



## Productivity and profitability of pigeonpea (*Cajanus cajan*)–greengram (*Vigna radiata*) intercropping system under various moisture conservation practices in rainfed conditions

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Received: 2 July 2015; Accepted: 22 January 2016

**Key words:** Moisture conservation, Net B:C ratio, Net return, Nutrient (P and S) uptake and Pigeonpea + greengram intercropping

Pigeonpea [*Cajanus cajan* (L) Millsp] is an important grain legume crop under rainfed conditions. At present, the total production of pigeonpea in India is 2.9 Mt from an area of 3.86 Mha, with an average productivity of 751 kg/ha (Kumawat *et al.* 2012). Greengram [*Vigna radiata* (L.) Wilczek] is another important legume crop of rainfed conditions. Productions of both crops are stagnating or increasing in very small amounts since last decades. This is due to the fact that both crops are cultivated under rainfed conditions, which is subjected to deficit and erratic distribution of rainfall and uncertainty in onset of monsoon. Beside this, 30–40% of the total rainfall of rainfed areas is lost as runoff, carrying productive soils and nutrients, which lead to higher cost of production for efficient soil management. In addition, rainfed farmers are reluctant to use moisture conservation practices, such as using straw mulch, dust mulch, anti-transpirants, hydrogel etc. This causes maximum reduction in crop production. So, there is a need for applying moisture conservation practices to cover the productive soil in order to prevent its loss, conserve *in situ* soil moisture and incorporation of nutrients through organic mulches. Therefore, the objective of this study was to evaluate the impact of moisture conservation practices, i.e. mulching and hydrogel application for enhancing productivity and profitability of pigeonpea and greengram in rainfed conditions.

A field experiment was conducted during rainy (*kharif*) season of 2013 at the Experimental Farm of the ICAR Indian Agricultural Research Institute, New Delhi (situated at 28° 40'N latitude, 77° 11'E longitude and at an altitude of about 228 m above mean sea level). The soil of experimental field for evaluating pigeonpea + greengram intercropping system under different moisture conservation practices was sandy loam with pH 7.3, oxidizable organic

carbon 0.38%, available N, P and K were 238.4, 33.9 and 124.5 kg/ha, respectively. Nine treatments of 3 combinations of cropping systems [sole pigeonpea (90 cm), pigeonpea (90 cm) + greengram (45 cm) (1:1) and pigeonpea (90 cm) + greengram (30 cm) (1:2)] and 3 moisture conservation practices [control, hydrogel @ 2.5 kg/ha and mulching @ 2.5 tonnes of barley straw per hectare] were tested with three replicates under randomized complete block design. Sowing of pigeonpea and greengram was done on 13 July 2013. Seeds of pigeonpea variety (Pusa 992) and greengram (Pusa-672) were sown in line using *pura* method (dropping the seeds in furrow behind the plough) of sowing. Seed rate of pigeonpea was 10 kg/ha in all three cropping systems, whereas the seed rate used for greengram was decided according to space dimension used for intercropping with pigeonpea. Therefore, the seed rate for greengram was 6 kg/ha for plots under pigeonpea-greengram (1:1) cropping system and 12 kg/ha under pigeonpea-greengram (1:2) cropping system. 25 kg N and 50 kg P<sub>2</sub>O<sub>5</sub>/ha was applied in the form of di-ammonium phosphate (DAP) as a basal dose to both crops at the time of sowing and then, light planking was done immediately to cover the seeds. The uniform application of FYM @ 5 tonnes/ha was done at the time of harrowing. Hydrogel is water loving biopolymer and having capacity to absorb water about 400 times of its own weight (Narjary *et al.* 2012). Hydrogel @ 2.5 kg/ha (Varidharji-1) was mixed with sand and drilled below seed zone at sowing, whereas barley (previous crop) straw mulch application was done at 14 days after sowing (DAS). Harvesting of pigeonpea was done on 18 December 2013. The greengram crop variety was an indeterminate type, therefore, harvesting was done by two pickings of dried pods. First picking was carried out on 23 September and the second on 13 October 2013.

Data of pigeonpea on growth attributes as well as yield and yield attributes and data of greengram on grain yield were taken at the time of the physiological maturity stage, except LAI was taken at flowering stage. Soil moisture was measured at 7 days interval with the help of a TDR-300 moisture meter (at 0-30 cm depth). The samples of grain

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and stalk of pigeonpea were digested with the help of diacid ( $\text{HClO}_4 + \text{HNO}_3$ ) for analysis of P (phosphorus) and S (sulphur). Phosphorus and sulphur contents were estimated by Vanadomolybdophosphoric yellow color method (Jackson 1958) and the turbidimetric method (Tabatabai and Bremner 1970), respectively. Then, total uptake (grain + stalk) of P and S were calculated in terms of kg/ha for pigeonpea. The experimental data were treated through statistical test by ANOVA technique as recommended by Cochran and Cox (1957). Wherever variance ratio (F value) was significant, the critical difference (CD) values at the 95 % level of probability were computed for making comparisons between treatments.

The cropping system failed to cause any significant variation in the plant height, branches/plant at harvest and LAI at flowering stage of pigeonpea (Table 1). Kumar and Rana (2007) reported that there might be possibility of lack of competition between main crop (pigeonpea) and the intercrop (greengram) for growth resources such as nutrients uptake, sunlight, soil moisture due to lesser duration and non-spreading nature of greengram. Data pertaining to growth attributes such as plant height (cm), LAI were positively influenced by moisture conservation practices, except the branches/plant (Table 1). Among the moisture conservation practices, plots with mulching had higher plant height and LAI by 8.2 and 11.4% respectively, over control. The plots with hydrogel had similar LAI and plant height to control plots. Under correlation matrix, at 1% level of significance, grain yield is positively correlated with plant height and pods/plant. This means that the increase in plant height as well as pods/plant significantly contributed to pigeonpea grain yield. Plant height positively affected the pods/plant at 1% level of significance and LAI also influenced grain yield at 5% level of significance (Table 2). Plant height and LAI may have contributed to the increased pods/plant and grain yields, respectively, due to translocation of photosynthates from leaves to seeds.

The significant variations in grain yield and yield attributes of pigeonpea were not seen under cropping systems, except pods/plant. Kumar *et al.* (2013) also reported non-significant variation in yield attributes such as pods/plant, grains/pod and 1 000-grain weight between sole pigeonpea and pigeonpea + mungbean cropping system. Pods/plant and grain yield of pigeonpea had shown significant variations among moisture conservation practices, except grains/pod and test weight (g). Plots with mulching had 41.9 and 16.4% higher pigeonpea grain yield than control and hydrogel treated plots, respectively. Chinnathurai *et al.* (2012) also reported that 47.8% increased grain yield of pigeonpea under organic mulch treatment over control without mulch at Madurai, Tamil Nadu during a one year experiment. Cropping systems and moisture conservation practices positively and significantly influenced the pigeonpea equivalent yield (PEY). 1:2 intercropping system showed 7.4 and 44% increase in pigeonpea equivalent yield over 1:1 intercropping and sole systems, respectively. Plots

Table 1 Effect of cropping system and moisture conservation practices on biometric observations and total nutrient (P and S) uptake of pigeonpea as well as pigeonpea equivalent yield and grain yield of greengram

Treatment	Plant height at harvest (cm)	LAI at flowering	Branches/plant	Pods/plant	Grains/pod	Test weight (g)	Pigeonpea		Total nutrient uptake	
							Grain yield (q/ha)	equivalent yield (q/ha)	Phosphorus (P) (kg P/ha)	Sulphur (S) (kg S/ha)
<b>Cropping systems (CS)</b>										
Sole (PP)	129.9	2.3	12.5	170.1	3.61	79.36	4.76	4.76	3.4	3.8
PP+GG (1:1)	125.7	2.2	14.0	147.3	3.22	79.83	4.39	7.88	3.2	3.5
PP+GG (1:2)	127.9	2.22	13.8	152.8	3.53	79.91	4.25	8.51	3.2	3.5
SEM±	3.04	0.07	0.6	4.8	0.13	1.21	0.18	0.2	0.1	0.1
CD (P = 0.05)	NS	NS	NS	14.4	NS	NS	NS	0.59	NS	NS
<b>Moisture conservation practices (M)</b>										
Control	123.5	2.08	13.1	147.8	3.29	80.14	3.18	3.53	2.5	2.8
Hydrogel @ 2.5 kg/ha	125.4	2.29	13.4	155.4	3.52	78.93	4.58	3.7	3.4	3.7
Mulching @ 2.5 t/ha	134.6	2.35	13.8	167.1	3.54	80.02	5.48	4.12	4.1	4.4
SEM±	3.04	0.07	0.6	4.8	0.13	1.21	0.18	0.13	0.1	0.1
CD (P = 0.05)	9.11	0.21	NS	14.4	NS	NS	0.53	0.41	0.3	0.4
Interaction (CS × M)/CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

PP- Pigeonpea, GG- Green gram, LAI- Leaf Area Index, NS- Non-significant

Table 2 Correlation matrix between biometric observations of pigeonpea (n = 5)

	Leaf Area Index (LAI)	Branches/plant	Plant height	Pods/plant
Branches/plant	0.11901			
Plant height	-0.10786	0.06207		
Pods/plant	0.21198	-0.26587	0.50883**	
Grain yield	0.38195*	0.12937	0.49977**	0.53719**

\* 5% level of significance, \*\* 1% level of significance, n = Number of observations.

with 1:1 intercropping system performed 39.5% better over sole cropping system. Likewise, pigeonpea + greengram intercropping system (1:1 and 1:2) performed better over sole pigeonpea in terms of pigeonpea equivalent yield as observed by Sharma and Guled (2012).

Among moisture conservation practices, mulching gave 32.5 and 14.3% higher pigeonpea equivalent yield over the control and hydrogel, respectively. Hydrogel showed 21.2 % better response over the control. The overall lower yield in pigeonpea and greengram was due to severe infestation of blister beetle (*Mylabris phalerata*) and legume pod borer (*Maruca vitrata*) during the reproductive and grain filling stage. Dasbak *et al.* (2012) and Shinde (2013) also reported that drastic reductions in yields of pigeonpea and greengram were observed due to blister beetle and legume pod borer feeding on flower buds, undeveloped pods and developing seeds. Cropping system had no effect on the total uptake of P and S. Kumar and Rana (2007) also reported similar results during a two year experiment at IARI farm. The total uptakes of P and S were significantly higher under moisture conservation practices compared with control plots and mulching indicated highest uptake over control and hydrogel. The increased uptake of these nutrients under mulching treatment could be attributed to the higher yield of pigeonpea. This might due to the increased water availability and the enhanced microbial activity in soil which results in facilitating

Table 3 Effect of cropping system and moisture conservation practices on economics

Treatment	Cost of cultivation (× 10 <sup>3</sup> ₹/ha)	Gross returns (× 10 <sup>3</sup> ₹/ha)	Net returns (× 10 <sup>3</sup> ₹/ha)	Net B:C ratio
<i>Cropping systems (CS)</i>				
Sole (PP)	16.8	23.9	7	0.42
PP+GG (1:1)	17.6	39.2	21.5	1.23
PP+GG (1:2)	18.4	42.6	24.3	1.32
<i>Moisture conservation practices (M)</i>				
Control	15.1	28.4	13.3	0.88
Hydrogel @ 2.5 kg/ha	17.6	35.6	18.1	1.03
Mulching @ 2.5 tonnes/ha	20.1	41.5	21.5	1.07

efficient nutrient uptake by the crop and ultimately yield was increased. Russel and Barber (1960) reported that crop growth and dry matter production are possibly enhanced by ample moisture supply, which affects the availability and uptake of nutrients in both direct and indirect ways.

Soil moisture data were taken at seven-day intervals from the date of sowing towards crop harvest. These data showed fluctuations in soil moisture percentage in relation to rainfall fluxes. The significant variations in data were found at 56, 63, 70, 77, 112, 119, 126, 133, 140, 147 and 154 days after sowing (Fig 1). Among moisture conservation practices, mulch treatment resulted in better conservation of soil moisture than control and hydrogel treatments. There was no such significant differences found within the moisture conservation practices during the rainy days, but the marked significant difference within moisture conservation treatments during a dry spell period was observed especially in mulch treatment.

Data relating to cost of cultivation gross and net returns and net B:C ratio were also affected by cropping systems and moisture conservation practices (Table 3). Pigeonpea + greengram intercropping system (1:2) recorded higher net

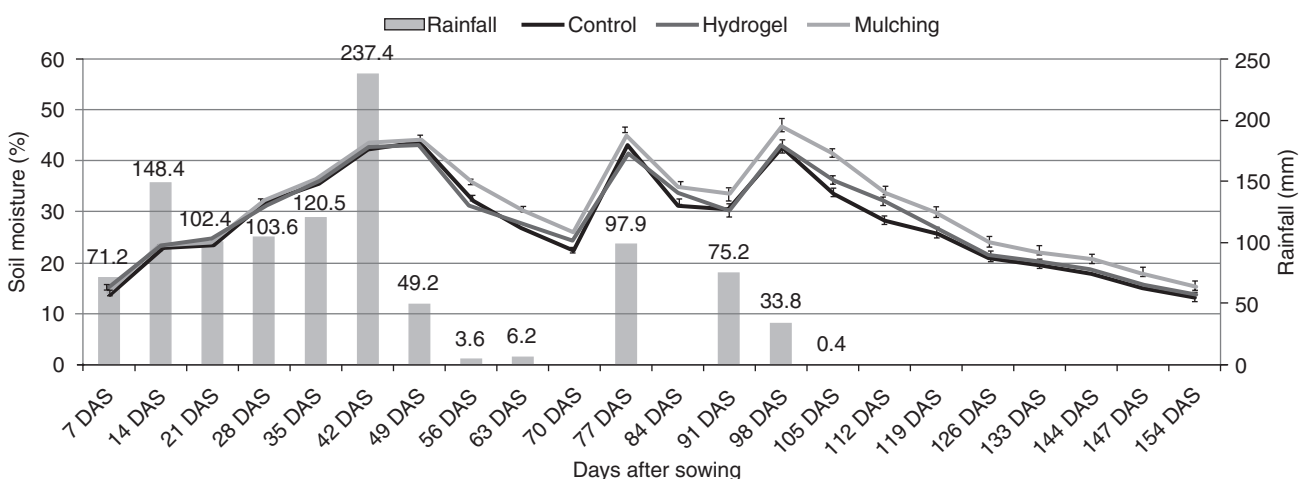


Fig 1 Soil moisture percentage (0-30 cm depth) at 7 days interval during cropping season (I - SEM±)

return (₹ 24.3 × 10<sup>3</sup>) and net B:C ratio (1.32) compared with 1:1 intercropping system and sole pigeonpea cropping system. Likewise, Sharma and Guled (2012) recorded significantly higher net return and B:C ratio in pigeonpea + greengram (1:2) intercropping system under set-furrow compared with sole pigeonpea at Agricultural Research Station, Gulbaraga during two year experiment on field. Moisture conservation practices exhibited considerable variation in net returns and net B:C ratios. Mulching fetched highest net return (₹ 21.5 × 10<sup>3</sup>) as well as net B:C ratio (1.07) over control and hydrogel.

#### SUMMARY

Among cropping systems, 1:2 pigeonpea [*Cajanus cajan* (L) Millsp] greengram [*Vigna radiata* (L) Wilczek] intercropping had higher grain yields and economically feasible net returns. In case of moisture conservation practices, barley straw residue (mulch) @ 2.5 tonnes/ha had not only the better economic net returns, but also increased nutrient uptake due to incorporation of nutrients and sufficient moisture conservation in soils throughout cropping season. Although rainfall during the cropping season was sufficient and well distributed (hence moisture availability nearly same among all treatments except under dry spell), straw residue mulch had an advantage of addition of nutrients and organic fractions to the soil. Therefore, farmers can integrate 1:2 pigeonpea-greengram intercropping system without reducing spacing of the main crop and apply previous crop residues as mulch if possible. This not only conserves soil moisture during a dry spell period, but also enhances nutrients uptake under rainfed conditions.

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