sufficient to meet the requirement of most of the pulse crops (Karwasra and Anil Kumar, 2007). Pigeonpea can be knitted into many cropping systems, viz. intercropping, mixed cropping and sequential cropping etc. The initial slow growth, deep rooting pattern, ability to tolerate drought and low soil moisture has made it highly suitable crop for intercropping systems. It is intercropped with many short duration legumes, cereals and commercial crops. With the complementary effect of pigeonpea on soil fertility, improvement, nutrient recycling, smothering of weeds and efficient utilization of soil moisture under different cropping systems it occupies more area in cropping systems than as a sole crop.

Materials and Methods

The field experiment was conducted during the rainy season (*kharif)* 2016 and 2017 at Agronomy Farm, College of Agriculture, Parbhani (Maharashtra). The soil was clayey in texture with pH 7.85. The soil was low in organic carbon (0.50%), low in available nitrogen (198.00 kg/ha), phosphorus (14.26 kg/ha) and high in potash (492.60 kg/ha). The experiment consisted of 28 treatment combinations of 4 sowing dates ((D_1- sowing within a week period after regular commencement of monsoon, D_2- sowing 15 days after D_1, D_3- sowing 15 days after D_2 and

D_4- sowing 15 days after D_3) and 7 cropping system treatments i.e. I_1-pigeonpea+soybean (2:3), I_2- pigeon pea+ pearlmillet (2:1), I_3-pigeonpea+niger (2:3), I_4-sole pigeon pea, I_5-sole soybean, I_6- sole pearlmillet and I_7- sole niger.) in sub-plot was laid out in split-plot design and replicated 2 times. The gross and net plot size was taken 6.6 m x 6.0 m and 5.4 m x 4.8 m respectively.

Pigeonpea variety 'BDN 711', soybean 'MAUS 71', pearlmillet 'ABPC 4-3' and 'PNS 6' were sown on 27 June 2016 and 24 June 2017 as first sowing date (D_1) and D_2, D_3 and D_4 sowing was done after 15 days interval between each sowing date respectively. The seeds were sown in 60 cm x 20 cm spacing for sole pigeonpea, 30 cm x 15 cm for sole soybean and sole niger and 60 cm x 15 cm for sole pearlmillet. In intercrop situation, pigeonpea was sown in paired rows at 60 cm keeping 120 cm distance between 2 pair to adjust 3 rows of intercrop for soybean and niger (2:3) and 1 row (2:1) for pearlmillet (60/120 cm). The plant-to-plant distance of 20 cm in pigeonpea and 15 cm in intercrops was maintained. The recommended seed rates of 12-15 kg ha^{-1}, 60-65 kg ha^{-1}, 4-5 kg ha^{-1} and 3-4 kg ha^{-1} of pigeonpea, soybean, pearlmillet and niger for sole and intercrops, respectively, were used in the experiment. The recommended dose of 25 kg N/ha through urea and 50 kg P_20_5/ha through single superphosphate was applied to sole pigeonpea as well as in intercrops. Also the recommended dose of 30:60:30 NPK kg ha^{-1} for soybean, RDF 60:30:30 NPK kg ha^{-1} for pearlmillet and RDF 20:20:0 NPK kg ha^{-1} for niger crop through urea, SSP and MOP were drilled before sowing as a basal application. To maintain healthy and good crop stand follow the all recommended package of practices like thining, weeding and plant protection measures as and when required. The experimental data obtained on various selected variables were analyzed by the standard method of statistical analysis (Panse and Sukhatme, 1967).

Results and Discussions

Data pertaining to pigeonpea equivalent yield, GMR, NMR and B:C were influenced by the various treatments during 2016, 2017 and pooled analysis. There were significant differences due to sowing dates and cropping systems for the system PEY, GMR, NMR and B:C ratio during both the years of the experimentation.

Sowing dates

It indicates that effect of sowing dates on system pigeonpea equivalent yield of pigeonpea was significant during 2016, 2017 and pooled analysis. Sowing date (D_1) found significantly superior for pigeonpea equivalent yield (1640 and 1681 kg ha^{-1}) and was at par with D_2 (1498 and 1518 kg ha^{-1}) than other sowing dates (D_3 and D_4) during both the years. Similar trend was followed during pooled results.

The gross monetary returns, net monetary returns and benefit: cost ratio was significantly influenced by sowing dates treatments during both the years. First sowing date (D_1) registered significantly higher gross monetary returns (Rs. 83,387 Rs. 93,181 and Rs. 88,284 ha^{-1}) as compared to sowing date treatments (D_3 and D_4) but it was uniformity with sowing date D_2 (Rs.177,352; Rs. 84,164 and Rs. 80,758) during both the year and in pooled analysis respectively. Lowest system gross monetary returns were seen in sowing date D_4 in 2016, 2017 and pooled analysis.

First sowing date (D_1) observed significantly higher net monetary returns (Rs. 38,379; Rs. 48,172 and Rs. 43,225 ha^{-1}) as compared D_2, D_3 and D_4 sowing date, during both the year and in pooled analysis. A lowest system net

monetary return was seen in sowing date D_4 in 2016, 2017 and pooled analysis.

Benefit cost ratio was influenced by different date of sowing and cropping system during both the years. The highest benefit cost ratio (1.9 and 2.1) was obtained by first sowing date (D_1) as compared to other dates (D_2, D_3 and D_4) during both the years. Similar trend was followed in mean of two years.

Cropping systems

The difference observed due to cropping system in respect of pigeonpea equivalent yield were found significant during both the years of experimentation and pooled analysis. Pigeonpea equivalent yield of pigeonpea + soybean (I_1) found superior i.e. 1968 and 1948 kg ha^{-1} over pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3), Sole soybean (I_5), sole pearlmillet (I_6) and sole niger (I_7), but on par with sole pigeonpea (I_4) during 2016 and pooled data except in 2017 year of experimentation (Rathod *et al*., 2004).

The deviation find due to cropping system in respect of gross monetary returns, net monetary returns and benefit: cost ratio were found significant during both the years of experimentation and pooled analysis. System gross monetary returns of pigeonpea + soybean (I_1) found superior i.e. Rs. 99,388 ha^{-1} and Rs. 1,06,145 ha^{-1} over pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3), Sole soybean (I_5), sole pearlmillet (I_6) and sole niger (I_7), but on par with sole pigeonpea (I_4) during 2017 and pooled data except in 2016 it was on par with sole pigeonpea (I_4).

A lowest gross monetary return was seen in sole pearlmillet during (I_6) 2016 and in 2017 and pooled analysis observed in sole niger (I_7). The results are in conformity with those reported by Lingaraju *et al.*, (2008).

The net monetary returns of pigeonpea + soybean (I_1) found maximum i.e. Rs. 51,070 ha^{-1}, Rs. 57,827 ha^{-1} and Rs. 54,449 ha^{-1} over pigeonpea + pearlmillet (I_2), pigeonpea + niger (I_3), sole pigeonpea (I_4), Sole soybean (I_5), sole pearlmillet (I_6) and sole niger (I_7) during 2016, 2017 and pooled data. Lowest system net monetary returns was confirmed in sole pearlmillet during (I_6) 2016 and pooled analysis and in 2017 observed in sole niger (I_7)

The pigeonpea + soybean (I_1) registered maximum benefit cost ratio (2.1) during 2016 results. But during second year and also in polled analysis pigeonpea + Pearlmillet (I_2) recorded higher 2.3 and 2.2 benefit cost ratio than other treatments.

Interaction (*Sowing dates* x *Cropping systems*)

System pigeonpea equivalent yield (kg ha^{-1})

The interaction effect of sowing dates (D) and cropping systems (I) on system pigeonpea equivalent yield was found to be significant during 2016-17 and 2017-18 and in pooled results. It could be derived from the data presented in table 1.

Data on system pigeonpea equivalent yield of pigeonpea during 2016-17 presented in Table 1 revealed that pigeonpea + soybean (I_1) (2523 kg ha^{-1}) sown on first date (D_1) was found significantly superior over other treatments and it was at par with D_2I_1 (2300 kg ha^{-1}). Also it was found significantly superior

Over pigeonpea + pearlmillet (D_1I_2), pigeonpea + niger (D_1I_3), Sole soybean (D_1I_5), sole pearlmillet (D_1I_6) and sole niger (D_1I_7). D_1I_4 was the next best treatment combination.

Table.1 Pigeon pea equivalent yield (kg ha^{-1}), GMR (Rs. ha^{-1}), NMR (Rs. ha^{-1}) and B:C Ratio as influenced by dates of sowing and different cropping systems during 2016-17, 2017-2018 and poole

Treatments	Pigeonpea equivalent yield (Kg ha^{-1})			Gross Monetary Return (Rs. ha^{-1})			Net Monetary Return (Rs. ha^{-1})			B:C Ratio		
	2016	**2017**	**Pool**	**2016**	**2017**	**Pool**	**2016**	**2017**	**Pool**	**2016**	**2017**	**Mean**
A) DOS												
D_1	1640	1681	1661	83,387	93,181	88,284	38,379	48,172	43,275	**1.9**	**2.1**	**2.0**
D_2	1498	1518	1508	77,352	84,164	80,758	32,344	39,155	35,750	1.7	1.9	1.8
D_3	1198	1182	1181	60,887	65,478	63,183	15,878	20,470	18,174	1.3	1.5	1.4
D_4	890	862	876	45,897	47,753	46,825	889	2,745	1,817	1.0	1.1	1.0
S.E. (m)	40	36	35	2,030	2,020	1,854	1,319	1,887	1,731	---	---	---
C.D. (0.05)	188	169	163	9,462	9,415	8,644	3,845	5,500	5,044	---	---	---
B) CS												
I_1- PP+SOY	1968	1948	1958	99,388	1,06,145	1,02,766	51,070	57,827	54,449	**2.1**	2.2	**2.2**
I_2-PP+PM	1537	1695	1616	80,325	94,508	87,416	39,556	53,739	46,647	2.0	**2.3**	**2.2**
I_3- PP+ NI	1570	1677	1624	79,284	91,413	85,349	36,243	48,372	42,307	1.9	2.2	2.0
I_4- SOLE PP	1924	1839	1882	97,175	1,00,226	98,700	45,181	48,232	46,706	1.9	1.9	1.9
I_5-SOLESOY	818	844	831	41,292	46,017	43,655	-9,169	-4,444	-6,807	0.8	0.9	0.9
I_6- SOLE PM	568	605	587	33,953	39,248	36,601	-9,649	-4,354	-7,001	0.8	0.9	0.8
I_7- SOLE NI	728	568	648	36,749	30,952	33,851	-125	-5,922	-3,024	1.0	0.8	0.9
S.E. (m)	36	31	30	1,764	1,648	1,545	1,079	1,324	1,232	---	---	---
C.D. (0.05)	105	92	89	5,181	4,839	4,537	3,143	3,857	3,590	---	---	---
C) D X I												
S.E. (m)	78	68	66	3,846	3,659	3,410	2157	2647	2,464	---	---	---
C.D. (0.05)	264	234	226	13,142	12,667	11,751	6287	7714	7,180	---	---	---
GM	**1304**	**1311**	**1307**	**67,480**	**72,644**	**69,762**	**22,472**	**27,636**	**24,754**	**1.49**	**1.62**	**1.55**

During next year of investigation i.e. 2017-18, data recorded in table 1 revealed that pigeonpea + soybean (D_1I_1) (2590 kg ha^{-1}) sown on first date (D_1) was found significantly superior over rest of the treatment combinations as well as it was found superior over pigeonpea + pearlmillet (D_1I_2), pigeonpea + niger (D_1I_3) and sole pigeonpea (D_1I_4) Sole soybean (D_1I_5), sole pearlmillet (D_1I_6) and sole niger (D_1I_7). It was followed by D_2I_1.

Similar trend was noticed in pooled results (Table 1).

System gross monetary returns (Rsha^{-1})

The interaction effect of sowing dates (D) and cropping systems (I) on system gross monetary returns was found to be significant during 2016-17 and 2017-18 and pooled results. It could be derived from the data presented in table 1.

Data on system gross monetary returns of pigeonpea during 2016-17 in Table 1 revealed that pigeonpea + soybean (D_1I_1) (Rs. 1,27,410 ha^{-1}) was found significantly superior over rest of the treatment combination except with D_2I_1(Rs. 1,16,151 ha^{-1}) which was at par with D_1I_1. Also it was found significantly superior over other cropping system i.e. pigeonpea + pearlmillet (D_1I_2), pigeonpea + niger (D_1I_3), sole pigeonpea (D_1I_4), Sole soybean (D_1I_5), sole pearlmillet (D_1I_6) and sole niger (D_1I_7) during 2016-17.

During 2017-18 year of investigation data recorded in table 1 concluded pigeonpea + soybean (D_1I_1) (Rs. 1,39,518 ha^{-1}) was found significantly superior over rest of the treatments except D_2I_1 and D_1I_3 which were at par with each other. Also it was found significantly higher over cropping system pigeonpea + pearlmillet (D_1I_2), sole pigeonpea(D_1I_4) Sole soybean(D_1I_5), sole pearlmillet (D_1I_6) and sole niger (D_1I_7), but on par with pigeonpea + niger (D_1I_3) (Rs. 1,32,908 ha^{-1}) during 2017-18.

Hence concluded, among the four date of sowing D_1, D_2, D_3 and D_4 first sowing date D_1 was found highest in respect of pigeonpea equivalent yield, gross monetary return, and net monetary return as well as benefit cost ratio and which was at par with sowing dates D_2. Also from seven cropping system the I_1-pigeonpea+soybean cropping system was found highest in terms of pigeonpea equivalent yield and gross monetary return which was at par with I_4-sole pigeonpea. For net monetary return I_1-pigeonpea+soybean shows beneficial over rest of the treatment which is on par with I_3-pigeonpea+niger. The result of benefit:cost ratio was found highest for I_3-pigeonpea+niger cropping system and slightly highest over I_1-pigeonpea+soybean.

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