Research Article

Studies on Water Use by Soybean and Pigeon Pea Intercropping System Grown under South Eastern Rajasthan

Harphool Meena[1]*, Rajendra K. Yadav[1], Manoj[2], Uditi Dhakar[3], Chaman K. Jadon[1], Pratap Singh[1], R. S. Narolia[1], Rakesh K. Bairwa[4], Shankar Lal Yadav[1] and Madhu Lata Bhaskar[1]

[1]Agricultural Research Station (Agriculture University), Kota (Raj.)-324001
[2]Departemnt of Soil Science and Agricultural Chemistry, SKNAU, Jobner (Raj.)-303328
[3]College of Agriculture (Agriculture University), Kota (Raj.)-324001
[4]Krishi Vigyan Kendra (Agriculture University), Kota (Raj.)-324001

Abstract

An experiment conducted during three consecutive years of *kharif* (2014 to 2016) at Agricultural Research Station-Ummedganj, Agriculture University, Kota (Rajasthan) on soybean + pigeon pea intercropping system. The experiment consisted of ten treatment combinations *viz*. two irrigation regimes (irrigation at 60 % depletion of ASM- available soil moisture and rainfed) and five intercropping system (soybean + pigeon pea (4:2), soybean + pigeon pea (2:3), soybean + pigeon pea (3:2), sole soybean and sole pigeon pea) were under taken in split plot design with four replications. Pooled data of three years revealed that, significantly higher soybean equivalent yield (1701 kg/ha) was recorded under soybean + pigeonpea (4:2) intercropping system, but it was found at par with soybean + pigeon pea (3:2) intercropping system (1626 kg/ha) over soybean + pigeon pea (2:3), sole soybean and sole pigeon pea. The maximum water use efficiency (26.78 kg/ha-cm) was observed under soybean + pigeon pea (4:2) intercropping system over soybean + pigeon pea (2:3), sole soybean and sole pigeon pea. However, it was found at par with soybean + pigeon pea (3:2) intercropping system (25.27 kg/ha-cm). The maximum net return (Rs.38503/-) and B: C ratio (1.83) were observed under soybean + pigeon pea (4:2) intercropping system over soybean + pigeon pea (2:3), sole soybean and sole pigeon pea. However, it was found at par with soybean + pigeon pea (3:2) intercropping system. Soybean equivalent yield, water use efficiency, net returns and B:C ratio were not significantly influenced by irrigation regimes.

Keywords: Intercropping system, irrigation regimes, soybean, pigeon pea and water use efficiency

***Correspondence**
Author: Harphool Meena
Email: hpagron@rediffmail.com

Introduction

Soybean (*Glycine max* (L.) Merrill) has paramount importance in human and animal nutrition, because it is a major source of edible vegetable oil and high protein feed as well as food in the world. Soybean is considered as miracle crop because it contains 38-42 per cent good quality protein, 23 per cent carbohydrates, 18-20 per cent oil, rich in poly unsaturated fatty acids, good amount of minerals and vitamins especially B-complex and tocopherols. It provides high amounts of phyto-chemicals and good quality dietary fibre which enables to protect human body against cancers and diabetes [1]. Pigeon pea (*Cajanus cajan* (L) Mill sp.) is an important pulse crop in India. Early and medium duration varieties of pigeon pea have carved a niche and are intercropped with soybean, where soybean completes its life cycle before the grand growth period of pigeon pea, being a deep-rooted crop may also withstand effectively under drought encountered at later stages of its growth [2]. However, medium duration pigeon pea, which at present covers a large area in intercropping systems on vertisols of the semi-arid tropics of central India, suffer from lack of water during the reproductive phase resulting in reduced yields.

Agriculture is largest user of water, consuming more than 80 per cent of the country exploitable water resources. It is estimated that the allocation is to be reduced to 71 per cent in the next two decades. Development of appropriate water management technologies to maximize the crop productivity per drop of water is the need of the hour [3]. Increased water uses efficiency of crops can be possible through appropriate irrigation scheduling by providing only the water that match the crop evapotranspiration and irrigating at critical growth stages [4]. Regulated irrigation under intercropping system are very promising when the optimum irrigation scheduling is identified for the crop at particular agro-climatic zone. Irrigation schedules can be classified as full and deficit irrigation, on basis of plant, soil, and climatic conditions [5].

Intercropping is the practice of growing two or more crops together in a single field it is very productive and remunerative system to get higher crop production with proper land utilization. The main purpose of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop efficiently. Legume intercropping systems play a significant role in the efficient utilization of resources. Cereal-legume intercropping is a more productive and profitable cropping system in comparison with solitary cropping [6]. The main subject of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs including labours [7].

Materials and Methods

An experiment was conducted on soybean + pigeon pea intercropping system during *kharif* season 2014 to 2016 at Agricultural Research Station, Ummedganj, Kota (Rajasthan). In Rajasthan, this region falls under Agro-climatic zone-v humid south eastern plain zone of Rajasthan. This zone possesses typical sub-tropical conditions with maximum and minimum temperatures ranged between 34.2°C to 38.0°C and 18.6°C to 24.0 °C during *kharif* season. The average amount of rainfall received during crop growing seasons was 840 mm. The soil of experimental site was clay loam in texture, slightly saline in reaction. The experimental soil was medium in available nitrogen (264 kg ha^{-1}) and phosphorus (21.7 kg ha-1) while high in potassium (388 kg ha-1) and sufficient in DTPA extractable micronutrients with pH (7.61) and EC (0.52 dS m^{-1}). Source of nutrients applied were urea for nitrogen, DAP for phosphorus and mutate of potash for potassium. The total quantity of recommended dose of fertilizer was applied before sowing of crop as basal dose.

The experiment consisted of ten treatment combinations *viz*. two irrigation regimes (irrigation at 60 % depletion of ASM- available soil moisture and rainfed) and five intercropping system (soybean + pigeon pea (4:2), soybean + pigeon pea (2:3), soybean + pigeon pea (3:2), sole soybean and sole pigeon pea) were under taken in split plot design with four replications. The row ratio was maintained during sowing of intercrops, between row to row spacing was 30 cm. During *kharif* seasons 2014 and 2015 irrigation were not applied, because available soil moisture depletion was not reached at 60 % and one irrigation was also applied during *kharif* season 2016 at 60 % available soil moisture depletion due to early onset of monsoon. The data of soybean equivalent yield, water use efficiency, net returns and B: C ratio were recorded as per standard procedures and also statistically analysed by adopting appropriate method of standard analysis of variance [8].

Crop equivalent yield (CEY) was calculated by following formula:

$$CEY = \frac{\text{Intercrop yield (kg ha}^{-1}\text{) x Price of intercrop yield (Rs. kg}^{-1}\text{)}}{\text{Price of main crop (Rs. kg}^{-1}\text{)}}$$

Irrigation water use efficiency was estimated as the ratio of seed yield (kg/ha) and irrigation water applied (mm) based on below formula.

$$WUE = \text{Seed yield (kg/ha)} / \text{Irrigation water applied (mm)}$$

Results and Discussion

Effect of irrigation regimes and intercropping system on soybean equivalent yield

A perusal of data presented in **Table 1** showed that the irrigation regimes did not significantly influence soybean equivalent yield during *kharif* 2014 and 2015 as well as in the pooled analysis. Under application of irrigation regime at 60 % available soil moisture depletion was recorded significantly higher soybean equivalent yield (1676 kg/ha) over rainfed (1417 kg/ha) during *kharif* 2016. The significantly higher soybean equivalent yield (1701 kg/ha) was recorded under soybean + pigeon pea (4:2) intercropping system as compared to soybean + pigeon pea (2:3), sole soybean and sole pigeon pea (1403, 1383 and 1236 kg/ha) soybean equivalent yield, respectively. However, it was found at par with soybean + pigeon pea (3:2) intercropping system soybean equivalent yield (1626 kg/ha) in the pooled analysis.

The higher yield of mungbean under pigeon pea + mungbean (1:2) inter cropping systems was obtained because of a greater number of mungbean rows and reduced competition between and within crop plants due to more availability of space [9]. It might be due to synergistic effect of component crop. Similar results were obtained by [10] and [11]. Under scheduling of irrigation at 75 % CPE with sole crop of pigeon pea was recorded significantly higher seed yield as compared to control [12].

Table 1 Effect of irrigation regimes and intercropping system on soybean equivalent yield, water use efficiency and monetary returns

Treatment	Soybean equivalent yield (kg/ha)				WUE (kg/ ha-cm)				Net returns (Rs./ha)				B:C ratio			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled	2014	2015	2016	Pooled
A. Irrigation regimes																
Irrigation at 60 % depletion of ASM	1417	1448	1676	1514	24.73	26.52	19.01	23.42	26417	30343	40034	32265	1.30	1.49	1.93	1.57
Rainfed (Control)	1416	1442	1417	1425	24.72	26.42	17.24	22.79	26404	30140	30847	29130	1.30	1.48	1.51	1.43
SEm ±	46	31	29	32	0.80	0.57	0.34	0.52	1512	1081	1037	1113	0.07	0.05	0.05	0.052
CD (P=0.05)	NS	NS	129	NS	NS	NS	1.52	NS	NS	NS	4664	NS	NS	NS	0.23	NS
B. Intercropping system																
Soybean + Pigeon pea (4:2)	1649	1677	1778	1701	28.78	30.71	20.84	26.78	33617	37895	43398	38503	1.62	1.82	2.06	1.83
Soybean + Pigeon pea (2:3)	1348	1380	1482	1403	23.52	25.27	17.36	22.05	24148	27980	33081	28403	1.19	1.38	1.61	1.39
Soybean + Pigeon pea (3:2)	1573	1601	1703	1626	27.44	29.32	19.96	25.57	31693	35835	41232	36253	1.57	1.77	2.02	1.78
Sole Soybean	1332	1357	1459	1383	23.25	24.85	17.09	21.73	22573	26095	31185	26618	1.05	1.22	1.44	1.23
Sole Pigeon pea	1183	1212	1313	1236	20.64	22.19	15.38	19.40	20023	23403	28310	23912	1.05	1.23	1.47	1.25
SEm ±	81	66	63	65	1.41	1.22	0.74	1.03	2666	2327	2262	2225	0.13	0.12	0.11	0.11
CD (P=0.05)	236	194	185	188	4.11	3.55	2.17	3.01	7780	6792	6601	6495	0.38	0.34	0.33	0.32

Effect of irrigation regimes and intercropping system on water use efficiency

The pooled data presented in Table 1 showed that the water use efficiency did not significant influence during *kharif* 2014 and 2015 under irrigation regimes. The application of irrigation at 60 % available soil moisture depletion was recorded higher water use efficiency (19.01 kg/ha-cm) over rainfed (17.24 kg/ha-cm) during *kharif* 2016. The water use efficiency (26.78 and 25.57 kg/ha-cm) were found at par under soybean + pigeon pea (4:2) and soybean + pigeon pea (3:2) intercropping system, but it was found significantly superior over soybean + pigeon pea (2:3), sole soybean and sole pigeon pea (22.05, 21.73 and 19.40 kg/ha-cm), respectively.

Among the cropping systems, soybean + pigeon pea intercropping (4:2) row proportions recorded significantly higher water use efficiency as compared to rest of intercropping systems. This might be due to higher soybean equivalent yield of both the component crops under intercropping system. Under scheduling of irrigation at 50 % CPE was recorded significantly higher water use efficiency under intercropping system. The results are in arrangement with finding of [13], [14] and [15].

Effect of irrigation regimes and intercropping system on monetary returns

It is evident from pooled data presented in Table 1 showed that the application of irrigation regimes under soybean + pigeon pea intercropping system had no significant effect on monetary returns during *kharif* 2014 and 2015. The application of irrigation at 60 % available soil moisture depletion was recorded higher net returns (Rs.40034/- ha^{-1}) and B: C ratio (1.93) over rainfed (Rs.30847/- ha^{-1}) and B: C ratio (1.51) during *kharif* 2016. The maximum net returns (Rs.38503/- ha^{-1}) and B: C ratio (1.83) were observed under soybean + pigeon pea (4:2) intercropping system over soybean + pigeon pea (2:3) (Rs.28403/- ha^{-1} and 1.39), sole soybean (Rs.26618/- ha^{-1} and 1.23) and sole pigeon pea (Rs.23912/- ha^{-1} and 1.25), respectively. However, it was found at par with soybean + pigeon pea (3:2) intercropping system net returns (Rs.36253/- ha^{-1}) and B:C ration (1.78) in the pooled analysis.

The pigeon pea + mungbean intercropping system fetched higher gross returns, net return as well as B:C ratio than sole pigeon pea [16]. This might be due to higher seed yield of pigeon pea and additional yield of mungbean, which resulted in higher net return in pigeon pea + mungbean cropping systems than in sole pigeon pea. Under irrigation scheduling at 0.8 IW/CPE ratio recorded significantly higher net returns and B:C ratio in urdbean was reported by [17]. Similar results were also reported by [18] in clusterbean and [19] in chickpea intercropping system.

Conclusion

It is concluded that the three years pooled data gave significantly higher soybean equivalent yield, water use efficiency and monetary return under soybean + pigeon pea (4:2) intercropping system. Hence this intercropping system is proved as productive and beneficial to the farmers for obtaining higher returns under south eastern Rajasthan.

References

[1] Chouhan, G.S. 2007. Soybean [*Glycine max* (L.) Merrill] products and their export potential. Green Farming 1: 55-57.

[2] Kumar Rao, J.V.D.K., Johansen, C., Chauhan, Y.S., Jain, V.K., Jain, K.C. and Talwar, H.S. 2001. An analysis of yield variation among long duration pigeonpea genotypes in relation to season, irrigation and plant population. *Journal of Agriculture Science 136*: 291-299.

[3] Kumar, V., Sharma, A., Soni, J.K. and Pawar, N. 2017. Physiological response of C3, C4 and CAM plants in changeable climate. *The Pharma Innovation* 6:70.

[4] Deng, X.P., Shan, L., Zhang, H. and Turner, N. 2006. Improving agricultural water use efficiency in arid and semiarid areas of China. *Agriculture Water Management* 80:23- 40.

[5] Fabeiro, C., De Santa Olalla, F. and De Juan, J. 2002. Production of muskmelon (*Cucumis melo* L.) under controlled deficit irrigation in a semi-arid climate. *Agriculture Water Management* 54:93-105.

[6] Evans, J., Mcneill, A.M., Unkovich, M.J., Fettell, N.A., and Heenan, D.P. 2001. Net nitrogen balances for cool-season grain legume intercropping and contributions to wheat nitrogen uptake: A review. *Australian Journal of Experimental Agriculture* 41:347-359.

[7] Marer, S.B., Lingaraju, B.S. and Shashidhara, G.B. 2007. Productivity and economics of maize and pigeon pea intercropping under rainfed condition in northern transitional zone of Karnataka. *Karnataka Journal of Agriculture Science* 20:1-3.

[8] Gomez, K. A. and Gomez, V.A. 1984. Statistical Procedure for Agriculture Research. John Wiley and Sons Inc., New York, USA.

[9] Bishnoi, K.C., Singh, B. and Singh, A. 1987. Studies on compatibility of mungbean and urdbean cultivars in pigeon pea based intercropping systems. *Indian Journal of Agronomy* 32: 127-129.

[10] Kumar, S., Singh, R.C. and Kadian, V.S. 2005. Compatibility of pigeon pea and mungbean intercropping systems in relation to row ratio and row spacing. *Legume Research* 28: 213-215.

[11] Kumar, P., Rana, K.S. and Rana, D.S. 2012. Effect of planting systems and phosphorus with bio-fertilizers on the performance of sole and intercropped pigeon pea (*Cajanus cajan* L.) under rainfed conditions. *Indian Journal of Agronomy* 57: 127-132.

[12] Mahalakshmi, K., Avil, K. K., Reddy, M. D. and Uma, D. M. 2011. Response of *rabi* pigeon pea [*Cajanus cajan* (L.)] to different levels of drip irrigation. *Journal Research* ANGRAU 39:101-103.

[13] Jadhav, K. T., Chavan, A. S., Raskar, S. K. and Lahase, R. U. 2018. Influence of spacing and drip irrigation on yield attributes, productivity and economics of pigeon pea (*Cajanus cajan* L.). *International Journal of Current Microbiology and Applied Sciences* 7: 3498-3506.

[14] Muniyappa, Mudalagiriyappa, Ramachandrappa, B. K., Nagaraju and Sathish, A. 2017. Studies on the influence of depth and interval of drip irrigation on yield, water use efficiency and economics of chickpea (*Cicer arietinum* L.). *International Journal of Pure and Applied Bioscience* 5: 771-776.

[15] Ranjitha, P. S., Ramulu, V., Jayasree, G. and Reddy, S. N. 2018. Growth, yield and water use efficiency of groundnut (*Arachis hypogaea*) under drip and surface furrow irrigation. *International Journal of Current Microbiology and Applied Sciences* 7: 1371-1376.

[16] Kantwa, S. R., Ahlawat, I. P. S. and Gangaiah, B. 2005. Performance of sole and intercropped pigeon pea (*Cajanus cajan* L.) as influenced by land configuration, post monsoon irrigation and phosphorus fertilization. *Indian Journal of Agriculture Science* 76: 635-637.

[17] Kumbhar, N. M., Patel, J. S., Gediya, K. M., Suryawanshi and Patel, C. J. 2015. Influence of irrigation

scheduling (IW/CPE) and sulphur on yield of urdbean (*Vigna mungo* L.). *Madras Agriculture Journal* 95: 57-60.

[18] Deewan, P., Regar, K. L., Jajoriya, M., Meena, M. and Verma, R., 2017. Influence of irrigation scheduling and plant growth regulators on quality, yield and economics of summer clusterbean (*Cyamopsis tetragonoloba* L.) under middle Gujarat conditions. *International Journal of Chemical Studies* 5: 467-471.

[19] Pramod, M. C., Arun, B. K., Pankaj, U. R. and Sanjay, S. C. 2006. Effect of intercropping of pigeon pea, sorghum and cotton on productivity and yield advantages of soybean (*Glycine max* L.) under rainfed condition. *International Journal of Agriculture Science* 2: 478-479.

Publication History

Received	11.02.2023
Revised	02.05.2023
Accepted	03.05.2023
Online	31.05.2023