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Study on soil moisture pattern and soil properties in livelihood security through pigeonpea (*Cajanus cajan* L.) Based intercropping under rainfed condition

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Abstract

A field experiment was conducted during two consecutive years of *kharif* 2015-16 and 2016-17 at Soil Conservation and Water Management Farm of the C. S. Azad University of Agriculture and Technology, Kanpur to find out the effect of cropping systems, and moisture conservation practices on moisture use efficiency, splash loss and soil studies of crops under rainfed condition. The soil of experimental field was sandy loam in texture with pH 7.6, 0.38% organic carbon, 0.027% total N, 172.1 kg ha⁻¹ available N, 18.2 kg ha⁻¹ available P₂O₅ and 182.2 kg ha⁻¹ available K₂O. The field capacity, wilting point and bulk density were 18.6%, 6.2% and 1.35 Mg m⁻³, respectively. The treatments comprised of 6 cropping systems *i.e.* (i) Sole pigeonpea at 60cm by regular sowing (ii) Sole pigeonpea paired 40/80 (iii) Sole sorghum at 45 cm by regular sowing (iv) Sole urdbean at 45 cm by regular sowing (v) Pigeonpea + sorghum - paired sowing. 40/80 and (vi) Pigeonpea + urdbean - paired sowing 40/80 ; 3 moisture conservation practices *i.e.* (i) Control (ii) Ridging and furrowing in between the crop rows after three weeks of sowing and (iii) Weeding and hoeing once at 35 DAS the crop rows were tested in Split plot design with 3 replications during the course of investigation envisages. Results obtained that the moisture studies and soil studies of individual crop depressed in additive intercropping where depression was more in sorghum than blackgram. Moreover, total moisture use, consumptive water use and moisture use efficiency were also found to be the highest, while the lowest derived from the sole sorghum. Simultaneously, maximum splash loss was observed under sole pigeonpea paired sowing and minimum under sole blackgram treatment. In addition, total moisture use, moisture use efficiency was also noticed higher, but splash loss was lower. The higher splash loss was observed under conventional practice over ridging and furrowing practice during both the years of experimentation.

Keywords: moisture, soil properties, pigeonpea, *Cajanus cajan*

Introduction

The production of pigeonpea in India has shared 90 per cent to the total produce at global level. In India, it is cultivated as annual crop, but in other countries it is grown as perennial crop where pods are harvested at regular intervals. Pulses are grown under poor management practices. Among pulses, pigeonpea (*Cajanus cajan* L.) or red gram vernacularly known as Arhar, Tur, Tuwar, Thuvarya, Kandula billakandi etc. consumed mainly in the form of dal. In the Indian sub continent, it is mostly consumed as *dal*, but hot dry or green seed is consumed in Eastern Africa and mainly as cooked grain seed in Central America.

Pigeonpea (*Cajanus cajan* L.) is one of the oldest crops of our country. After chickpea, arhar is the second most important pulse crop of India. It accounts for about 11.8 percent of the total pulse area and 17 percent of total pulse production of the country. It is a rich source of protein and supplies a major share of the protein requirement of the vegetarian population of the country. Seeds of arhar are also rich in iron and iodine. Woody parts of the plant are used for fuel and other domestic purpose. Pigeonpea contributes about 15 percent in total pulses area as well as production of India.

Runoff and soil erosion occur when the soil surface is not able to hold the rain water. One of the basic principles of soil and water conservation is to keep land surface into rough condition or to provide vegetative cover on it or to put barriers against runoff flow so to facilitate rain water to infiltrate into the soil. The practices like leveling, bunding, mulching, etc help arrest rainfall at the site of occurrence and provide more opportunity and time to rain water to go into the soil and consequently reduce runoff and soil loss and in turn increase crop yield.

Material and Method**Details of experiment**

The experiment was carried out in split plot design with the three replications having 18 treatments combination which are allocated randomly in all plots. The details of treatments are given below.

A. Cropping systems - 6

1. Sole pigeonpea at 60cm by regular sowing
2. Sole pigeonpea paired 40/80
3. Sole sorghum at 45 cm by regular sowing
4. Sole urdbean at 45 cm by regular sowing
5. Pigeonpea + sorghum - paired sowing. 40/80
6. Pigeonpea + urdbean - paired sowing 40/80

B. Moisture conservation practices - 3

1. Control
2. Ridging and furrowing in between the crop rows after three weeks of sowing
3. Weeding and hoeing once at 35 DAS

Results of soil moisture studies**Soil moisture**

The data for soil moisture up to one meter depth (mm) at different stages of crop growth have been summarized in Table -1 for the years 2015-16 and 2016-17.

The data reveal that soil moisture up to one meter depth at different stages of plant growth appeared remarkable variation

as affected by cropping systems. The maximum soil moisture content was recorded at 30, 60 and 90 DAS under blackgram sole during both the years moreover, the soil moisture content under pigeonpea sole regular, pigeonpea sole paired and sorghum sole showed almost similar pattern with slight variation but after harvest of blackgram and sorghum crops, higher soil moisture was noticed under pigeonpea sole regular followed by pigeonpea + blackgram (1+2) paired sowing and lower under pigeonpea + sorghum (1+2) paired cropping system in both the years.

Higher soil moisture was observed under ridging and furrowing technique under ridging and furrowing technique over weeding and hoeing plot at all the stages of plant during both the experimental years.

Consumptive use

The data for consumptive use (mm) depth at different stages of crop growth have been presented in Table -2 for the years 2015-16 and 2016-17.

The data indicate pigeonpea +sorghum (1+2) paired exerted the maximum moisture use closely pigeonpea +blackgram paired (1+2), pigeonpea sole paired and the minimum under the blackgram sole but after harvest of sorghum and blackgram crops, higher soil moisture extraction was noticed under pigeonpea sole paired during both the years.

The crop grown under ridging and furrowing resulted in lower consumptive use in comparison to conventional practice at all the growth stages during both the years.

Table 1: Effect of cropping system and moisture conservation practices on soil moisture content upto one meter depth (mm) at different interval during 2015-16 and 2016- 2017.

Treatment	Soil moisture content up to 1 meter depth (mm)									
	Sowing time	30 Das	60 Das	90 Das	120 Das	150 Das	180 Das	210 Das	240 Das	At maturity
2015-2016										
Cropping systems										
Sole pigeonpea regular	280	241.9	222.0	204.6	200.6	195.5	183.9	159.9	136.3	102.0
Sole pigeonpea paired	280	241.9	221.3	203.1	198.5	192.7	180.3	155.4	131.1	96.2
Sole sorghum regular	280	241.6	224.2	208.6	206.5	-	-	-	-	-
Sole urdbean regular	280	242.8	227.4	213.9	-	-	-	-	-	-
Pigeonpea + sorghum paired	280	240.8	219.6	200.6	194.9	188.1	174.9	149.1	125.5	88.1
Pigeonpea + urdbean paired	280	241.1	220.2	201.7	196.5	190.2	177.5	152.1	129.1	92.2
Moisture conservation practices										
Control	280	241.3	221.3	203.6	197.2	189.3	176.5	150.8	128.4	90.2
Ridging & Furrowing	280	242.3	223.9	207.5	202.0	194.3	182.4	158.1	134.1	99.6
Weeding & hoeing	280	241.4	222.2	205.2	199.0	191.2	178.7	153.5	129.0	94.1
2016-2017										
Cropping systems										
Sole pigeonpea regular	290	258.1	244.8	239.4	219.5	198.8	175.9	170.5	135.0	101.7
Sole pigeonpea paired	290	257.7	244.5	238.9	218.4	197.2	173.9	167.1	131.0	97.2
Sole sorghum regular	290	258.7	246.9	242.1	224.6	-	-	-	-	-
Sole urdbean regular	290	259.5	249.6	249.0	-	-	-	-	-	-
Pigeonpea + sorghum paired	290	257.3	241.7	235.4	213.7	190.9	166.9	159.8	121.6	88.6
Pigeonpea + urdbean paired	290	257.9	242.8	237.1	216.0	193.9	170.3	164.0	126.5	91.5
Moisture conservation practices										
Control	290	257.9	243.2	237.8	215.8	192.7	169.0	161.5	124.3	89.8
Ridging & Furrowing	290	259.0	246.9	242.8	221.1	197.7	174.7	170.0	133.5	99.9
Weeding & hoeing	290	257.7	245.0	240.4	218.4	195.1	171.6	164.5	127.7	94.5

Table 2: Effect of cropping system and moisture conservation practices on consumptive use (mm per meter soil depth) at different intervals during 2015-16 2016-17.

Treatment	Consumptive use (mm per meter soil depth)									
	30 Das	60 Das	90 Das	120 Das	150 Das	180 Das	210 Das	240 Das	At maturity	
2015-16										
Cropping systems										
Sole pigeonpea regular	128.3	98.8	78.1	20.3	25.3	22.5	26.8	33.1	34.9	
Sole pigeonpea paired	127.9	99.5	78.8	21.0	26.0	23.4	27.7	33.8	35.5	

Sole sorghum regular	128.2	96.3	76.1	18.4	-	-	-	-	-
Sole urdbean regular	127.0	94.2	74.1	-	-	-	-	-	-
Pigeonpea + sorghum paired	129.0	100.1	79.5	22.0	27.1	24.1	28.6	34.7	36.5
Pigeonpea + urdbean paired	128.7	99.8	79.1	21.5	26.5	23.7	28.2	34.3	36.0
Moisture conservation practices									
Control	128.7	98.9	78.2	21.2	26.8	23.8	28.4	34.4	36.3
Ridging & Furrowing	127.4	97.4	77.0	20.1	25.6	22.9	27.1	33.2	35.1
Weeding & hoeing	128.4	98.1	77.6	20.7	26.2	23.5	27.9	34.4	35.7
2016-17									
Cropping systems									
Sole pigeonpea regular	214.3	60.6	48.8	20.0	20.7	23.3	31.2	36.1	33.3
Sole pigeonpea paired	214.7	60.5	49.2	20.4	21.2	23.6	32.6	36.7	33.8
Sole sorghum regular	213.7	59.1	48.3	17.5	-	-	-	-	-
Sole urdbean regular	212.9	57.3	44.1	-	-	-	-	-	-
Pigeonpea + sorghum paired	215.1	62.9	49.8	21.7	22.8	24.4	33.9	38.7	33.0
Pigeonpea + urdbean paired	214.5	62.4	49.2	21.1	22.1	24.0	33.1	38.1	35.0
Moisture conservation practices									
Control	214.4	62.0	48.9	20.7	22.3	24.2	33.2	37.8	34.5
Ridging & Furrowing	213.4	59.3	47.6	19.7	21.2	23.4	32.0	37.1	33.6
Weeding & hoeing	214.7	60.0	48.1	20.0	21.6	23.9	32.9	37.4	33.2

Total moisture use

The data on total moisture use (mm) by the crops have been summarized in table -3 and also graphically depicted in both the cropping seasons.

The data reveal that the maximum total moisture use recorded under pigeonpea + sorghum (1+2) paired being during first and second year respectively.

Weeding and hoeing, as a moisture conservation practices recorded higher total moisture use in comparison to those found under ridging and furrowing practice during two crop seasons.

Moisture use efficiency (MUE)

The data pertaining to moisture use efficiency (kg seed ha⁻¹ mm⁻¹ of water) have been presented in table -3 for both the experimental years.

The data clearly indicate that highest MUE was observed under pigeonpea + blackgram (1+2) paired sowing being 4.78

and 4.74 kg seed ha mm⁻¹ of water followed by pigeonpea + sorghum.

Ridging and furrowing practice recorded higher MUE of water during 2015-16 and 2016-17, respectively in comparison to weeding and hoeing of water during first and second year, respectively.

Moisture extraction pattern (MEP)

Data recorded on the soil moisture extraction pattern (%) have been epitomized in Table-4.

Data reveal that different cropping systems and moisture conservation practices could not bring about any large difference in soil during both the years of experimentation. the surface layer 0-25 cm exhibited soil which was extent of followed by 25-50 cm which showed extraction while lowest was observed the layer 75-100 cm during 2015-16 and 2016-17, respectively in 2016-17, soil moisture extraction was more from deeper layers as compared to normal year of 2015-16.

Table 3: Effect of cropping system and moisture conservation practices on total water use (mm) and water use efficiency (kg seed /ha/mm water).

Treatment	Total moisture use (mm)		moisture use efficiency (kg/seed/ha/mm water)	
	2015-16	2016-17	2015-16	2016-17
Cropping systems				
Sole pigeonpea regular	468.1	488.3	3.16	3.24
Sole pigeonpea paired	473.5	492.8	3.67	3.79
Sole sorghum regular	319.1	338.6	2.04	2.02
Sole urdbean regular	295.4	314.2	2.96	3.12
Pigeonpea + sorghum paired	481.5	502.4	3.95	4.01
Pigeonpea + urdbean paired	477.8	499.5	4.78	4.74
Moisture conservation practices				
Control	423.4	444.1	2.92	2.99
Ridging & Furrowing	414.6	435.0	4.08	4.05
Weeding & hoeing	419.6	438.8	3.28	3.42

Table 4: Effect of cropping system and moisture conservation practices on soil moisture extraction pattern (%)

Treatment	2015-16				2016-17			
	Soil depth (cm)				Soil depth (cm)			
	0-25	25-50	50-75	75-100	0-25	25-50	50-75	75-100
Cropping systems								
Sole pigeonpea regular	38.04	28.62	21.34	12.00	38.46	28.94	21.06	11.54
Sole pigeonpea paired	37.70	28.51	21.46	12.33	38.27	28.70	21.25	11.78
Sole sorghum regular	45.10	28.32	17.15	9.43	45.38	28.58	17.08	8.96
Sole urdbean regular	45.94	28.52	16.58	8.96	46.15	28.77	16.52	8.56
Pigeonpea + sorghum paired	37.36	28.58	21.56	12.50	37.59	28.76	21.41	12.24
Pigeonpea + urdbean paired	37.42	28.62	21.50	12.46	37.80	28.93	21.19	12.08
Moisture conservation practices								

Control	40.05	28.26	20.07	11.62	40.28	28.51	20.02	11.19
Ridging & Furrowing	40.47	28.81	19.44	11.28	40.91	28.96	19.52	10.61
Weeding & hoeing	40.26	28.52	20.28	10.94	40.64	28.87	19.71	10.78

Splash Loss

Data presented in table -5 reveal that different cropping systems caused marked variation for splash loss ($t\ ha^{-1}$) of soil, minimum splash loss of 2.71 and 2.78 $t\ ha^{-1}$ were observed under blackgram sole and maximum of 4.08 and 5.02 $t\ ha^{-1}$ under pigeonpea sole paired sowing during the

year 2015-16 and 2016-17, respectively. Splash loss during both the years, different cropping systems may be categorized as given below. Conventional practice caused higher splash loss during first and second year, respectively over ridging and furrowing practice during both the years.

Table 5: Effect of cropping systems and moisture conservation practices on splash loss (t/ha).

Treatment	Moisture conservation practices			Mean
	Control	Ridging & Furrowing	Weeding & hoeing	
2015-16				
Cropping systems				
Sole pigeonpea regular	4.08	5.25	5.55	5.20
Sole pigeonpea paired	5.08	5.45	5.70	5.41
Sole sorghum regular	4.56	4.91	5.11	4.80
sole urdbean regular	2.71	2.98	3.01	2.90
Pigeonpea + sorghum paired	3.71	4.01	4.04	3.92
Pigeonpea + urdbean paired	3.14	3.40	3.51	3.35
Mean	4.00	4.33	4.49	-
2016-17				
Sole pigeonpea regular	5.02	5.43	5.69	5.38
Sole pigeonpea paired	5.36	5.70	5.86	5.64
Sole sorghum regular	4.69	5.00	5.28	4.99
sole urdbean regular	2.78	2.99	3.14	2.97
Pigeonpea + sorghum paired	3.88	4.16	4.32	4.12
Pigeonpea + urdbean paired	3.39	3.58	3.80	3.59
Mean	4.19	4.48	4.68	-

Soil properties after crop harvest

Analytical data of surface soil samples collection from various treatments after the harvest of crop during second year (2016-17) have been presented in Table - 6 for mechanical composition, physical, physico-chemical and chemical properties.

Mechanical composition

The data indicate that cropping systems, moisture conservation practices did not have any effect on mechanical composition of soil collected after the harvest of crops during second year.

Table 6: Effect of cropping system and moisture conservation practices on physical, physico-chemical and chemical properties of soil after harvest of second year crop.

Treatment	Properties														
	Physical									Physico-chemical		Chemical			
	Mechanical composition (%)				(mg/m ³)		Properties in (%)			pH	EC (ds/m)	OC (%)	Properties kg ha ⁻¹ .		
	Coarse sand	Fine sand	Silt	clay	PD	BD	Porosity	Field capacity	Wilt. point				N	P ₂ O ₅	K ₂ O
Cropping systems															
Sole pigeonpea regular	48.9	14.8	18.2	17.3	2.62	1.35	48.5	18.6	6.2	7.6	0.35	0.38	172.1	18.2	182.2
Sole pigeonpea paired	49.1	14.8	18.2	17.3	2.62	1.35	48.5	18.6	6.2	7.6	0.35	0.38	171.7	18.0	181.7
Sole sorghum regular	50.3	14.6	17.3	17.0	2.64	1.37	48.1	18.4	6.0	7.7	0.37	0.36	168.8	16.2	180.5
Sole urdbean regular	48.5	14.8	18.5	17.7	2.60	1.32	49.2	18.9	6.4	7.4	0.34	0.40	173.7	18.8	183.4
Pigeonpea + sorghum paired	49.3	14.7	18.0	17.1	2.63	1.36	48.3	18.5	6.1	7.6	0.36	0.37	170.5	17.8	181.5
Pigeonpea + urdbean paired	48.7	14.9	18.3	17.5	2.61	1.34	48.6	18.7	6.3	7.5	0.34	0.39	172.6	18.5	182.7
Moisture conservation practices															
Control	50.0	14.9	17.9	16.8	2.62	1.37	47.7	18.6	6.2	7.6	0.35	0.39	172.0	18.1	182.4
Ridging & Furrowing	48.5	14.7	18.3	17.8	2.62	1.33	49.2	18.6	6.2	7.6	0.35	0.37	171.1	17.7	181.4
Weeding & hoeing	48.8	14.8	18.1	17.3	2.62	1.35	48.5	18.6	6.2	7.6	0.35	0.38	171.7	17.9	182.2

Conclusion

On the basis of results obtained during course of investigation, following conclusion may be inferred: The maximum soil moisture content was recorded at 30, 60 and 90 DAS under sole blackgram during both the years. Moreover, the soil moisture content under pigeonpea sole regular, pigeonpea sole paired and sorghum sole showed almost similar pattern with slight variation but after harvest of blackgram and sorghum crops, higher soil moisture was noticed under pigeonpea sole regular followed by pigeonpea + blackgram (1+2) paired sowing and lower under pigeonpea intercropped with sorghum in both the years. Higher soil moisture was observed under ridging and furrowing technique over weeding and hoeing plot at all stages of plant growth during 2015-16 and 2016-17 in sandy loam soil under rainfed condition at Kanpur.

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