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Jitendra Singh
Assistant Professor, College of Agricultural Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

Supriya
Assistant Professor, College of Agricultural Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

Shakuli Saxena
Assistant Professor, College of Agricultural Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

P Mishra
Assistant professor, College of Agriculture, JNKVV, Powarkheda, Hoshangabad, Madhya Pradesh, India

RB Singh
Professor, Department of Mathematics and Statistics, College of Agricultural, JNKVV, Jabalpur, Madhya Pradesh, India

Correspondence
Jitendra Singh
Assistant Professor, College of Agricultural Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

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Effect of fertigation doses and amount of water applied on the growth and yield of pigeon pea (*Cajanus Cajan*) CV. PUSA 992

Jitendra Singh, Supriya, Shakuli Saxena, P Mishra and RB Singh

Abstract
Field experiments were carried out during kharif seasons (July-November) of 2015 at PFDC, Water Technology Centre to study the effect of fertigation doses and amount of water applied on the growth and yield of pigeonpea (*Cajanus Cajan*) cv. PUSA 992. The treatments consists of three main plots (100% RDF, 80% RDF, 60 % RDF) with water soluble fertilizer (WSF) through drip and three sub-plots (100 %, 80 %, 60 % computed water requirement of crop) and control (flood irrigation). The treatments were laid out in Split plot Design with three replications. The results revealed that drip irrigation at 100 % WRc with fertigation at 100 % RDF through WSF registered significantly highest grain yield. Surface irrigation with conventional method of fertilizer application recorded lower water use efficiency and lower yield. The increase in grain yield with drip irrigation at 100 % WRc + fertigation with 100 % RDF through WSF was mainly attributed by greater and consistent availability of soil moisture and nutrients which resulted in better crop growth, yield components and ultimately reflected on water use efficiency and yield of pigeonpea Cajanus cajan.

Keywords: pigeonpea, drip fertigation, available soil nutrient, nutrient uptake, yield attribute and yield

Introduction

Pulses are major sources of proteins among the vegetarians in India, and complement the staple cereals in the diets with proteins, essential amino acids, vitamins and minerals. They contain 22-24% protein, which is almost twice the protein in wheat and thrice that of rice. Pulses provide significant nutritional and health benefits, and are known to reduce several non-communicable diseases such as colon cancer and cardiovascular diseases (Yude *et al.*, 1993; Jukanti *et al.*, 2012) [3, 19]. Pulses can be grown on range of soil and climatic conditions and play important role in crop rotation, mixed and inter-cropping, maintaining soil fertility through nitrogen fixation, release of soil-bound phosphorus, and thus contribute significantly to sustainability of the farming systems. Pigeonpea is the most widely grown crop in the country and has been under cultivation for over three thousand years. Pigeonpea is mainly consumed in the form of split pulse as dhal, which is an essential supplement of cereal based diet. In India, pulses production has been hovering around 13.5 -15.0 million tonnes during the last decade, while annual domestic demand is 18-19 million tonnes. Pigeonpea is grown on an area of about 3.25 million hectares with the production of 2.23 million tonnes in the country. The national productivity of pigeonpea is only 678 kg per hectare. It is second most important crop after chickpea among different pulse crops grown in the country. One of the main reason attributed is non-availability of adequate quantity of quality seeds to produce adequate pulses. The availability of adequate, timely and assured supply of water is an important determinant of agricultural productivity. Agriculture is by far the largest (81%) water consumer in India and hence more efficient use of water in agriculture needs to be the top most priority (INCID, 2006) [4].

Surface drip irrigation and fertigation are important key factors that will decide the seed production at larger extent in India and world in future water conservation and fertigation will result in saving of precious foreign exchange. Drip fertigation thus offers the scope to increase the seed yield per unit area, save time and result in quality seed production through precise application of water and fertilizers at the critical stages and prevent the vagaries caused by environmental stress. When fertilizer is applied through drip, it is observed that 30 per cent of the fertilizer could be saved as compared to broadcast or band placement.

Fertigation is a relatively new but revolutionary concept in applying fertilizer through irrigation as it helps to achieve both fertilizer-use efficiency and water-use efficiency. When fertilizer is applied through drip, it is observed that 30% of the fertilizer could be saved (Sivanappan and Ranghaswami, 2005) [14].

The efficient use of fertilizers is necessary for optimum growth and yield. Hence knowledge about the availability of nutrients in the soil is very essential. For scheduling a fertilizer programme, analysis of plant nutrient status has been found useful to prevent the deficiency or excess of nutrient effects in any horticultural crops. The concentration and uptake of nutrient in plant varies with the age of the crop, season, plant parts, stage of the crop and cultivars. Plant analysis serves as an elegant tool for understanding the growth and physiology of the plant at various phases of its growth (Hartz and Hochmuth, 1996) [5].

Adoption of surface drip fertigation system may also help in increasing yields and quality parameters of pigeon pea due to improved irrigation, nutrients and energy use efficiencies. Keeping these considerations in view, the present study was undertaken to estimate the 'Effect of fertigation doses and amount of water applied on the growth and yield of pigeonpea (Cajanus Cajan) cv. PUSA 992'.

Material and Methods

The present investigation entitled "Effect of fertigation doses and amount of water applied on the growth and yield of pigeonpea (Cajanus Cajan) cv. PUSA 992"was conducted at PFDC Field at Water Technology Centre in Indian Agricultural Research Centre during the *kharif* season of 2014 and 2015. The soils of the experimental fields were analyzed for their physico-chemical properties and are also presented in Table 1 along with the site characteristics. The details of materials used and methods employed during the course of investigation are being described in this chapter.

Seeds were treated with carbendazim followed by bacterial inoculation with rhizobium and then sown in line over the raised bed of 75 cm width at the spacing of 60x20 cm. Surface drip fertigation with RDF (25:50:25 NPK kg ha^{-1} in two splits, which was used as base for calculating the fertigation schedule. The fertigation was done once in six days starting from 15 DAS to 90 DAS in three consecutive steps such as wetting the root zone before fertigation, fertigating the field and flushing the nutrients with water. The assessment of growth characteristics was done in each experimental plot; ten plants were selected at random and tagged for recording biometric observations.

Table 1 Characteristics of the study area

S. No.	Parameter	Value
01	Texture	Sandy loam
02	pH (1:2.5)	7.50
03	EC (dS/m)	0.35
04	Organic Carbon %	0.38
05	Available N (kg/ha)	281.75
06	Available P (kg/ha)	25.68
07	Available K (kg/ha)	285.49

Table 2: Treatment Structure

Treatment details	
T1	100 % RDF through WSF with 100 % Water Requirement
T2	100 % RDF through WSF with 80 % Water Requirement
T3	100 % RDF through WSF with 60 % Water Requirement
T4	80 % RDF through WSF with 100 % Water Requirement
T5	80 % RDF through WSF with 80 % Water Requirement
T6	80 % RDF through WSF with 60 % Water Requirement
T8	60 % RDF through WSF with 100 % Water Requirement
T9	60 % RDF through WSF with 80 % Water Requirement
T10	60 % RDF through WSF with 60 % Water Requirement
Control	Flood Irrigation

Aberrations: RDF: Recommended doses of fertilizer, WSF: Water soluble fertilizer

After harvesting of crop, soil samples were collected from each treament. Available nitrogen in soil was determined by the procedure outlined by Subbiah and Assija (1956). Available phosphorus in the soil was extracted by 0.5 M Sodium bicarbonate ($NaHCO_3$) adjusted to pH 8.5 and P in the aliquot was determined by Ascorbic acid method (*Olsen et al.*; 1954). Available K was extracted by 1*N* neutral ammonium acetate as an extractant, (Hanway and Heidel, 1952) and K in the extract was determined by Flame photometer. Plant sample were analyzed for total N, P, K. The total N content was estimated through Automatic N analyzer using 0.2 gm grounded samples. For P and K analysis, plant samples were wet digested in di acid mixture. P was determined by Vanadomolybidosphosphoric yellow colour method (Jackson, 1973), K by Flame Photometer (Jackson, 1973).

Harvest index (HI) %

Harvesting Index was calculated by dividing the grain yield with above-ground biomass and multiplying by 100. HI=grain yield (kg)/ above-ground biomass (kg) × 100

Statistical analysis

Statistical analyses of the data were carried out according to Split plot design. The experimental data were pooled and the mean data for two years are subjected to statistical scrutiny as per methods suggested by Gomez and Gomez (1984). All the parameters were subjected to analysis of variance (ANOVA) and the data were analyzed using statistical software. Fisher's Least Significant Difference (LSD) was used to test the significant differences between the means, at probability level $P \leq 0.05$ using the ANOVA. The non-significant treatment differences were denoted as NS

Results and Discussion

Content and uptake

Data pertaining on the nitrogen, phosphorus and potassium content and uptake of grain during 2014-2015 are given in Table. Data in Table 3 indicated that the different treatment combinations had significantly influence on N concentration grain in PUSA 992 verities of pigeon pea. The N concentration of grain varied from 3.08 to 2.43 %during 2014 and 2015 (Table 3). The highest grain N concentration 3.08

%, 2.73% was observed in treatment 100 % RDF with water soluble fertilizer in both year, respectively. Similar results were observed by Rahman *et al*. 2005. The range of N uptake by grain was 73.49 to 40.18 kg/ha. The highest N uptake (73.49, 65.16 kg/ha) by grain was obtained in treatment 100 % RDF with water soluble fertilizer in both year, respectively. Similar, results are found in phosphorus and potassium content and uptake during both the years.

Application of 100 % RDF with WSF recorded highest content and uptake of NPK. Uptake of nutrients was maximum with 100% RDF followed by 80% RDF. Thus, plants might have developed extensive rooting patterns even under deeper layers and were able to absorb higher quantity of nutrients (Sharma and Abrol 2007). Overall it is concluded that application of 100% RDF with 100% WRc is highly beneficial for pigeon pea in medium fertile alluvial sandy loam soils of northern plains zone of India.

Table 3: Effect of fertigation doses and amount of water applied on the content of NPK and uptake of pigeon pea crop

Treatments	Content %						Uptake (kg/ha)					
	Nitrogen		Phosphorus		Potassium		Nitrogen	Phosphorus		Potassium		
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
100%RDF	3.08	2.73	0.85	0.84	1.81	1.81	73.49	65.16	20.41	20.07	43.20	43.18
80%RDF	2.88	2.68	0.84	0.82	1.78	1.74	63.61	59.16	18.62	18.15	39.19	38.39
60%RDF	2.83	2.72	0.83	0.78	1.74	1.71	58.57	56.28	17.15	16.21	36.09	35.30
Control	2.48	2.43	0.79	0.78	1.65	1.63	40.18	43.56	14.05	11.64	31.05	28.65
CD	0.03	0.02	0.08	0.02	0.08	0.024	7.75	2.09	0.47	0.84	0.94	1.39
100%WR	3.01	2.75	0.860	0.87	1.793	1.820	70.71	64.52	20.16	20.48	42.05	42.68
80%WR	2.92	2.70	0.83	0.81	1.767	1.753	65.84	60.75	18.59	18.25	39.74	39.47
60%WR	2.86	2.68	0.84	0.76	1.777	1.680	59.13	55.34	17.43	15.70	36.72	34.73
CD	0.02	0.05	0.05	0.07	0.05	0.08	11.02	2.04	0.26	0.32	0.56	0.62

Table 4: Effect of fertigation doses and amount of water applied on the content of NPK and uptake of pigeon pea crop

Treatments	Plant Height (cm)		Green Seeker		Chlorophyll meter		Branches/plant		Yield (kg/ha)		Biological yield (kg/ha)		Harvest Index (%)	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
100%RDF	203.33	203.00	0.81	0.79	411.42	419.79	17.00	17.00	2382.26	2610.7	8116.68	8120.02	29.209	32.46
80%RDF	200.33	197.00	0.77	0.76	389.08	392.72	15.33	15.67	2206.60	2545.7	7899.38	7961.87	28.253	31.64
60%RDF	193.00	194.33	0.73	0.73	375.59	380.83	15.00	15.00	2066.04	2333.3	7555.55	7816.72	26.422	29.82
Control	188.75	189.56	0.65	0.66	315.29	318.77	13.55	13.85	1829.49	1956.4	6478.2	6879.2	23.20	25.72
CD	1.34	1.672	0.02	0.02	4.86	5.97	0.37	0.29	29.45	28.0	27.68	31.97	0.25	0.24
100%WR	198.33	198.00	0.81	0.78	407.23	416.97	17.00	16.67	2342.77	2636.3	8012.764	8168.793	29.33	31.954
80%WR	195.33	193.33	0.76	0.78	389.00	392.04	15.33	16.00	2247.22	2520.3	7947.65	7931.71	27.92	32.08
60%WR	191.55	190.77	0.75	0.72	379.87	384.33	15.00	15.00	2064.90	2333.0	7811.20	7798.12	26.63	29.90
CD	0.85	0.76	0.01	0.01	2.88	3.15	0.19	0.25	25.24	28.0	27.68	31.97	0.25	0.24

Higher yields were obtained with the application of phosphorus 100% RDF with 100% WRc. The concentration and availability of various nutrients in the soil for plant uptake depends on the soil solution phase which is mainly determined by soil moisture availability. The higher available soil moisture provided due to continuous water supply under drip fertigation had led to higher availability of nutrients in the soil and thereby increased the nutrient uptake by the crop. The increased nutrient uptake under drip fertigation was the result of increased biomass production due to continuous availability of water and nutrients to the crop. The increased uptake may also be due to split application of N and K under drip fertigation that resulted in minimal loss of nutrients thereby making them available continuously to the crop. The application of fertilizer through drip fertigation than soil application produced significantly higher yield (Tumbare *et al*., 1999) [18]. Higher yield under fertigation is due to more nutrient uptake, fertilizer utilization efficiency and percentage of nutrient derived from fertilizer as compared with soil application (Mohammad, 2004) [10]. Similar findings of higher nutrient uptake with drip fertigation of nutrient were reported by Bharambe *et al*. (1997) [2] and Veeraputhiran (2000) [17].

Growth and attribute yield

Higher frequency of irrigation and increased availability of soil moisture under drip irrigation might have led to effective uptake and utilization of available nutrients and better proliferation of roots resulting in quick canopy growth reported by Mahesh R. (2009) [9], Sivanappan RK, and Ranghaswami MV (2005) [14].

Branching is an important growth phase in cultivation of pigeon pea. The number of branches produced and their survival reflects on the total number of flowers initiated, pods at harvest which ultimately determine crop fecundity and seed yield. Similar results were found by Prabhu T. (2006) [11] who reported that drip fertigation of 100% RDF as water soluble fertilizer with micronutrients *viz*., $ZnSO_4$, $FeSO_4$ as foliar spray registered the highest values for morphological characters.

Generally the pigeon pea yield increased with increase in fertilizer level (Table 4). Drip fertigated pigeon pea at 100% RDF with WSF recorded significantly higher grain yield of 25.26 and 27.29 q/ha during 2014-2015. Application of water soluble fertilizer also influenced the grain yield of pigeon pea compared to straight fertilizer. In this present investigation, drip fertigation with 100% RDF in WSF increased the grain yield. The increase in yield under 100% RDF with WSF might be due to the fact that fertigation with more readily available form obviously resulted in higher availability of all the three (NPK) major nutrients in the soil solution which led to higher uptake and better translocation of assimilates from source to sink thus in turn increased the yield. Iqbal *et al*., (2003) [7] reported that application of DAP at the lower rate (33 kg P /ha) through fertigation resulted in almost the same wheat grain yield as obtained by the higher dose (44 kg P /ha) applied by broadcast method. The highest number of fruits plant 1 under liquid fertilizer treatments could be due to continuous supply of NPK from the liquid fertilizers as reported by Kadam and Karthikeyan (2006) [8] in tomato. Hebbar *et al*., (2014) [6] reported that fertigation with normal fertilizer gave significantly lower yield compared to fertigation with water soluble fertilizers. This was attributed to complete solubility and availability of the water soluble fertilizer as compared to normal fertilizer. Water soluble fertilizer had higher concentration of available plant nutrient in top layer (Selva Rani, A., 2009) [13].

Water Use Efficiency (WUE)
The water saving under drip irrigation was due to low application rate at frequent intervals matching the actual crop water needs at various stages. Drip fertigation at 100 per cent RDF recorded higher WUE followed by fertigation at 80 per cent RDF as WSF (Fig.1). WUE was higher under drip fertigation treatments compared to surface irrigation method. The increase in WUE in all drip irrigated treatments over surface irrigation was mainly due to considerable saving of irrigation water, greater increase in yield of crops and higher nutrient use efficiency. This was in agreement with Ramah (2008) [12]. Ardell (2006) [1] reported that application of N and P fertilizer increases crop yields, thereby increasing crop water use efficiency. Adequate levels of essential plant nutrients are needed to optimize crop yields and WUE

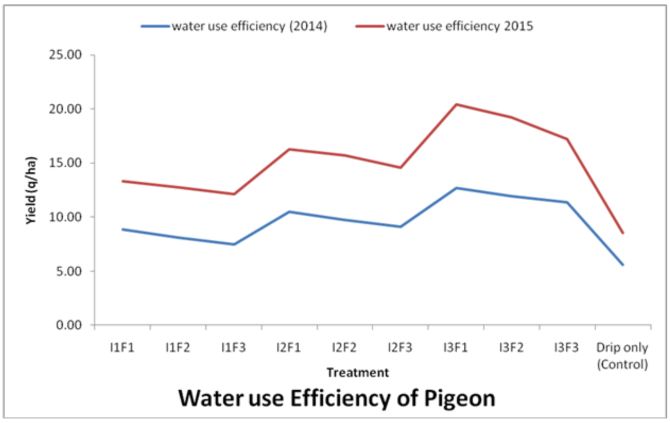

Fig 1: Effect of Fertigation doses and amount of water applied on yield and water use efficiency (WUE)

Conclusion
Based on the present findings it is inferred that drip fertigation has a decisive role in determining the yield, which intern influence the yield attributing characters of pigeon pea crop in both years. Thus, the study highlighted that that the fertigation with 100% of RDF as WSF proved better than other treatments.

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