

Original Research Article

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## Dry matter, Nutrient Uptake and Yield of Short Duration Pigeon pea (*Cajanus cajan* L.) Varieties under Drip Fertigation system

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### ABSTRACT

Field experiment was conducted at Millet Breeding Station, Tamil Nadu Agricultural University, Coimbatore during 2015 and 2016 with the objective of Dry matter, Nutrient uptake and yield of short duration Pigeon pea (*Cajanus cajan* L.) varieties under Drip fertigation system. The experiment was laid out in strip plot design with three replications. The main plot treatments were allotted with three varieties viz., Co (Rg) 7, APK 1 and VBN 3. The sub plot treatments comprised of three drip fertigation levels viz., 75 %, 100 % and 125 % RDF (@ 25:50:25 kg NPK ha<sup>-1</sup>) through WSF with Azophosmet and foliar spray of PPFM and drip fertigation at 100% RDF through WSF alone along with surface irrigation with conventional fertilizers. The effect of varieties and nutrient application methods (drip fertigation and soil application) the highest NPK uptake during *kharif* 2015 and *summer* 2016 (187.32, 17.04, 107.4 and 165.85, 15.9, 95.40 kg ha<sup>-1</sup>) dry matter production of (7042 and 6235 kg ha<sup>-1</sup> during *kharif* 2015 and *summer* 2016). The grain yield 1992 and 1758 kg ha<sup>-1</sup> were significantly observed under drip fertigation with 125% RDF through WSF with Azophosmet and foliar spray of 1% PPFM. Among the pigeonpea varieties, Co (Rg)7 performed well compared to APK 1 and VBN 3 varieties.

#### Keywords

Drip fertigation, Dry matter production, Nutrient uptake rate, Pigeonpea and yield.

#### Article Info

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### Introduction

Pigeonpea is produced in all tropical and semi-tropical regions of the world and grown as an annual or as a perennial crop in 50 countries of Asia, Africa and the Caribbean. In India, pigeonpea is grown in areas lying between 14° and 28° N latitude at which majority of the world's pigeonpea is produced (Prasad *et al.*, 2010). According to FAO statistics, pigeonpea is grown worldwide in an area of 4.23 m.ha. With a production and productivity of 4.68 m.t. and 751 kg ha<sup>-1</sup> respectively. India is the largest producer of pigeonpea accounting for about 80 % of the total world pigeonpea production. In India, it

occupies an area of 3.71 m.ha. with a production and a productivity of 2.78 m.t. and 750 kg ha<sup>-1</sup> respectively (GoI, 2015). The demand for pulses is increasing due to increasing population and hence pigeonpea productivity has to be increased to meet the demand. Drip fertigation is the best option to increase the production and productivity of pigeonpea. Drip fertigation is a recent innovative cultural method, by which fertilizers are applied along with irrigation water through drip system to get higher fertilizer use efficiency besides increasing the crop yields. Pulses are an integral part of

many diets across the globe and they have great potential to improve human health, conserve our soils, protect the environment and contribute to global food security. The United Nations declared 2016 as “International Year of Pulses” (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. The demand for pulses is increasing due to increasing population, and hence to meet the demand, pigeonpea productivity has to be increased. Drip irrigation is a technique which might help in increasing area under irrigation, productivity of crops and increase the water use efficiency (Tarawalie *et al.*, 2012). The method of fertilizer application is very important in obtaining optimal use of fertilizer.

Fertilizers should be applied in a form that becomes available in synchrony with crop demand for maximum utilization of nutrient from fertilizers (Anitta Fanish and Muthukrishnan 2013). This will increase the amount of fertilizer used by the plant and reduce the amount lost by leaching. To meet out the requirement, the only way is to increase the production and productivity for that drip fertigation is the best option. Drip fertigation allows precise timing and uniform distribution of fertilizer nutrients, and is an efficient and agronomically sound method of providing soluble plant nutrients directly to the active plant root zone. Usually optimizing nutrient management with drip irrigation would require that attention be paid to soil nutrient dynamics, crop nutrient requirements, as well as soil and plant monitoring techniques.

### **Materials and Methods**

Field experiment was conducted at Millet Breeding Station at Tamil Nadu Agricultural University, Coimbatore. The location is

geographically situated at 11°N Latitude and 77° E longitude at an Altitude of 426.7 m above MSL.

Each plot was 40 m<sup>2</sup> and contained 8 rows with 28 lines. Paired row planting system was adopted under drip irrigation with spacing of 90/30×30 cm. One lateral with inline dripper (discharge rate @ 4 lph) was laid at the centre of the raised bed and it covered the two rows of pigeonpea. The lateral spacing between two raised flat beds was 1.2 m and furrow in-between with 30 cm width and 15 cm depth. Each treatment was supplied with an independent fertigation system consist of a drip tubes and controlled tapes. A tank filled with fertigation water was placed 1 m above the ground to maintain enough water pressure 1 kg/cm<sup>2</sup>. Surface irrigation was given as and when cumulative pan evaporation (CPE) value reached the level of 83 mm, which is in accordance with IW/CPE ratio of 0.60.

Pigeonpea varieties *viz.* Co (Rg)7 (V<sub>1</sub>), APK1 (V<sub>2</sub>) and VBN3 (V<sub>3</sub>) were selected. As per the treatments schedule, 75 percent of recommended dose of water soluble fertilizers (V<sub>1</sub>F<sub>3</sub>, V<sub>2</sub>F<sub>3</sub> and V<sub>3</sub>F<sub>3</sub>), 100 percent of recommended dose of water soluble fertilizers (V<sub>1</sub>F<sub>2</sub>, V<sub>2</sub>F<sub>2</sub> and V<sub>3</sub>F<sub>2</sub> and V<sub>1</sub>F<sub>4</sub>, V<sub>2</sub>F<sub>4</sub> and V<sub>3</sub>F<sub>4</sub>) and 125 percent of recommended dose of water soluble fertilizers (V<sub>1</sub>F<sub>5</sub>, V<sub>2</sub>F<sub>5</sub> and V<sub>3</sub>F<sub>5</sub>) were applied through the drip as per the fertigation schedule. The recommended doses of inorganic fertilizers @ 25:50:25 NPK kg ha<sup>-1</sup> were applied through drip as per the fertigation schedule in the form of water soluble fertilizers *viz.*, Mono Ammonium Phosphate (12:61 % N and P), Urea (46 % N), Poly feed (19:19:19 % NPK) and Sulphate of potash (50% K). The fertilizer solution was prepared by dissolving the required quantity of fertilizer with water in 1:5 ratio and injected into the irrigation system through venturi assembly. Fertigation interval was scheduled once in 7 days interval. The

recommended doses (25:50:25 NPK kg ha<sup>-1</sup>) of inorganic fertilizers *i.e.*, urea (46 % N), single super phosphate (16 % P<sub>2</sub>O<sub>5</sub>) and muriate of potash (60 % K<sub>2</sub>O) were applied as basal to the surface irrigated treatments (V<sub>1</sub>F<sub>1</sub>, V<sub>2</sub>F<sub>1</sub> and V<sub>2</sub>F<sub>3</sub>) (GOTN, 2012). Plant samples collected for dry matter estimation at 60, 90, 120 DAS and at harvest stages from the respective treatments were oven-dried and finely ground in Willey mill and used for estimating N, P and K content as per the standard procedure. Data were collected for pigeonpea dry matter production, nutrient uptake grain yield and straw yield at harvest stage. The nutrient content uptake values obtained as percentage in the analysis was multiplied by the respective dry matter content for computing N, P and K uptake expressed in kg ha<sup>-1</sup>.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Percentage of nutrient content} \times \text{Total dry matter production (kg ha}^{-1}\text{)}}{100}$$

## Results and Discussion

### Dry matter production

Drip fertigation at 125 per cent RDF through WSF with Azophosmet and 1 % PPFM foliar spray followed by 100 per cent RDF through WSF with Azophosmet and 1 % PPFM foliar spray recorded higher dry matter production (7042 and 6235 kg ha<sup>-1</sup> during *kharif* 2015 and *summer* 2016) as compared to surface irrigation with soil application of fertilizers.

This was mainly due to optimum moisture supply and timely nutrient application which could have enhanced the assimilatory efficiency resulting in increased number of leaves per plant, better branching and LAI which contributed for higher dry matter production as well as promoted the activity of photosynthesis and simultaneous accumulation of dry matter. Similar findings

were recorded in banana for fertigation of 100 per cent RDF through drip as WSF by Sivalingam (2011). As the native soil was low in nitrogen, there was a good response to the excess fertilizer applied, coupled with optimum moisture availability which might have resulted in inducing growth in pigeonpea (Vimalendran, 2013). Dry matter production was favorably influenced by drip fertigation levels as compared to soil application of fertilizers with surface irrigation. Due to excess irrigation in surface irrigation methods, fertilizer nutrients might have been leached beyond the root zone, whereas in drip fertigation, fertilizers were applied through drip irrigation in desired split doses throughout the growing period according to crop requirements, so that the losses were minimized and opportunity was provided to take up more nutrients, which reflected on the higher plant growth rate and DMP Sathiyaraj (2010) (Table 1).

### Yield performance of pigeonpea under different fertigation levels

Grain yield per hectare was significantly influenced by fertigation levels (Table 2). Drip irrigated pigeonpea with WSF recorded significantly higher grain yield during the experiment compared to surface method of irrigation. Among the three short duration pigeonpea varieties, Co (Rg)7 performed well under arid condition compared to APK1 and VBN3. The variety Co (Rg)7 significantly registered highest grain yield of 1650 kg ha<sup>-1</sup>, while APK 1 and VBN 3 registered significantly lower grain yield of 1301 and 1076 kg ha<sup>-1</sup>. Among the drip fertigation levels, drip fertigation at 125 percent RDF through WSF with Azophosmet and foliar spray of PPFM registered significantly the highest grain yield of 1642 kg ha<sup>-1</sup>, which was 74.3 percent yield increase over surface irrigation method with RDF through conventional method of application (942 kg ha<sup>-1</sup>).

**Table.1** Effect of drip fertigation levels on dry matter production and NPK uptake of short duration pigeonpea varieties

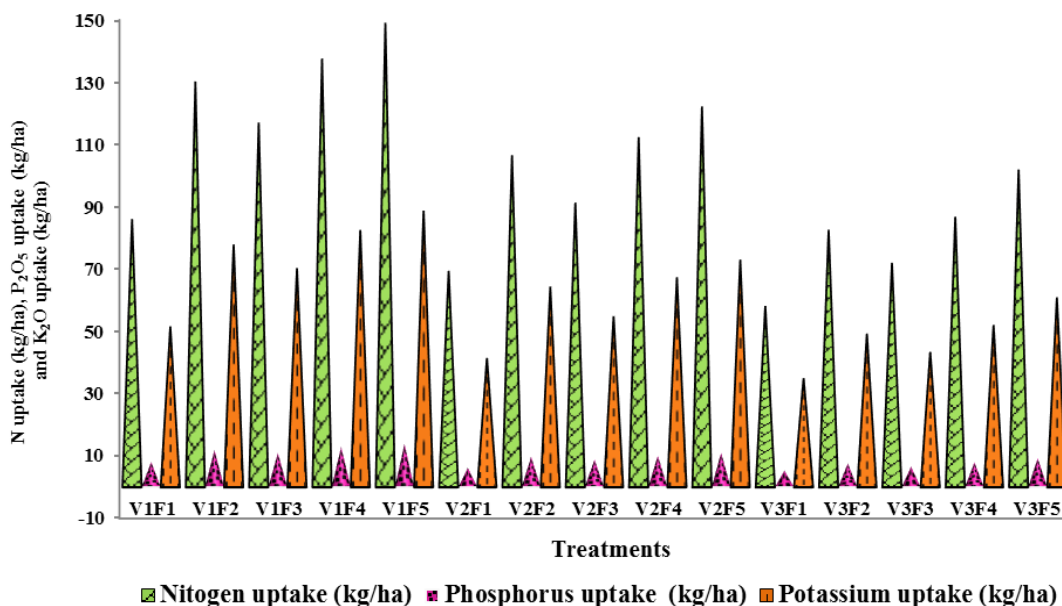
Treatments	2015	2016	2015			2016		
	DMP	DMP	N uptake	P uptake	K uptake	N uptake	P uptake	K uptake
<b>Varieties</b>								
V <sub>1</sub> -Co (Rg) 7	5850	5130	154.17	14.23	88.99	135.21	12.48	78.04
V <sub>2</sub> -APK 1	4665	4154	121.06	11.36	72.46	107.79	10.12	64.53
V <sub>3</sub> -VBN 3	3876	3433	102.17	9.06	61.29	90.48	8.02	54.28
<b>SEd</b>	117	158	3.19	0.33	2.37	2.85	0.29	2.37
<b>CD (0.05)</b>	324	438	8.86	0.91	6.57	7.90	0.80	6.57
<b>Fertigation</b>								
F <sub>1</sub>	3341	2997	87.22	7.93	51.32	78.24	7.11	46.04
F <sub>2</sub>	5053	4478	131.21	12.01	77.77	116.29	10.64	68.94
F <sub>3</sub>	4401	3915	115.03	10.84	68.01	102.32	9.63	60.53
F <sub>4</sub>	5305	4728	139.72	12.75	82.53	124.50	11.36	73.56
F <sub>5</sub>	5886	5079	155.82	14.22	91.62	134.45	12.28	79.02
<b>SEd</b>	117	124	4.02	0.35	2.19	3.83	0.36	2.19
<b>CD (0.05)</b>	270	287	2.27	0.80	5.06	8.82	0.84	5.06
<b>Interaction</b>								
V <sub>1</sub> ×F <sub>1</sub>	4039	3598	106.23	9.57	60.99	94.63	8.53	54.33
V <sub>1</sub> ×F <sub>2</sub>	6149	5352	159.87	14.70	92.85	139.15	12.79	80.82
V <sub>1</sub> ×F <sub>3</sub>	5509	4727	144.89	14.21	83.74	124.32	12.20	71.85
V <sub>1</sub> ×F <sub>4</sub>	6512	5739	172.57	15.63	99.63	152.08	13.77	87.81
V <sub>1</sub> ×F <sub>5</sub>	7042	6235	187.32	17.04	107.74	165.85	15.09	95.40
V <sub>2</sub> ×F <sub>1</sub>	3187	2910	81.91	7.74	49.08	74.79	7.07	44.81
V <sub>2</sub> ×F <sub>2</sub>	5015	4468	129.89	12.04	77.73	115.72	10.72	69.25
V <sub>2</sub> ×F <sub>3</sub>	4220	3830	108.88	10.26	65.41	98.81	9.31	59.37
V <sub>2</sub> ×F <sub>4</sub>	5216	4662	135.62	12.78	81.37	121.21	11.42	72.73
V <sub>2</sub> ×F <sub>5</sub>	5687	4902	149.00	13.99	88.72	128.43	12.06	76.47
V <sub>3</sub> ×F <sub>1</sub>	2796	2483	73.54	6.46	43.90	65.30	5.74	38.98
V <sub>3</sub> ×F <sub>2</sub>	3995	3615	103.87	9.31	62.72	93.99	8.42	56.76
V <sub>3</sub> ×F <sub>3</sub>	3473	3187	91.34	8.06	54.87	83.82	7.39	50.36
V <sub>3</sub> ×F <sub>4</sub>	4188	3782	110.98	9.84	66.59	100.22	8.89	60.13
V <sub>3</sub> ×F <sub>5</sub>	4930	4100	131.14	11.64	78.39	109.06	9.68	65.19
<b>SEd</b>	151	141	3.40	0.33	2.13	3.39	0.32	1.70
<b>CD (0.05)</b>	321	299	7.20	0.71	4.52	7.19	0.67	3.61

**Table.2** Effect of drip fertigation levels on yield and yield attributes of short duration pigeonpea varieties

Treatments	2015			2016		
	Grain yield (kg ha <sup>-1</sup> )	Stalk yield (kg ha <sup>-1</sup> )	Harvest Index	Grain yield (kg ha <sup>-1</sup> )	Stalk yield (kg ha <sup>-1</sup> )	Harvest Index
<b>Varieties</b>						
V <sub>1</sub> -Co (Rg) 7	1650	3872	30.19	1449	3333	30.24
V <sub>2</sub> -APK 1	1301	2941	29.88	1175	2740	29.98
V <sub>3</sub> -VBN 3	1076	2484	29.71	968	2281	29.75
<b>SEd</b>	41	69	0.75	30	83	0.753
<b>CD (0.05)</b>	116	191	ns	83	230	ns
<b>Fertigation levels</b>						
F <sub>1</sub>	942	2143	29.58	852	2025	29.59
F <sub>2</sub>	1414	3239	29.91	1267	2956	29.98
F <sub>3</sub>	1235	2876	29.72	1111	2615	29.79
F <sub>4</sub>	1479	3418	30.07	1325	3060	30.19
F <sub>5</sub>	1642	3819	30.36	1431	3267	30.41
<b>SEd</b>	31	59	0.42	33	60	0.42
<b>CD (0.05)</b>	71	136	ns	77	138	ns
<b>Varieties × Fertigation</b>						
V <sub>1</sub> ×F <sub>1</sub>	1145	2704	29.76	1022	2425	29.64
V <sub>1</sub> ×F <sub>2</sub>	1731	4007	30.12	1512	3490	30.23
V <sub>1</sub> ×F <sub>3</sub>	1556	3656	29.94	1348	3140	30.04
V <sub>1</sub> ×F <sub>4</sub>	1827	4254	30.30	1606	3680	30.38
V <sub>1</sub> ×F <sub>5</sub>	1992	4740	30.83	1758	3930	30.91
V <sub>2</sub> ×F <sub>1</sub>	898	2001	29.59	821	1940	29.64
V <sub>2</sub> ×F <sub>2</sub>	1399	3134	29.85	1268	2975	30.23
V <sub>2</sub> ×F <sub>3</sub>	1184	2711	29.74	1085	2545	30.04
V <sub>2</sub> ×F <sub>4</sub>	1451	3268	30.04	1308	3030	30.38
V <sub>2</sub> ×F <sub>5</sub>	1574	3589	30.17	1392	3210	30.91
V <sub>3</sub> ×F <sub>1</sub>	783	1724	29.40	712	1710	29.40
V <sub>3</sub> ×F <sub>2</sub>	1111	2577	29.75	1021	2403	29.82
V <sub>3</sub> ×F <sub>3</sub>	966	2260	29.49	901	2160	29.43
V <sub>3</sub> ×F <sub>4</sub>	1158	2733	29.86	1060	2470	30.03
V <sub>3</sub> ×F <sub>5</sub>	1360	3128	30.07	1144	2660	30.07
<b>SEd</b>	52	83	0.78	34	92	0.783
<b>CD (0.05)</b>	110	176	ns	72	194	ns

ns- Non Significant

**Fig.1** Effect of drip fertigation levels on N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O uptake (kg ha<sup>-1</sup>) of pigeonpea varieties



Among the drip fertigation levels and varieties, variety of Co (Rg)7 with drip fertigation at 125 percent RDF through WSF with Azophosmet and foliar spray of PPFM significantly registered highest grain yield of 1992 kg ha<sup>-1</sup>. The result on stalk yield also indicated significant difference as that of grain yield. The pigeonpea variety of Co (Rg)7 with drip fertigation at 125 percent RDF through WSF with Azophosmet and foliar spray of PPFM significantly registered highest stalk yield of 4740 kg ha<sup>-1</sup>.

### Nutrient uptake

The higher nitrogen uptake of 17.46, 63.58, 124.47 and 155.82 kg ha<sup>-1</sup> during *kharif* 2015 and 15.15, 54.66, 108.37 and 134.45 kg ha<sup>-1</sup> during *summer* 2016 were observed under fertigation with 125 per cent RDF through WSF with the concentration and availability of various nutrients in the soil for plant uptake depends on the soil solution phase, which is mainly determined by the soil moisture availability (Fig. 1). The higher available soil moisture, provided by continuous water

supply under drip irrigation, had led to higher availability of nutrients in the soil and thereby increased the nutrient uptake by the crop. The availability of N, P and K nutrient was higher in root zone area of drip fertigated plot which in turn increased the uptake of nutrients (Sathya *et al.*, 2008). Similar findings of higher nutrient uptake with drip fertigation over soil application of nutrients were also reported in hybrid cotton by Veeraputhiran (2000). In the conventional method of fertilizer application with surface irrigation, nutrients were applied only 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 applied nutrients. Similar absorption pattern with varying irrigation methods was narrated by Escobar (1995). Lower uptake was observed with surface irrigation with soil application of fertilizers. However, this treatment resulted in higher uptake of nutrients at vegetative stage due to surface application of fertilizers. Jayakumar *et al.*,

(2014) reported that drip fertigation with 150 per cent recommended dose of NPK and biofertigation was significantly superior in nutrient uptake with the highest N, P and K uptake of 110.9, 28.2 and 110.6 kg ha<sup>-1</sup> at 120 DAS, respectively.

### **Yield performance at drip fertigation levels as compared to conventional fertilizer**

The yield with Co (Rg)7 under drip fertigation at 125 per cent RDF through WSF with Azophosmet and foliar spray of 1% PPFM was 15.1 to 16.3 per cent higher than drip fertigation at 100 per cent RDF through WSF and 72.0 to 74.0 per cent higher than surface irrigation with the application of conventional fertilizer. The yield increases of pigeonpea with 125 percent RDF through WSF might be due to the fact that fertigation at higher dose obviously resulted in higher availability of all three major nutrients (NP and K) in the soil solution, which led to higher uptake and better translocation of assimilates from source to sink, thus in turn increased the yield. Similar linear response to higher doses of fertilizer was obtained in long duration pigeonpea under drip fertigation by Vimalendren and Latha (2014). The yield attributing characters of pigeonpea were higher under drip irrigation with fertigation at 125 percent RDF through WSF because better crop growth at higher nutrient levels might have influenced the yield favorably. These results were accordance with the findings of Jeetendra Kumar Soni (2015). Under drip fertigation, the WSF were applied at the site of high concentration of active roots with more number of splits *i.e* once in seven days up to reproductive stage which might have resulted in higher availability and higher uptake by the roots and ultimately resulted in higher yield characters and yield of the crop. Whereas in the surface applied plots, the fertilizers were applied in excess on the soil with minimum number of splits *i.e.*, one basal

for pigeonpea. So the availability of nutrients would be very high during first 20-30 days, which have resulted in higher growth parameters during that stage, but at reproductive stage the applied nutrients would have been depleted or leached off and not available to the crops which might have resulted in lower yield attributing characters and yield of the crops. Similar findings of higher yield under drip irrigated crops were observed by Sampathkumar *et al.*, (2006). The perusal of the yield data showed the favourable effect of drip fertigation on yield of pigeonpea. The yield per hectare was significantly improved by the application of major nutrients through fertigation which boosted the overall vegetative growth and biological efficiency of the plant. Another plausible reason was the timely availability of nutrients during the flower production which favorably increases the number of flowers plant. Better crop growth at higher nutrient levels might have influenced the yield attributes favorably. The increase in yield might be due to better proportion of air-soil-water which was maintained throughout the life period of crop in drip irrigation as compared to surface irrigation as reported by Khalil Ajdary (2007).

Increased drymatter production, nutrient uptake, seed yield per ha<sup>-1</sup> and stalk yield per ha<sup>-1</sup> relative to 125 percent RDF through WSF under drip fertigation. This is important for understanding the impacts of different fertigation regimes compared to surface irrigation regimes. The findings of the foregoing experiments have clearly established that fertigation is definitely advantageous over the surface irrigation with basal application of fertilizers.

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