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Effect of Surface Drip Fertigation on Growth and Seed Yield in Pigeonpea (*Cajanus cajan* L.) cv. VBN3.

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ABSTRACT: *Investigations conducted at Agricultural College and Research Institute, Madurai, during* kharif- *main crop 2010 and* rabi- *ratoon 2010 to study the influence of surface drip fertigation on the growth and seed yield of pigeonpea* (Cajanus cajan *L.) cv. VBN3 revealed that drip fertigation scheduled once in six days and foliar application provided at 45, 55 & 65 days after sowing the growth and yield attributes were higher in 100 per cent SRDF as WSF with foliar feeding with 0.5 per cent Zinc Sulphate* (F_3FS_1) *and lowest with 50per cent SRDF as WSF through drip during both main crop and ratoon. Between main crop and ratoon, main crop recorded 35.2 per cent increased seed yield as compared to ratoon crop when compared against normal soil application of fertilizers. The increased in seed yield with 100 per cent SRDF as WSF with foliar feeding with 0.5 per cent Zinc Sulphate was mainly attributed to greater and consistent availability of nutrients, growth hormones and soil moisture which resulted in better crop growth, seed yield components and ultimately reflected on the seed yield.*

Keywords: *Drip fertigation, main crop, ratoon, foliar feeding, pigeonpea*

INTRODUCTION

Pigeonpea is the most widely grown crop in the country and has been under cultivation for over three thousand years. With 22 per cent protein, which is almost three times that of cereals, pigeonpea supplies a major share of protein requirement of the predominantly vegetarian population in the country. The biological value improves greatly, when wheat or rice is combined with pigeonpea because of the complementary relationship of the essential amino acids. It is particularly rich in lysine, riboflavin, thiamine, niacin and iron. 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 per cent of the fertilizer could be saved (Sivanappan and Ranghaswami, 2005). The main cause for low seed multiplication rate is that pigeonpea is mainly grown under agro-ecological constraints compounded by paucity of nutrients and hormones. Pigeonpea seed crop requires well irrigated schedule to provide quality seeds and any method to save water will help in mitigating the harm caused by reduced water and formation of hard seeds. Water requirement is though low during the first 60-70 days, increases during flowering and pod formation. One of the possible ways to bridge the gap between demand and supply of water is to increase the pigeonpea seed yield and water saved per unit area by adopting appropriate production and management technologies.

Pigeonpea is a short-lived perennial, and has a number of advantages over other leguminous crops. These include drought tolerance, lodging and shattering resistance. Its perennial nature allows the possibility of ratoon cropping, its use in animal feed production systems and incorporation as crop residue. Ratoon seed cropping is a novel technique of allowing a crop to produce two crops of yield from one planting. The principles involved are that, the ratoon crop has well developed root system, earlier maturity, perennial nature, higher genetic purity saving labour cost on rouging. Although high seed yields are possible using this production system, it had limited application in many agricultural environments of the subtropics and tropics because

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of its inherent managerial complexity and also because pod and seed development occurs during the coolest or the driest period of the year. In warmer environments, the production system has been more successful. Ratoon cropping is feasible in favourable environments (Wallis *et al*. 1981) and yields exceeding 4 t/ha/year from two harvests have been achieved.

In India, medium duration pigeonpea (*Cajanus cajan*) are normally sown soon after the onset of the monsoon, in June or July; they mature around December, when they are usually cut down and removed from the field. However, if they are harvested by ratooning or by picking the pods, the plants go on to produce a second flush of pods, which matures around March (Venkataratnam and Sheldrake, 2003). 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. Since research in pigeonpea drip fertigation for seed crop is scanty, the present study was undertaken to study the performance of drip fertigation in pigeonpea seed production and follow it up for ratoon.

MATERIAL AND METHODS

The present study on the Influence of drip fertigation on the growth and seed yield of pigeonpea cv. VBN3 was carried out during *kharif* 2010 and *rabi* 2010 at Central farm, Agricultural College and Research Institute, Madurai.(Plate 1). The soil of the study area was clayey with a pH of 7.4, available N, P, K status of 180, 10 and 312 N P K kg.ha^{-1} respectively. The organic carbon content was 0.48% and EC 0.42 dSm^{-1}. Seeds were treated and were sown in raised bed at the spacing of 45 x 30 cm as direct spot seeding on raised beds of 90 cm width and furrows of 10 cm.

Lay Out of Drip System

Laterals (12mm) from sub main were fixed at a spacing of 120 cm and inline lateral emitters in fixed at 20 cm with a 16 mm tap at the head of each lateral. The drip irrigation system was well maintained by flushing and cleaning the filters. The quantity of water was calculated as follows:

Volume (lit ha-1) = PE × Kp × Area (m2), PE = pan evaporation , K p= Pan Factor (0.80)

Time of operation of drip system to deliver the required volume of water per plot was computed based on the formula :

$$Time\,of\,application = \frac{Volume\,of\,water\,required(1)}{Emitter\,discharge(lit\,ha^{-1})x\,No.of\,emitters\,/\,plot}$$

The experiment was laid out in split plot design with three replications with spacing of 45 X 30 cm with treatment (main and sub) (given below) and compared with control.

Treatments	Details
F_1	50 per cent of SRDF through drip
F_2	75 per cent of SRDF through drip
F_3	100 per cent of SRDF through drip
F_4	150 per cent SRDF through drip

*SRDF = Seed crop Recommended Dose of Fertilizer (25:50:25 kg NPK ha^{-1})

Sub Plot Treatment: Foliar spray at 45,55 and 65 DAS

Treatments	Details
S_1	Foliar spray of 0.5 per cent Zinc sulphate
S_2	Foliar spray of 100 ppm Succinic acid
S_3	Foliar spray of 100 ppm Humic acid

Absolute control: Surface irrigation with SRDF of 25:50:25 NPK kg ha^{-1} by two splits. (Absolute control plot was maintained separately outside the experimental area and all recommended practices based on the Tamil Nadu Crop Production Guide, 2005) with foliar spray of DAP (twice).

Fertigation

The SRDF dose (25:50:25 NPK kg ha^{-1} in two splits) was used as base for calculating the fertigation schedule. Fertigation was done once in six days starting from 15 DAS to 90 DAS in three consecutive steps *viz.,* wetting the root zone before fertigation, fertigating the field and flushing the nutrients with water.

Ratooning

After harvesting the first crop, the main stem was severed at 30 cm above ground. Drip fertigation as per the first crop schedule was applied. Growth components were recorded at three stages of crop growth, *viz*., 60 DAS (flowering stage), 90 DAS and maturity stage.

RESULTS AND DISCUSSION

Drip fertigation and foliar spray treatments significantly influenced the morphological characters such as plant height, number of branches per plant, stem girth and physiological parameters like Leaf area index, leaf area duration and crop growth rate at 90 DAS. All these morphological and physiological traits were significantly higher in main crop as compared to ratoon. Among the crops, main crop recorded 17.9 per cent per cent higher plants as compared to ratoon with combination of 100per cent SRDF as WSF (F_3) + 0.5 per cent Zinc Sulphate that recorded higher plant height at 90 DAS/DAR. Drip fertigation and foliar spray treatments in general increased the crop growth. Similar results were found by Prabhu (2006) in chillies fertigated and foliar sprayed with $ZnSO_4$, $FeSO_4$ as compared to drip fertigation at 100 per cent RDF alone. Similar results were observed with respect to yield parameters. Foliar feeding of Zn and Mn along with enhanced doses of NPK favourably influenced the growth parameters of maize (Mahmoud, 2001).

Plant Height

The plant height, number of branches, stem girth, dry weight.plant^{-1} and number of flower were significantly influenced by surface drip fertigation. The plant height at 90 DAS and 90 DAR which was 152.4 cm and 129.4 cm was higher by 15.5 per cent and 20.5 per cent in main crop and ratoon crop respectively with treatment 100 per cent SRDF as WSF F_3 compared 50 per cent SRDF as WSF similar results were found by Shanmugham *et al.* (2007) reported that drip fertigation with 125 per cent recommended dose of NPK ha^{-1} recorded significantly higher plant height of cotton at 30, 60 and 90 DAS than surface irrigation and soil application of 100 per cent recommended fertilizer as also visulalized by Sampath Kumar *et al.* (2006) in cotton (Table 1)

Leaf Area Index, Leaf Area Duration and Crop Growth Rate

The importance of leaf area in determining canopy and water used by a crop is well recognized. The leaf area index was significantly higher in main crop (2.52) than ratoon (2.10) through combination of 100per cent SRDF as WSF (F_3) + 0.5 per cent Zinc Sulphate treatment. The same best treatment combination also the values of Leaf area index, Leaf area duration and crop growth rate (Table 2, 3 & 4). Leaf area duration is an important factor for growth and development of a crop (Evans, 1975, Sinclair and Dewit 1976). Similar results were expressed by Veeraputhiran (2000) attributing enhanced physiological parameters such as LAI, CGR and CGR using drip fertigation over the furrow band application of cotton. Hassan *et al.* (2010) revealed that maximum stem girth (6.86 cm), green fodder yield (91.25 t.ha^{-1}), total dry matter (8.90 t.ha^{-1}), leaf area index (15.57), leaf area duration (201 days), N content (1.35per cent) and N uptake (120.42 kg ha^{-1}) were observed with the application of 140 kg N ha^{-1} through drip fertigation in maize.

The numbers of pods per plant and seed yield per plant are the major yield components that determine the final seed yield and represent the reproductive efficacy of a seed crop. The statistically analyzed results showed that drip fertigation, foliar spray treatments, between crops and their interaction significantly influenced number of pods.plant^{-1}, seed yield.plant^{-1}, seed yield.plot^{-1} and seed yield (kg.ha^{-1}) (Table 5).

The enhanced dry weight of reproductive parts by growth regulators, organics and nutrients may be due to increased translocation of assimilates from leaf and stem to the reproductive parts as also reported in pigeonpea due to application of Zinc Sulphate, Succinic Acid and Humic Acid (Singh *et al.*, 1993 and Brar *et al.*, 1992). Improvement in dry weight of reproductive parts due to the growth regulator application was recorded by Dashora and Jain (1994). Seed yield was maximum when $ZnSO_4$ (0.5 %) was given as a foliar spray. Zinc plays a vital role as activator of carbohydrate and protein synthesis as well as their transport to the site of seed formation. Sharma *et al.* (1989) reported that seed yield was significantly correlated with number of pods per plant and 100 grain weight in soybean during kharif season.

Seed Yield (kg.ha^{-1})

Maximum seed yield (kg.ha^{-1}) of 1416kg.ha^{-1} in main crop and 1106 kg.ha^{-1} in ratoon an increase by 40.2per cent and 58.0per cent higher in main crop over ratoon respectively was obtained by the treatment viz., 100per cent SRDF as WSF + 0.5 per cent Zinc Sulphate when compared to F_1+FS_3 treatment combination (1010 kg/ha in main crop and 700 kg/ha in ratoon) (Table 6). This might be due to enhancement in growth and yield parameters as well as uptake of nutrients by this crop. Obviously, the cumulative effects of these parameters contributed to increased yield. Whereas, control plot recorded 41.6per cent and 58.0per cent per cent lower seed yield compared to best treatment combinations under drip fertigation in main crop and ratoon respectively as also found by Somu (1995) who reported that the seed yield was 37 per cent lesser in the ratoon crop than in main crop of pigeonpea and Shashidhara (2006) in chillies. Tayo (1990) observed that at the end of the first and second regrowths, the plants ratooned at 30 and 60 cm had performed better

Table 1
Influence of fertigation and foliar spray on Plant height (cm) at 90 DAS & DAR in pigeonpea cv. VBN 3 (Main crop& Ratoon)

F- Fertigation Treatments	*Plant height (cm) at 90 Days after ratooning FS - Foliar spraying treatments*											
	Main crop (C_1)				*Ratoon crop (C_2)*				*Pooled mean*			
	FS_1	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*
F_1	140.6	129.5	125.5	131.9	112.2	108.0	102.1	107.4	126.4	118.8	113.8	119.6
F_2	143.4	136.4	131.6	137.1	121.6	114.1	109.4	115.0	132.5	125.3	120.5	126.1
F_3	157.4	153.5	146.4	152.4	133.5	129.3	125.3	129.4	145.5	141.4	135.9	140.9
F_4	151.7	145.6	141.6	146.3	130.2	124.0	118.5	124.2	141.0	134.8	130.1	135.3
Mean	148.3	141.3	136.3	141.9	124.4	118.9	113.8	119.0	136.3	130.1	125.1	130.5
	F	FS	F X FS	FS X F	F	FS	F X FS	FS X F			SEd	CD(P=0.05)
SEd	0.742	0.649	1.294	1.299	0.566	0.447	0.924	0.894		C	0.407	0.896**
CD(P=0.05)	1.815**	1.376**	2.882*	2.753*	1.385**	0.948**	2.071*	1.895*		F	0.970	2.114**
										FS	0.832	1.696**
										F X FS	1.670	NS
Absolute Control		125.5				100				C X F	1.680	3.661**
										C X FS	1.177	2.398**
										C X F X FS	2.354	NS

Table 2
Influence of fertigation and foliar spray on Leaf Area Index at 90 DAS & 90 DAR in pigeonpea cv. VBN 3 (Main crop& Ratoon)

F- Fertigation Treatments	*LAI at 90 DAR FS - Foliar spraying treatments*											
	Main crop (C_1)				*Ratoon crop (C_2)*				*Pooled mean*			
	FS_1	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*
F_1	5.63	5.46	5.35	5.48	4.55	4.30	4.08	4.31	5.09	4.88	4.72	4.90
F_2	5.81	5.66	5.65	5.71	4.71	4.52	4.43	4.55	5.26	5.09	5.04	5.13
F_3	6.44	6.35	6.25	6.35	5.27	5.15	5.12	5.18	5.86	5.75	5.69	5.76
F_4	6.22	5.89	5.81	5.97	5.09	4.84	4.68	4.87	5.66	5.37	5.25	5.42
Mean	6.03	5.84	5.77	5.88	4.91	4.70	4.58	4.73	5.47	5.27	5.17	5.30
	F	FS	F X FS	FS X F	F	FS	F X FS	FS X F			SEd	CD(P=0.05)
SEd	0.017	0.018	0.033	0.035	0.024	0.018	0.038	0.036		C	0.013	0.028**
CD(P=0.05)	0.042**	0.037**	0.074**	0.075**	0.058**	0.038**	0.085**	0.077**		F	0.015	0.032**
										FS	0.013	0.026**
										F X FS	0.025	0.051**
Absolute Control		5.12				4.05				C X F	0.025	0.055**
										C X FS	0.018	0.036**
										C X F X FS	0.036	NS

Table 3
Influence of fertigation and foliar spray on Leaf Area Duration in pigeonpea cv. VBN 3 (Main crop & Ratoon)

F- Fertigation Treatments	*LAD – leaf area duration FS - Foliar spraying treatments*											
	Main crop (C_1)				*Ratoon crop (C_2)*				*Pooled mean*			
	FS_1	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*
F_1	110.4	105.0	101.6	105.7	88.5	82.5	77.7	82.9	99.5	93.8	89.7	94.3
F_2	117.6	112.6	109.5	113.2	92.9	89.7	87.5	90.0	105.2	101.2	98.5	101.6
F_3	134.5	130.8	128.5	131.3	110.2	104.3	100.1	104.9	122.4	117.5	114.3	118.1
F_4	128.8	120.6	116.5	122.0	102.4	96.6	93.5	97.5	115.6	108.6	105.0	109.7
Mean	122.8	117.3	114.0	118.0	98.5	93.3	89.7	93.8	110.7	105.3	101.9	105.9
	F	FS	F X FS	FS X F	F	FS	F X FS	FS X F			SEd	CD(P=0.05)
SEd	0.356	0.365	0.693	0.729	0.412	0.369	0.730	0.738		C	0.408	0.899**
CD(P=0.05)	0.870**	0.773**	1.530**	1.546**	1.009**	0.782**	1.624**	1.565**		F	0.272	0.593**
										FS	0.259	0.528**
										F X FS	0.503	1.025**
										C X F	0.471	1.027**
Absolute Control		101.2				77.5				C X FS	0.366	NS
										C X F X FS	0.733	1.492**

Table 4
Influence of fertigation and foliar spray on Crop Growth Rate (g m^{-2} d^{-1}) in pigeonpea cv. VBN 3 (Main crop & Ratoon)

F- Fertigation Treatments	*Crop Growth Rate - CGR g m^{-2} d^{-1} FS - Foliar spraying treatments*											
	Main crop (C_1)				*Ratoon crop (C_2)*				*Pooled mean*			
	FS_1	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*
F_1	16.5	16.3	15.3	16.0	9.0	8.1	7.0	8.1	12.8	12.2	11.2	12.0
F_2	20.2	16.8	15.9	17.6	9.8	8.4	7.7	8.6	15.0	12.6	11.8	13.1
F_3	23.6	23.0	22.6	23.1	13.6	14.0	13.6	13.7	18.6	18.5	18.1	18.4
F_4	18.6	17.6	16.5	17.6	11.9	9.2	8.7	9.9	15.2	13.4	12.6	13.7
Mean	19.7	18.4	17.6	18.6	11.1	9.9	9.3	10.1	15.4	14.2	13.4	14.3
	F	FS	F X FS	FS X F	F	FS	F X FS	FS X F			SEd	CD(P=0.05)
SEd	0.182	0.395	0.671	0.790	0.196	0.222	0.412	0.444		C	0.211	0.463**
CD(P=0.05)	0.447**	0.838**	1.438*	1.675*	0.479**	0.470**	0.903**	0.940**		F	0.134	0.291**
										FS	0.226	0.461**
										F X FS	0.393	0.801**
Absolute Control		14.5				7.5				C X F	0.231	0.504**
										C X FS	0.320	NS
										C X F X FS	0.641	NS

Table 5
Influence of fertigation and foliar spray on Number of pods per plant in pigeonpea cv. VBN 3 (Main crop & Ratoon)

F- Fertigation Treatments	*Number of pods per plant FS - Foliar spraying treatments*											
	Main crop (C_1)				*Ratoon crop (C_2)*				*Pooled mean*			
	FS_1	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*
F_1	299	282	267	283	159	142	126	142	229	212	197	213
F_2	320	304	291	305	180	163	150	164	250	234	221	235
F_3	415	400	387	401	275	259	246	260	345	330	317	330
F_4	379	366	357	367	239	225	217	227	309	296	287	297
Mean	353	338	326	339	213	197	185	198	283	268	255	269
	F	FS	F X FS	FS X F	F	FS	F X FS	FS X F			SEd	CD(P=0.05)
SEd	0.609	0.687	1.277	1.374	1.404	0.991	2.142	1.982		C	0.106	0.234**
CD(P=0.05)	1.489**	1.457**	2.801**	2.914**	3.435**	2.101**	4.843*	4.202*		F	0.765	1.667**
										FS	0.603	1.228**
										F X FS	1.247	2.540**
Absolute Control		250				120				C X F	1.325	NS
										C X FS	0.853	NS
										C X F X FS	1.705	NS

Table 6
Influence of fertigation and foliar spray on seed yield (kg.ha^{-1}) in pigeonpea cv. VBN 3 (Main crop & Ratoon)

F-Fertigation Treatments	*Seed yield per ha (kg) FS - Foliar spraying treatments*											
	Main crop (C_1)				*Ratoon crop (C_2)*				*Pooled mean*			
	FS_1	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*	*FS_1*	*FS_2*	*FS_3*	*Mean*
F_1	1056	1035	1010	1034	746	725	700	724	901	880	855	879
F_2	1143	1101	1075	1106	833	791	765	796	988	946	920	951
F_3	1416	1367	1344	1376	1106	1057	1034	1066	1261	1212	1189	1221
F_4	1276	1244	1215	1245	966	934	905	935	1121	1089	1060	1090
Mean	1223	1187	1161	1190	913	877	851	880	1068	1032	1006	1035
	F	FS	F X FS	FS X F	F	FS	F X FS	FS X F			SEd	CD(P=0.05)
SEd	3.237	2.225	4.865	4.449	5.287	2.784	6.973	5.568		C	0.067	0.147**
CD(P=0.05)	7.920**	4.716**	11.019**	9.432**	12.938**	5.902**	16.094*	11.803*		F	3.100	NS
										FS	1.782	NS
										F X FS	4.251	NS
Absolute Control		1000				700				C X F	5.369	11.698**
										C X FS	2.520	5.133**
										C X F X FS	5.040	10.266**

Plate 1: Stages of drip fertigated pigeonpea seed crop

than those left intact in terms of growth and yield characters as well as seed yield in pigeon pea (variety Cita-1).

CONCLUSION

The treatment combination of 100 per cent SRDF as WSF with foliar spraying with 0.5 per cent Zinc Sulphate (F_3FS_1) and maximized the yield, in addition to better crop growth, higher yield attributes, yield and substantial quantity of water saving. Thus, it clearly indicated the feasibility of introducing drip fertigation in pigeonpea seed production for higher water productivity; higher fertilizer use efficiency and sustainability in future pigeonpea seed production. Seed yield per unit area can be maximized through rationing as it saves time, money and labour.

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