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EFFECT OF IRRIGATION METHODS AND CROP GEOMETRY ON GROWTH, YIELD AND ECONOMICS OF PIGEONPEA + GROUNDNUT INTERCROPPING SYSTEMS

V. M. Londhe[1], A. V. Solanke[2], P. B. Pawar[3] S. K. Dingre[4], and J. D. Jadhav[5]

Zonal Agricultural Research Station, Solapur, Maharashtra (India)

[1]Student Ph.D. (Agril), MPKV, Rahuri (Maharashtra)

[2]Sugarcane Specialist, Central Sugarcane Research Station, Padegaon

[3]Junior Research Assistant, Zonal Agricultural Research Station, Solapur, Maharashtra

[4]Er. S.K. Dingre, Assistant Professor, Irrigation & Drainage Engineering, IFD-IWM, PGI, MPKV, Rahuri

[5]Agrometeorologist, Zonal Agricultural Research Station, Solapur, Maharashtra

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Abstract: *The present study was undertaken at AICRP on Groundnut Scheme under Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri Maharashtra for two consecutive years 2010 and 2011 to work out effect of different crop geometry and irrigation methods on growth, yield and economics of pigeonpea + groundnut intercropping systems. The experiment was laid out in Strip Plot Design with four replications. The treatment were comprised with two irrigation methods viz., surface irrigation (at 80mm CPE) and drip irrigation (CPE at 4 days interval) and six crop geometries viz., Sole Pigeonpea (90cm × 30cm), Sole Groundnut (30cm × 10cm), Pigeonpea (180cm × 30cm) + Groundnut (30cm × 10cm) 1:5 ratio, Pigeonpea (180cm × 60cm) + Groundnut (30cm × 10cm) 1:5 ratio, Pigeonpea (90-180cm × 30 cm) + Groundnut (30cm × 10cm) 2:5 ratio and Pigeonpea (90cm-180cm × 60cm) + Groundnut (30cm × 10cm) 2:5 ratio. The results revealed that use of drip irrigation for pigeonpea as well as for groundnut recorded higher all yield attributing characters; seed and stick yields in pigeonpea; pod and haulm yields in groundnut than surface irrigation. The growth and yield attributes of pigeonpea were found to be significantly higher with the crop geometry C4 :pigeonpea (180cm × 60cm) + groundnut (30cm × 10cm) 1:5 ratio. Seed yield and stick yield in pigeonpea as well as pigeonpea seed equivalent were higher in crop geometry of sole pigeonpea (90cm × 30cm). Drip irrigation recorded higher seasonal cost and gross monetary returns. However, net seasonal income, B:C ratio and land equivalent ratio was recorded significantly higher with surface irrigation method for both the crops. Higher seasonal cost ha^{-1} was recorded with sole groundnut. Pigeonpea when intercropped with groundnut were observed to be superior for gross monetary returns ha^{-1}, net seasonal income, B:C ratio and LER during both the years of experimentation. Intercropping of pigeonpea and groundnut showed higher pigeonpea equivalent yield (33.61 and 35.99 q ha^{-1}, respectively). From the above results, it can be concluded that for higher productivity and profitability of pigeonpea + groundnut intercropping cropping system, crop geometry of pigeonpea (180cm × 30cm) + groundnut (30cm × 10cm) 1:5 ratio during Kharif season along with surface irrigation at 80 mm CPE is advisable.*

Keywords: *pigeonpea, groundnut, intercropping, surface irrigation, drip irrigation.*

Introduction

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is one of the important and protein rich grain legume of semi-arid tropics grown throughout the tropical and sub-tropical regions of the world. India is producing 14.76 million tonnes of pulses from an area of 23.63 million hectare, which is one of the largest pulses producing countries in the world. However, about 2-3 million tonnes of pulses are imported annually to meet the domestic consumption requirement. Thus, there is need to increase production and productivity of pulses in the country by more intensive interventions. In order to increase production further there is no other option except to increase

productivity by using available resources most efficiently. Water and crop geometry are the most important resources and inputs, which have great influence on the productivity of pigeonpea. Any strategy to make suitable adjustment in these two vital inputs will go a long way in enhancing the productivity of pigeonpea. Among the different agronomic practices, optimum plant population is an important non cash input, which claim a paramount importance in determination of maximum yield potential of a pigeonpea. Groundnut plays an important role in the oil economy of the world. In India, groundnut is producing on 5.94 M ha area with a production of 7.53 million tonnes (Anonymous, 2011). During *Kharif* season it accounts for more than 80 % of the total groundnut production. Due to *rainfed* cultivation by resource poor, small and marginal farmers, productivity has been exhibiting large year to-year fluctuations. The crop occupies a prominent place in several cropping systems such as sequential, multiple and intercropping. According to Sampath Kumar *et al.* (2010) groundnut has gaining importance in intercropping system due to its short duration and photo insensitivity. Water is primary input in enhancing crop production as it is directly or indirectly involved in all the physiological process in plants. In the zone of low and erratic rainfall in Maharashtra and Karnataka state, the lack of adequate water on a continuous basis is a serious obstacle to stable pigeonpea yields (Reddy and Virmani, 1980). Studies on water requirement of pigeonpea shows that "the term drought tolerance in pigeonpea refers only to survival" for obtaining a yield, water is important, particularly after flowering (Sinha, 1980). If scarce irrigation resources are to be optimally allocated among the competing crops, proper quantification of water requirement and irrigation schedules in relation to crop yield is needed. Further, to overcome this situation there is need to adopt pigeonpea based intercropping with optimum density along with drip irrigation facilities in *rainfed* situation. Therefore, present investigation was conducted to compare water and crop geometry management with optimum plant population in order to find out most effective interopping combination.

Material and Methods

The present investigation was carried out at AICRP on Groundnut, Scheme under Cotton Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri. The soil of the experimental field was clay in texture, low in available nitrogen (171 kg ha^{-1}), medium in available phosphorous (14.1 kg ha^{-1}) and rich in available potassium (458 kg ha^{-1}). Soil was slightly alkaline in reaction (pH 8.1) and electric conductivity was 0.28 dSm^{-1}. The experiment was laid out in Strip Plot Design with four replications. The treatment were comprised with two irrigation methods *viz.,* surface irrigation (at 80mm CPE) and drip irrigation (CPE at 4 days interval) and six crop geometries *viz.,* Sole Pigeonpea (90cm x 30cm), Sole Groundnut (30cm x 10cm), Pigeonpea (180cm x 30cm) + Groundnut (30cm x 10cm) 1:5 ratio, Pigeonpea (180cm x 60cm) + Groundnut (30cm x 10cm) 1:5 ratio, Pigeonpea (90-180cm x 30 cm) + Groundnut (30cm x 10cm) 2:5 ratio and Pigeonpea (90cm-180cm x 60cm) + Groundnut (30cm x 10cm) 2:5 ratio. The crop was fertilized as per the treatment with application of urea, diammonium phosphate and vermicompost at the time of sowing. Other cultural operations were done as per university recommendation and crop requirements. Finally the crop was harvested and produce was threshed, cleaned, dried and weighed. The data were analysed statistically following the procedure given by Gomez and Gomez (1984). Critical differences were worked out at five per cent probability level wherever the treatments were significant. The treatment differences that were non-significant were denoted as NS.

Results and Discussion

Performance of pigeon pea

Effect of Irrigation methods

Yield contributing attributes were found significant except pods $plant^{-1}$ and 100 seed weight due to drip irrigation during both the years. Whereas, number of pods $plant^{-1}$ were not influenced significantly due to drip irrigation during both the

years. Though number of pods plant^{-1} were not found significant during both the years due to drip irrigation it was compensated by increase in number of seeds pod^{-1} during 2010 and 2011 over surface. Further, it was noticed that increase in yield due to irrigation was correlated with increase in the number of pods plant^{-1}, seeds pods^{-1}, seed weight and 100 seed weight. These results are in collaborative with those reported by Sinha (1980), Mahalaxmi *et. al.,* (2011) and Saritha *et. al.,* (2012).

Seed and stick yield was influenced significantly due to drip irrigation during 2010 and 2011. Drip irrigation recorded the highest seed yield (23.80 q ha^{-1}) over surface irrigation (22.70 ha^{-1}). During second year, the highest yield was recorded with drip irrigation (23.89 q ha^{-1}) over surface (22.81 q ha^{-1}). Similar trend was observed in case of stick yield higher stick yield was recorded under drip irrigation over surface irrigation. These results are inline with those reported by Sinha (1980), Mula *et al.* (2011) and Mahalaxmi *et. al.,* (2011).

Effect of crop geometry

The treatment C_4-PP (180 x 60 cm)+ GN(30 x 10 cm)1:5 registered significantly higher number pods plant^{-1}, seed weight plant^{-1}and 100 seed weight than rest of the treatments. Similar results were reported by Mula *et. al.,* (2011). The significantly higher seed and stick yields was recorded in treatment C_1-Sole Pigeonpea (90 x 30 cm) than rest of the treatments during both the years. Similar results were reported by Mula *et. al.,* (2011) and Saritha *et. al.,* (2012).

Performance of ground nut

Effect of irrigation Methods

Number of aerial pegs plant^{-1}and number of undeveloped pods at harvest were recorded significantly lesser with drip irrigation. Significantly higher number of developed pods at harvest was recorded with drip irrigation. The total number of pods plant^{-1} at harvest was not differed significantly due to irrigation methods during both the years. Significantly higher dry pod weight and higher kernel weight plant^{-1} at harvest were recorded with drip irrigation. Similar results were observed with test weight, significantly higher test weight (g) at harvest were recorded with drip irrigation. Stress during pod development was most detrimental to all physiological and biochemical processes. These results are inline with those reported by Thorat (2002). The pod and haulm yields were differed significantly due to irrigation methods during both the years. Significantly higher dry pod yield and haulm yield was recorded with drip irrigation. These results are in collaborative with those reported by Sripunitha *et., al.* (2011).

Effect of crop geometry

There was no any significant difference was found in case of aerial pegs, number of undeveloped pods, number of developed pods, total number of developed pods and dry pod weight plant^{-1} at harvest during both the years of experimentation. The kernel weight plant^{-1} influenced significantly due to crop geometry during both the years. There was no any significant difference was found in case of test weight at harvest during both the years. Significantly higher kernel weight plant^{-1} was recorded in treatment C_2-Sole Groundnut (30 x 10 cm) (10.38 g) than rest of the treatments. The significantly higher dry pod yield was recorded in treatment C_2-Sole Groundnut (30 x 10 cm) (16.30 q ha^{-1}) than rest of the treatments. The dry haulm yield influenced significantly due to crop geometry during both the years. During 2010, significantly higher dry haulm yield was recorded in treatment Sole Groundnut (30 x 10 cm) (33.74 q ha^{-1}) than rest of the treatments. Similar results were reported by Rao and Mittra (1994).

Land equivalent ratio

The land equivalent ratio was higher in surface irrigation methods in comparison with drip irrigation during both the years.The treatment C_3-PP (180 x 30 cm) + GN (30 x 10 cm) 1:5 registered higher land equivalent ratio (1.57 and 1.56) during both the years.

Economic studies

The higher seasonal cost was recorded under drip irrigation during both the years. The drip irrigation recorded significantly higher gross

monetary returns over surface irrigation during both the years. The irrigation methods brought about significant differences in respect of net seasonal income. The surface irrigation recorded significantly higher net seasonal income over drip irrigation. The B:C ratio was higher in surface irrigation methods over drip irrigation during both the years.The higher seasonal cost was recorded in treatment C_2-Sole Groundnut (30 x 10 cm). The significantly higher gross and net monetary returns and B:C ratio was recorded in treatment C_3-PP (180 x 30 cm)+ GN(30 x 10 cm)1:5 over rest of the treatments. Similar results were reported by Hulihalli (1987).

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Table 1: Yield contributing characters of pigeon pea as influenced by different treatments

Treatments	2010				2011			
	Pods plant^{-1}	Seeds pod^{-1}	Seed weight plant^{-1} (g)	100 seed weight (g)	Pods plant^{-1}	Seeds pod^{-1}	Seed weight plant^{-1} (g)	100 seed weight (g)
Irrigation Methods								
I_1-Surface irrigation	362.53	3.65	128.94	9.74	385.61	3.71	142.25	9.94
I_2-Drip irrigation	382.66	3.76	144.24	9.96	403.41	3.87	158.48	10.11
S.Em±	8.52	0.01	2.71	0.05	5.85	0.02	3.43	0.05
CD at 5%	NS	0.08	12.20	0.22	NS	0.12	15.42	NS
Crop Geometry								
C_1-Sole Pigeonpea (90 x 30 cm)	211.87	3.66	75.92	9.79	225.82	3.74	84.15	9.95
C_2-Sole Groundnut (30 x 10 cm)	--	--	--	--	--	--	--	--
C_3-PP (180 x 30 cm) + GN (30 x 10 cm)1:5	350.58	3.76	129.74	9.85	374.20	3.81	143.48	10.05
C_4-PP (180 x 60 cm) + GN (30 x 10 cm)1:5	537.49	3.81	203.40	9.94	588.00	3.83	226.98	10.09
C_5-PP (90-180 x 30 cm) + GN (30 x 10 cm) 2:5	295.46	3.62	104.67	9.80	309.64	3.77	116.74	10.00
C_6-PP (90-180 x 60 cm) + GN (30 x 10 cm) 2:5	467.58	3.68	169.21	9.87	474.89	3.79	180.47	10.04
S.Em±	11.88	0.05	4.00	0.02	8.18	0.031	2.25	0.02
CD at 5%	36.63	NS	12.33	0.06	24.66	NS	6.95	0.07
Interaction								
S.Em±	13.88	0.05	4.19	0.04	15.77	0.06	6.19	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
General mean	372.60	3.71	136.59	8.95	328.76	3.79	150.36	0.96

Table 2: Yield attributing characters of groundnut as influenced by different treatments

Treatments	Number of aerial pegs plant^{-1}		Number of undeveloped pods plant^{-1}		Number of developed pods plant^{-1}		Total number of pods plant^{-1}		Dry pod weight plant^{-1} (g)		Kernel weight plant^{-1} (g)		100 kernel Weight (g)	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Irrigation Methods														
I_1-Surface irrigation	8.33	10.69	9.44	12.69	32.18	35.72	41.62	48.41	13.80	14.88	9.29	10.06	38.39	39.71
I_2-Drip irrigation	7.73	9.12	8.60	11.14	34.32	38.77	42.92	49.91	14.89	15.85	10.07	10.74	40.99	42.10
S.Em±	0.10	0.13	0.12	0.16	0.42	0.46	0.55	0.63	0.17	0.18	0.12	0.12	0.49	0.51
CD at 5%	0.49	0.62	0.54	0.76	1.93	2.09	NS	NS	0.80	0.85	0.54	0.57	2.21	2.30
Crop Geometry														
C_1-Sole Pigeonpea (90 x 30 cm)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
C_2-Sole Groundnut (30 x 10 cm)	7.48	9.20	8.39	10.81	35.89	39.28	44.28	50.09	15.14	15.93	10.38	11.19	40.56	41.72
C_3-PP (180 x 30 cm) + GN (30 x 10 cm) 1:5	8.07	9.43	8.74	12.25	33.50	36.68	42.23	48.93	14.10	15.42	9.41	10.25	39.70	41.08
C_4-PP (180 x 60 cm) + GN (30 x 10 cm) 1:5	7.98	10.03	8.84	11.62	34.39	38.33	43.23	49.94	15.31	16.48	10.34	11.11	39.95	41.62
C_5-PP (90-180 x 30 cm) + GN (30 x 10 cm) 2:5	8.43	10.73	9.68	12.62	30.55	35.11	40.22	47.72	13.23	14.36	8.86	9.59	39.08	39.83
C_6-PP (90-180 x 60 cm) + GN (30 x 10 cm) 2:5	8.20	10.16	9.48	12.29	31.92	36.86	41.40	49.15	13.95	14.63	9.38	9.88	39.17	40.28
S.Em±	0.28	0.35	0.32	0.43	1.19	1.32	1.51	1.75	0.50	0.54	0.34	0.36	1.41	1.46
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.05	1.13	NS	NS
Interaction														
S.Em±	0.18	0.23	0.20	0.27	0.80	0.89	1.01	1.16	0.35	0.37	0.23	0.25	0.92	0.96
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	**8.03**	**9.91**	**9.02**	**11.92**	**33.25**	**37.25**	**42.27**	**49.16**	**14.35**	**15.36**	**9.68**	**10.40**	**39.69**	**40.91**

Table 3: Seed, stick yield and seed equivalent yield (q ha^{-1}) of pigeonpea as influenced by different treatments

Treatments	Seed yield (q ha^{-1})		Stick yield (q ha^{-1})		Pod yield (q ha^{-1})		Haulm yield (q ha^{-1})	
	2010	2011	2010	2011	2010	2011	2010	2011
Irrigation Methods								
I_1-Surface irrigation	20.70	22.81	31.19	34.67	11.46	12.06	24.00	25.57
I_2-Drip irrigation	23.80	23.89	37.27	41.09	12.14	13.03	26.08	28.03
S.Em±	0.30	0.33	0.59	1.12	0.11	0.11	0.23	0.25
CD at 5%	1.36	1.52	2.65	5.07	0.50	0.53	1.07	1.14
Crop Geometry								
C_1-Sole Pigeonpea (90 x 30 cm)	26.73	29.84	53.93	57.09	--	--	--	--
C_2-Sole Groundnut (30 x 10 cm)	--	--	--	--	16.30	17.32	33.74	36.29
C_3-PP (180 x 30 cm) + GN (30 x 10 cm)1:5	22.70	25.29	32.81	35.43	11.64	12.37	24.52	26.30
C_4-PP (180 x 60 cm) + GN (30 x 10 cm)1:5	17.89	20.01	24.38	27.95	12.27	13.04	26.08	28.04
C_5-PP (90-180 x 30 cm) + GN (30 x 10 cm) 2:5	24.32	27.24	34.10	40.34	9.14	9.72	19.71	21.00
C_6-PP (90-180 x 60 cm) + GN (30 x 10 cm) 2:5	19.62	21.00	25.93	28.59	9.65	10.26	21.15	22.37
S.Em±	0.55	0.44	1.75	1.28	0.13	0.14	0.29	0.31
CD at 5%	1.70	1.38	5.40	3.96	0.42	0.45	0.90	0.96
Interaction								
S.Em±	0.64	0.86	2.72	1.42	0.24	0.26	0.52	0.55
CD at 5%	1.98	2.67	NS	4.37	NS	NS	NS	NS
General mean	**22.25**	**24.67**	**34.23**	**37.88**	**11.80**	**12.54**	**25.04**	**26.80**

Table 4: Seasonal cost, Gross monetary returns, Net Seasonal Income, B:C ratio and LER as influenced by different treatments

Treatments	Seasonal Cost (Rs. ha^{-1})		Gross Monetary Returns (Rs. ha^{-1})		Net Seasonal Income (Rs.ha^{-1})		B: C ratio		LER	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Irrigation Methods										
I_1-Surface irrigation	28423	30922	88445	107494	60022	91886	2.17	2.54	1.31	1.31
I_2-Drip irrigation	45661	42964	99117	122336	53456	95246	1.20	1.69	1.30	1.28
S.Em±	--	--	600	1038	600	1108	--	--	--	--
CD at 5%	--	--	2699	4670	2699	NS	--	--	--	--
Crop Geometry										
C_1-Sole Pigeonpea (90 x 30 cm)	33784	20696	90938	116106	57154	95410	1.81	2.66	1.00	1.00
C_2-Sole Groundnut (30 x 10 cm)	42247	44746	52271	59054	10023	14307	0.29	0.36	1.00	1.00
C_3-PP (180 x 30 cm) + GN (30 x 10 cm) 1:5	36555	39054	113310	139336	76755	100281	2.23	2.67	1.57	1.56
C_4-PP (180 x 60 cm) + GN (30 x 10 cm) 1:5	36555	39054	99088	121363	62533	82309	1.84	2.25	1.43	1.43
C_5-PP (90-180 x 30 cm) + GN (30 x 10 cm) 2:5	36555	39054	110635	138008	74080	98953	2.15	2.64	1.47	1.48
C_6-PP (90-180 x 60 cm) + GN (30 x 10 cm) 2:5	36555	39054	96443	115623	59888	76569	1.78	2.10	1.33	1.30
S.Em±	--	--	1754	1784	1754	3516	--	--	--	--
C.D.at 5%	--	--	5288	5378	5288	10597	--	--	--	--
Interaction										
S.Em±	--	--	2022	2950	2022	3989	--	--	--	--
CD at 5%	--	--	6096	8892	6096	12026	--	--	--	--
General mean	**44451**	**44331**	**93781**	**12312**	**56739**	**77972**	**1.68**	**2.11**	**--**	**--**