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Effect of drip fertigation on nutrient uptake and seed yield of pigeonpea [*Cajanus Cajan* (L.) Millsp.] under westeren agroclimatic zones of Tamil Nadu

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ABSTRACT

Field experiments were conducted at Agricultural College and Research Institute, Coimbatore during August to February of 2011-12 and 2012-13 to study the effect of drip irrigation, fertigation levels and frequencies on seed yield and nutrient uptake of pigeonpea. Three fertilizer levels (75 %, 100 % and 125 % recommended dose fertilizer (RDF) through water soluble fertilizer and conventional fertilizers), three irrigation levels (50 % computed water requirement of crop (WRc), 75 % WRc and 100 % WRc) and surface irrigation (IW/CPE ratio 0.6 with 100 per cent RDF through conventional fertilizer) were included as treatments in this study. Application of 100 per cent of RDF (WSF) once in 7 days along with 100 % WRc (T_9) recorded significantly higher uptake of total nitrogen, phosphorus and potassium. The lowest plant nutrient uptake was recorded by surface irrigation with application of 100 % RDF (T_{14}) applied as basal. The results revealed that application of nutrients through fertigation once in seven days with 125 % RDF (WSF) + irrigation 100 % WRc recorded higher total nutrient uptake (nitrogen, phosphorus and potassium) than surface irrigation with conventional fertilizer.

Key words: Nitrogen, Nutrient content, Phosphorus, Potassium, Uptake, Yield.

INTRODUCTION

Drip fertigation is a highly efficient method for fertilizer application, minimize losses and adverse environment impact on crop production. Both water and nutrients applied through fertigation will be used by the plants for photosynthesis finally enabling plants to produce new tissues which have influence on growth and production of crops.

Pulses occupy 53.23 million hectare area and contribute 43.29 million tonnes to world's food basket. India shares 37.91 per cent area and 63.36 per cent of the global production (FAOSTAT, 2012). In India, pulses are grown over an area of 22-24 million hectares with a production of 13-15 m.t. Pigeonpea [*Cajanus cajan* (L.) Millsp.] is nutritionally well balanced and is an excellent source of proteins (20–30%) (Snapp *et al*., 2003). In addition to proteins, pigeonpea provides carbohydrates and high levels of vitamins A and C. In India pigeonpea is grown in an area of 4.37 m.ha, with a production of 2.65 m.t and the average productivity is 655 kg ha^{-1} (FAOSTAT, 2012). In Tamil Nadu, pigeonpea is cultivated in an area of 35,800 hectare with a production of 31,300 tonnes with an average productivity of 662 kg ha^{-1}. Pigeonpea has good yield potential but production and productivity is very low because in most of the region it is cultivated as rainfed crop. Among the different production factors, irrigation and nutrient management are of immense importance. The low yield of pigeonpea is not only because of its cultivation in marginal lands, but also because of inadequate soil moisture and imbalanced fertility (Saritha *et al*., 2012).

For proper utilization of nutrients, its time of application should coincide with the demand of the crop. So application of nutrients in split doses will not only prevent nutrient losses but also will increases in efficiency. Application of adequate amount of nutrients is usually associated with increased yield and protein content of pigeonpea (Brar and Imas, 2010).

Pulses can meet their own nitrogen requirement by symbiotic fixation of atmospheric nitrogen. However, a starter dose of nitrogen and adequate amount of phosphorus are considered as essential for obtaining optimum yield. Phosphorus is one of the most important nutrients needed by legumes and it is referred as key nutrient in crop production due to its several vital functions. It affects seed germination, cell division, flowering, fruiting, synthesis of fat, starch and biochemical activity. Potassium is known to play a vital role in osmoregulation and activation of several enzymes. Besides this, it helps the plant to adapt under terminal moisture stress/abiotic stresses mostly experienced during reproductive stage. Potassium is involved in many physiological processes which affect crop quality, it activates more than 60 enzymes systems, aids photosynthesis, favours high energy status, regulates opening of leaf stomata, maintains cell turgor, promotes water uptake, regulates

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nutrient translocation, favours carbohydrate transport and hence enhance protein and starch synthesis (Brar and Imas, 2010). Pigeonpea under drip irrigation with 0.8 Epan throughout the crop period recorded higher plant height (61.6 cm), LAI (2.04) and total dry matter production (3731 kg ha^{-1}) at harvest stage (Mahalakshmi *et al.*, 2011). Whereas in direct sown pigeonpea (CO 6) at single row per lateral with 10 split application of N and K through drip fertigation + 100 per cent WRc recorded the highest grain yield (1486 kg ha^{-1}), net income and B:C ratio over different spacing in transplanted pigeonpea in the Western Zone of Tamil Nadu (Latha *et al*., 2012). In view of this, the present experiment was undertaken to assess the effect of drip fertigation on nutrient uptake and seed yield of pigeonpea.

MATERIALS AND METHODS

Field experiments were conducted during August-February of 2011-12 and 2012-13 at Tamil Nadu Agricultural University, Coimbatore in sandy clay loam soil. The experiments were laid out in a randomized block design with fourteen treatments and three replications. The treatments include combination of water and nutrients levels. Three irrigation regimes *viz*., 50 %, 75 %, 100 % computed water requirement of the crop (WRc) along with surface irrigation and three fertilizer levels (with conventional fertilizers and water soluble fertilizers) formed the treatment combinations.

The treatments were as follows; T_1- 50 % WRc + 75 % recommended dose of fertilizers (RDF-25:50:25 kg NPK ha^{-1}) through water soluble fertilizers (WSF),T_2- 75 % WRc + 75 % RDF (WSF), T_3- 100 % WRc + 75 % RDF (WSF), T_4- 50 % WRc + 100 % RDF (WSF), T_5-75 % WRc + 100 % RDF (WSF), T_6- 100 % WRc + 100 % RDF (WSF),T_7- 50 % WRc + 125 % RDF (WSF), T_8- 75 % WRc + 125 % RDF (WSF), T_9- 100 % WRc + 125 % RDF (WSF), T_{10}- 50 % WRc + 100 % RDF through conventional fertilizers (CF), T_{11}- 75 % WRc + 100 % RDF (CF), T_{12}- 100 % WRc + 100 % RDF (CF) ,T_{13}- 100 % WRc (Drip) + 100 % RDF (conventional fertilizers as basal) and T_{14}- Surface irrigation at 0.6 IW/CPE ratio with irrigation water of 50 mm throughout crop life + 100 % RDF through conventional fertilizers application of entire dose of fertilizer as basal application. The initial soil available nutrient status was low (226 kg ha^{-1}), medium (18 kg ha^{-1}) and (429 kg ha^{-1}) for nitrogen, phosphorus and potassium, respectively and the initial soil pH, organic carbon and EC were 7.55, 0.51 per cent and 0.78 d sm^{-1} respectively. The field capacity and permanent wilting point were 26.75 and 12.5 %, respectively. The fertigation was scheduled based on the nutrient assimilation curve. The weekly interval fertigation was followed evenly for drip fertigation treatments (Table 1). Whereas for treatments T_{10}, T_{11} and T_{12} source of fertilizer was conventional where fertilizer phosphorus was applied as basal and nitrogen and potassium were applied as split doses, in the treatment T_{13} N, P and K were applied as basal surface irrigation with IW/CPE ratio of 0.6.

The recommended dose of fertilizer was 25:50:25 N, P_2O_5 and K_2O respectively supplied through conventional and water soluble fertilizers. For this experiment the pigeonpea variety LRG 41, obtained from Agricultural Research Station, Lam centre, Andhra Pradesh was used. Seeds were sown with spacing 150 x 60 cm (150 cm between lateral and 60 cm in between the emitter). Drip irrigation was scheduled once in seven days by calculating computed water requirement of crop (WRc). Surface irrigation was given based on IW/CPE ratio of 0.6.

The plant samples collected for recording dry matter production were chopped into pieces, dried (65 $\pm$ 5æ%C) ground into fine powder (Willey mill) and analysed for total nitrogen, phosphorus and potassium. The methods used were micro-kjeldahl method (Humphries, 1956), tri-acid digestion method (Jackson,1973) and flame photometery method (Jackson,1973) for total nitrogen, phosphorus and potassium, respectively. The uptake values obtained as percentage in the analysis were computed to kg ha^{-1} by multiplying with corresponding total dry matter production. The data collected on various aspects related to the study were subjected to statistical analysis by Analysis of Variance (ANOVA) method as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant NPK uptake: Drip irrigation and fertigation levels had positively influenced the plant nutrient uptake of pigeonpea. The data on nutrient uptake at 60, 90, 120 DAS and at harvest stage data's are represented in the Tables 2 and 3.

Table 1: Fertigation schedule for long duration pigeonpea cv. LRG 41 at 100 % RDF through water soluble fertilizers

Stage	Duration (Days)	Number of applications (splits)	Application time (DAS)	Nutrient supplied (%)			Quantity of nutrients fertilizer grade (kg)		
				N	P_2O_5	K_2O	Urea	MAP	SOP
Seedling	1-30	3	10, 17 and 24	20	40	0	2.32	32.78	0
Vegetative	31-90	9	31, 38, 45, 52, 59, 66, 73, 80 and 87	30	30	25	9.87	24.58	12.5
Flowering	91-120	4	94, 101, 108 and 115	30	30	40	9.87	24.58	20
Pod development	121-140	3	122, 129 and 136	20	0	35	10.85	0	17.5
			Total	100	100	100	32.91	81.94	50

Table 2: Effect of drip irrigation and fertigation levels on total phosphorus uptake of pigeonpea at 60 and 90 DAS

Treatments	Total Nutrient uptake (kg ha^{-1})											
	60 DAS						90 DAS					
	N		P		K		N		P		K	
	I	II	I	II	I	II	I	II	I	II	I	II
T_1 - 50 % WRc + DF at 75 % RDF (WSF)	34.0	28.0	3.15	2.58	19.2	16.2	66.3	47.0	11.37	8.28	68.1	44.7
T_2 - 75 % WRc + DF at 75 % RDF (WSF)	36.7	29.4	3.30	2.70	19.5	16.8	67.4	49.2	11.98	9.65	70.3	46.3
T_3 - 100 % WRc + DF at 75 % RDF (WSF)	37.7	30.5	3.59	2.82	20.4	17.5	72.3	50.7	12.13	10.29	73.0	47.0
T_4 - 50 % WRc + DF at 100 % RDF (WSF)	41.2	31.6	3.63	2.97	21.3	18.0	80.7	52.4	12.29	10.59	75.4	50.2
T_5 - 75 % WRc + DF at 100 % RDF (WSF)	43.4	32.7	3.72	3.12	23.5	20.7	85.2	60.1	13.49	11.21	86.6	55.1
T_6 - 100 % WRc + DF at 100 % RDF (WSF)	50.0	41.4	4.27	3.57	25.7	22.9	89.4	64.8	15.61	12.14	94.3	58.3
T_7 - 50 % WRc + DF at 125 % RDF (WSF)	41.6	33.1	3.63	3.07	22.2	18.9	83.2	57.6	13.63	11.29	79.8	53.7
T_8 - 75 % WRc + DF at 125 % RDF (WSF)	45.7	35.6	4.07	3.34	23.9	21.8	86.3	66.8	14.82	11.51	90.5	60.0
T_9 - 100 % WRc + DF at 125 % RDF (WSF)	53.9	45.1	4.69	3.62	26.6	24.5	94.6	69.6	16.07	12.73	98.7	62.5
T_{10} - 50 % WRc + DF at 100 % RDF (CF*)	35.2	27.2	3.08	2.40	18.3	16.2	62.6	44.6	10.99	7.29	65.8	45.4
T_{11} - 75 % WRc + DF at 100 % RDF (CF*)	36.3	28.6	3.28	2.57	19.7	16.6	63.1	46.1	11.18	8.07	68.7	46.9
T_{12} - 100 % WRc + DF at 100 % RDF (CF*)	37.2	29.2	3.33	2.69	20.0	17.0	64.1	47.3	11.34	8.23	70.5	48.0
T_{13} - 100 % WRc + 100 % RDF (CF- all basal)	34.8	26.9	3.05	2.42	19.0	15.9	62.5	46.6	10.71	7.49	66.6	44.6
T_{14} - Surface irrigation +100 % RDF (CF- all basal)	32.8	26.1	2.96	2.39	17.7	15.7	61.1	44.3	10.47	7.27	63.2	43.5
SEd	2.3	2.1	0.26	0.22	1.15	0.84	3.3	2.2	0.72	0.65	4.51	2.54
CD(P=0.05)	4.7	4.3	0.54	0.47	2.37	1.73	6.7	4.6	1.49	1.24	9.27	5.22

I- 2011-12; II-2012-13; WRc – computed water requirement of crop; RDF – Recommended dose of fertilizers (25:50:25 NPK kg ha^{-1})
*P as basal; N and K through drip. WSF – Water soluble fertilizers; CF- Conventional fertilizers ; DAS – days after sowing

Table 3: Effect of drip irrigation and fertigation levels on total nutrient uptake of pigeonpea at 120 DAS and at harvest

Treatments	Total Nutrient uptake (kg ha^{-1})											
	120 DAS						At harvest					
	N		P		K		N		P		K	
	I	II	I	II	I	II	I	II	I	II	I	II
T_1 - 50 % WRc + DF at 75 % RDF (WSF)	89.0	80.8	21.8	17.5	90.4	72.4	104.0	89.5	24.4	20.0	110.2	89.2
T_2 - 75 % WRc + DF at 75 % RDF (WSF)	90.3	83.7	22.9	17.6	91.1	73.3	108.3	93.5	25.5	20.3	113.5	92.0
T_3 - 100 % WRc + DF at 75 % RDF (WSF)	93.8	87.8	23.5	19.7	95.3	78.6	109.5	96.2	26.8	21.5	118.1	97.5
T_4 - 50 % WRc + DF at 100 % RDF (WSF)	96.1	91.5	23.7	20.3	99.7	83.7	113.0	98.9	26.6	22.0	126.9	99.2
T_5 - 75 % WRc + DF at 100 % RDF (WSF)	99.8	94.2	24.8	21.0	114.4	92.2	133.8	107.5	31.4	24.7	136.0	109.0
T_6 - 100 % WRc + DF at 100 % RDF (WSF)	112.1	98.7	27.3	22.1	122.9	100.3	153.1	121.3	34.6	28.0	146.0	125.4
T_7 - 50 % WRc + DF at 125 % RDF (WSF)	98.5	95.6	23.9	19.7	103.2	87.7	121.3	108.2	28.5	22.6	130.7	102.9
T_8 - 75 % WRc + DF at 125 % RDF (WSF)	102.4	97.0	25.3	21.1	113.2	94.4	137.4	114.2	32.4	26.3	139.0	112.3
T_9 - 100 % WRc + DF at 125 % RDF (WSF)	116.3	108.4	28.4	23.5	127.9	105.9	157.3	126.0	36.5	29.5	155.2	128.4
T_{10} - 50 % WRc + DF at 100 % RDF (CF*)	82.4	73.9	19.8	16.2	84.1	72.2	96.8	84.0	23.8	18.5	103.5	86.3
T_{11} - 75 % WRc + DF at 100 % RDF (CF*)	83.2	76.6	20.7	16.8	88.2	73.8	100.5	86.8	24.5	19.2	108.6	85.7
T_{12} - 100 % WRc + DF at 100 % RDF (CF*)	87.9	78.3	21.0	17.4	89.5	75.5	102.8	91.4	25.5	20.2	111.4	89.6
T_{13} - 100 % WRc + 100 % RDF (CF- all basal)	83.2	74.1	18.9	16.8	84.4	70.2	95.9	83.6	23.2	18.6	103.4	83.9
T_{14} - Surface irrigation +100 % RDF (CF- all basal)	81.0	73.5	18.2	15.3	82.9	68.3	94.6	81.6	22.7	17.4	100.3	82.1
SEd	6.0	5.3	1.4	1.2	4.4	5.0	8.2	5.1	1.5	1.4	7.7	5.5
CD(P=0.05)	12.6	10.8	2.9	2.5	9.0	10.2	17.0	10.6	3.2	2.9	16.0	11.6

I- 2011-12; II-2012-13; WRc – computed water requirement of crop; RDF – Recommended dose of fertilizers (25:50:25 NPK kg ha^{-1})
*P as basal; N and K through drip. WSF – Water soluble fertilizers; CF- Conventional fertilizers ; DAS – days after sowing

Nitrogen uptake: The total nitrogen uptake by pigeonpea varied significantly due to drip irrigation and fertigation levels during the study. Among the treatments, highest total nitrogen uptake of 53.9, 94.6, 116.3, 157.3 kg ha^{-1} (2011-12) and 45.1, 69.6, 108.4, 126.0 kg ha^{-1} (2012-13), respectively at 60, 90, 120 DAS at harvest stages were recorded under drip irrigated crop at 100 % WRc with fertigation at 125 % RDF through WSF and this was comparable with drip irrigation at 100 % WRc along with fertigation at 100 per cent RDF through WSF. Based on the studies of Sheldrake and Narayanan (1979) the nitrogen uptake of pigeonpea is continued throughout the growing period *i.e.*, at initial growth stages (upto 30 DAS) the uptake rate is 27 g/ ha/ day and vegetative stage the uptake rate is high 1716 g/ ha/ day whereas during final stage the nitrogen uptake rate is 267 g/ ha/ day. The nitrogen per cent in stem and leaves declined as the plants developed and there was net mobilization of nitrogen from these organs. Pattern of uptake and remobilization of phosphorus resembled that of nitrogen. Surface irrigated crop with conventional method of fertilizer application recorded lesser than drip fertigated treatments and the total nitrogen uptake (32.8, 61.1, 81.0, 94.6 during 2011-12 and 26.1, 44.3, 73.5, 81.6 kg ha^{-1} during 2012-13) at 60, 90, 120 DAS and at harvest stages, respectively.

Total phosphorus uptake: Higher phosphorus uptake was obtained with drip irrigation at 100 % WRc with fertigation at 125 % RDF through WSF over the rest of the drip fertigation treatments. During both the years of study, surface irrigated crop with conventional method of fertilizer application registered less total phosphorus uptake. Phosphorus is another important nutrient that favours good growth, adequate flowers and proper pod setting and nodule development and usually 30-50 kg P_2O_5 ha^{-1} is necessary to harvest a good crop. Phosphate nutrition to pulses is universally recognized (Majumdar, 2011). Puste and Jana (1995) noted significant increase in nitrogen and phosphorus contents of seeds and uptake of nitrogen and phosphorus by application upto a level of 105 kg P_2O_5 ha^{-1}.

Total potassium uptake: Higher total potassium uptake of 26.6, 98.7, 127.9, 155.2 kg ha^{-1} (2011-12) and 24.5, 62.5, 105.9, 128.4 kg ha^{-1} (2012-13), at 60, 90, 120 DAS and at harvest stages, respectively recorded under drip irrigated crop at 100 % WRc with fertigation at 125 % RDF through WSF and this was comparable with drip irrigation at 100 per cent WRc along with fertigation at 100 % RDF through WSF. The lower values of total potassium uptake were recorded under surface irrigated crop with conventional method of fertilizer application (17.7, 63.2, 82.9, 100.3 kg ha^{-1} during 2011-12 and 15.7, 43.5, 68.3, 82.1 kg ha^{-1} during 2012-13) at 60, 90, 120 DAS and at harvest stages, respectively. Due to improved growth characters, the plants tend to take more nutrients from the soil since it is available nearer to root zone at required level. This was in confirmity with the findings of Black (1969), who reported increased nutrient uptake under high frequency irrigation due to increased plant growth. Higher nutrient uptake by chilli under fertigation was also reported by Tumbare and Nikam (2004). Reducing the fertilizer dose resulted in lower availability of nutrients which might be the reason for lower uptake of nutrients by crop at lower dose of fertilizers (75 %).

In the conventional method of fertilizer application with surface irrigation, nutrients were applied to the top soil layer. This layer was subjected to alternate drying and wetting cycles due to longer irrigation intervals. Low soil-water content as well as higher fixation with soil colloids and lesser mobility had reduced the availability of nutrients. Similar absorption pattern with varying irrigation methods was narrated by Escobar (1995). The cyclic regulation and continuous wetting of soil through drip irrigation maintained optimum moisture in the crop root zone. Due to this, the force exerted by the plant to extract water and nutrients would be less. Further, application of nutrients in more number of splits in drip fertigation resulted in minimum or no wastage of nutrients either through deep percolation or evaporation as reported by Kadam *et al.* (1995) and Rajput and Patel (2002) leading to higher uptake of nutrients. This enabled the crop to put forth better growth, yield attributes and reap bountiful yield.

Grain yield and nutrient uptake: The nutrient uptake of crop was determined from the yield of crop biomass, grain yield and its corresponding nutrient content. Among the drip irrigation and fertigation levels, pigeonpea crop receiving drip irrigation at 100 % WRc with fertigation at 125 % RDF through WSF registered significantly highest grain yield of 2812 and 2586 kg ha^{-1} during 2011-12 and 2012-13, respectively (Fig.1.) by 45 to 47 % higher over surface irrigation method (T_{14}) with recommended dose of fertilizers through conventional method of application (1908 and 1794 kg ha^{-1}). Thus grain yield and drymatter production were highest in drip irrigation at 100 % WRc + fertigation 125 % RDF through water soluble fertilizers. In surface irrigated plots basal application of nutrients shows decreased in percentage of plant nutrient uptake because of leaching and runoff of nutrients.

CONCLUSION

Based on the above experiments, it can be concluded that drip irrigation at 100 % WRc (Computed water requirement of crop) along with fertigation with 125 % RDF through water soluble fertilizers@ once in seven days recorded higher nutrient uptake and resulted in achieving higher grain yield of pigeonpea under drip fertigation.

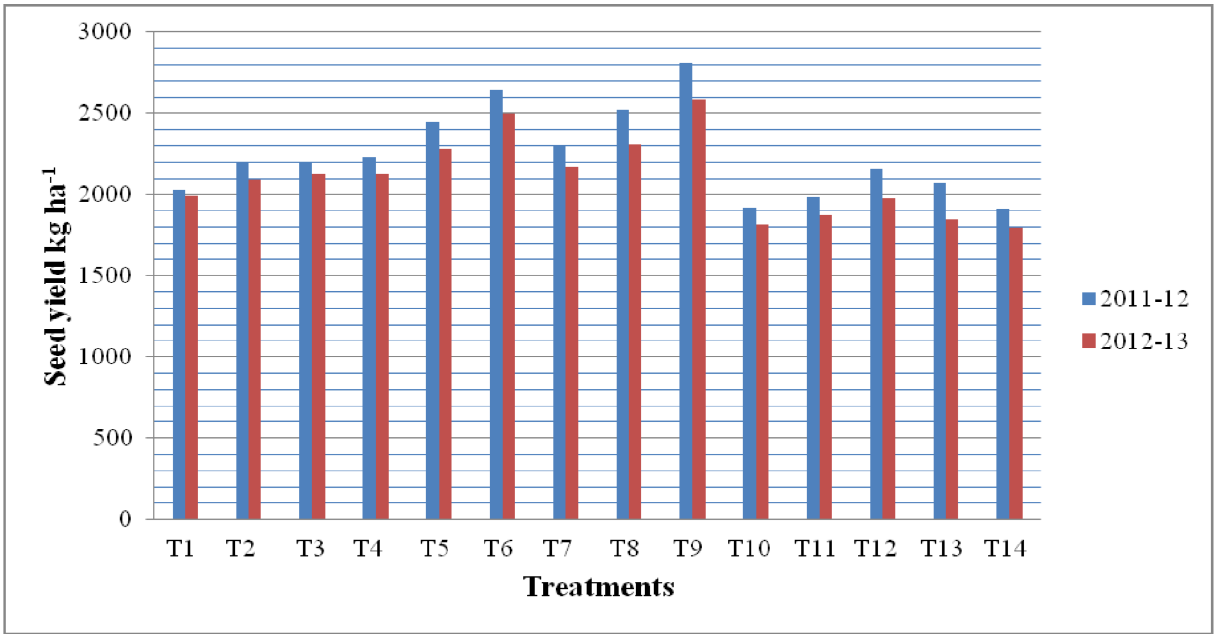

Fig 1: Effect of drip irrigation and fertigation levels on seed yield (kg ha^{-1}) of pigeonpea

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