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EFFECTS OF DRIP IRRIGATION REGIMES AND FERTIGATION LEVELS ON YIELD AND NUTRIENT USE EFFICIENCY OF LONG DURATION PIGEONPEA (*CAJANUS CAJAN* (L.) MILLSP.)

VIMALENDRAN LOGANATHAN* AND KR LATHA

Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore- 641003, India

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Abstract

Field experiments were conducted to study the effect of drip fertigation on seed yield, agronomic efficiency and partial factor productivity of pigeonpea. Higher values of agronomic efficiency (16.58 kg/kg nutrient applied) was recorded in drip irrigation at 100 per cent WRc along with 100 per cent RDF through WSF during 2011 - 12 and drip irrigation at 100 per cent WRc along with fertigation at 75 per cent RDF through WSF (15.27 kg/kg nutrient applied) during the second year (2012 - 13). Drip irrigation at 100 per cent WRc along with fertigation at 75 per cent RDF through WSF recorded higher partial factor productivity values of 29.40 and 28.40 kg/kg nutrient applied during 2011 - 12 and 2012 - 13, respectively and was at par with drip irrigation at 75 per cent WRc with fertigation at 75 per cent RDF through WSF.

Introduction

Drip fertigation is an effective way of fertilizer application to simultaneously meet water and nutrient demands of crops. Application of nutrients on need based could increase nutrient use efficiency and reduce potential adverse environmental effects. Fertigation allows an accurate and uniform application of nutrients to the wetted area where most active roots are concentrated. Therefore, it is possible to dispense adequate nutrient quantity at an appropriate concentration to meet the crop demand during a growing season. Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of the important and protein rich grain legumes of semi-arid tropics grown throughout the tropical and subtropical regions of the world. It is one of the top ten legumes grown globally. It is used in more diverse ways and is mainly cultivated for grain purpose as Dhal which is a cheap source of protein for poor population of the country. It fixes atmospheric nitrogen, makes available phosphorous, supplies substantial organic matter in the form of fallen leaves. The demand for pulses especially pigeonpea has increased due to increasing population therefore by adopting the micro irrigation increased yield could be achived. Information on yield, nutrient use efficiency on pigeonpea is very less under drip fertigation system. The partial factor productivity and agronomic efficiency believed to be useful parameters to precisely estimate the fertilizer needs of the crops (Zhang *et al*. 2010). Therefore, the present study was conducted to assess the nutrient use efficiency and partial factor productivity and seed yield of long duration pigeonpea under drip fertigation system.

Materials and Methods

Field experiments were conducted during 2011-12 and 2012-13 at Millet Breeding Station, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The soil was sandy clay loam with pH 7.65 and EC 1.50 dS/m, having 0.51 per cent organic carbon, 226 kg/ha available N, 18 kg/ha available P and 429 kg/ha available K. The experiments were laid

*Author for correspondence: <vimal.tnau@gmail.com>.

out in a randomized block design with 14 treatments and three replications. The treatments include combination of water regimes and nutrients levels. The treatments details are as follows T_1-50 % computed water requirement of crop (WRc) + 75% recommended dose of fertilizers (RDF 25 : 50 : 25 NPK kg/ha) 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 all basal) and T_{14}- Surface Irrigation + 100% RDF through conventional fertilizers (all basal). Recommended dose of fertilizer for pigeonpea was 25 : 50 : 25 kg NPK /a. Pigeonpea cv. LRG 41 was sown with spacing of 150 × 60 cm. The entire quantity of NPK was applied as basal in treatments T_{13} and T_{14}. For the treatment T_{10}, T_{11} and T_{12}, the phosphorus is applied as basal and N and K through drip fertigation through conventional fertilizers.

For the treatments T_1 to T_9 the required nutrients are supplied through water soluble fertilizers *viz.*, mono ammonium phosphate, poly feed and potassium sulphate (0 : 0 : 50) as water soluble fertilizers for supplying N, P and K, respectively. Drip irrigation and fertigation were given once in seven days by computing the water requirement of the crop (WRc). For surface irrigation method, subsequent irrigations were scheduled at 5.0 cm depth with IW/CPE ratio 0.60. Two indices were used to assess nutrient use efficiency (Rolf and Thomas 2004).

To estimate efficiency of nutrient, replicated absolute control without fertilizer application was maintained in the same field. The partial factor productivity (Pfp) from applied nutrients is a useful measure of nutrient use efficiency because it provides integrative index that quantifies total economic output related to utilization of all nutrient resources in the system (Cassmen *et al.* 1996). It is the ratio of yield in kg/ha to applied nutrients and stated as,

$$Pfp = \frac{Y}{Nr}$$

where, Y is the yield in kg/ha. Nr is the amount of fertilizer nutrients applied in kg/ha.

Agronomic efficiency (AE) often termed as nutrient efficiency is additional yield produced for each kg of fertilizer nutrient (FN) applied.

$$AE = \frac{Y_{FN} - Y_{oFN}}{FN}$$

where, AE_{FN}- kg yield increase/kg FN applied, Y_{FN} is the yield in a treatment with fertilizer nutrient application, Y_{oFN} is the yield in a treatment without fertilizer nutrient application, FN is the amount of fertilizer nutrient applied in kg/ha.

The data collected were subjected to statistical analysis as suggested by Gomez and Gomez (1984).

Results and Discussion

Generally the pigeonpea seed yield was increased with drip irrigation regimes and fertilizer levels (Table 1). Drip irrigation at 100 per cent WRc with 125 per cent RDF through WSF recorded significantly higher seed yield of 2812 and 2586 kg/ha during 2011 - 2012 and 2012 - 2013, respectively with a percentage yield increase of 47.4 (2011 - 2012) and 44.1 (2012 - 2013) compared to surface irrigation with conventional fertilizer application. This yield increase was

mainly due to increased nutrient use efficiency of crops. In this study, drip irrigation at 100 per cent WRc along with fertigation with 125 per cent RDF through WSF (T_9) increased the grain yield to the tune of 30 per cent during both the years of study, as compared to drip irrigation at 100 per cent WRc along with fertigation at 100 per cent RDF with conventional fertilizer (T_{12}). The increased yield due to better performance under drip was attributed to favourable soil moisture condition maintained in root zone, which helps the plants to utilize water and nutrients more efficiently from the wetted area (Singh *et al*. 2002). Hebbar *et al.* (2004) 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 water soluble fertilizer as compared to normal fertilizer. Water soluble fertilizer had higher concentration of available plant nutrient in top layer.

Table 1. Effect of drip irrigation regimes and fertigation levels on seed yield of pigeonpea.

Treatments	Seed yield (kg/ha)		Yield increase (%)	
	2011-12	2012-13	2011-12	2012-13
T_1 - 50 % WRc + Drip fertigation at 75 % RDF (WSF)	2028	1993	6.3	11.1
T_2 - 75 % WRc + Drip fertigation at 75 % RDF (WSF)	2197	2096	15.1	16.8
T_3 - 100 % WRc + Drip fertigation at 75 % RDF (WSF)	2205	2130	15.6	18.7
T_4 - 50 % WRc + Drip fertigation at 100 % RDF (WSF)	2231	2129	16.9	18.7
T_5 - 75 % WRc + Drip fertigation at 100 % RDF (WSF)	2447	2283	28.2	27.3
T_6 - 100 % WRc + Drip fertigation at 100 % RDF (WSF)	2643	2498	38.5	39.2
T_7 - 50 % WRc + Drip fertigation at 125 % RDF (WSF)	2306	2173	20.9	21.1
T_8 - 75 % WRc + Drip fertigation at 125 % RDF (WSF)	2520	2311	32.1	28.8
T_9 - 100 % WRc + Drip fertigation at 125 % RDF (WSF)	2812	2586	47.4	44.1
T_{10} - 50 % WRc + Drip fertigation at 100 % RDF (CF*)	1920	1816	0.6	1.2
T_{11} - 75 % WRc + Drip fertigation at 100 % RDF (CF*)	1983	1873	3.9	4.4
T_{12} - 100 % WRc + Drip fertigation at 100 % RDF (CF*)	2160	1978	13.2	10.3
T_{13} - Drip irrigation at 100 % WRc + 100 % RDF (CF- all basal)	2070	1844	8.5	2.8
T_{14} - Surface irrigation +100 % RDF (CF- all basal)	1908	1794	-	-
SEd	138.7	120.0	-	-
CD(P=0.05)	285.3	246.7	-	-

*P as basal; N and K through drip fertigation; WRc - Computed water requirement of crop; RDF - recommended dose of fertilizers (25 : 50 : 25 NPK kg/ha); CF- Conventional fertilizers.

The data on agronomic efficiency decreased with lower drip irrigation regimes (Table 3). Among drip irrigation and fertigation levels, drip irrigation at 100 per cent WRc along with fertigation at 100 per cent RDF through WSF recorded higher value of agronomic use efficiency of 16.58 kg/kg nutrient applied during 2011 - 12 and drip irrigation at 100 per cent WRc along with fertigation at 75 per cent RDF through WSF recorded higher agronomic use efficiency of 15.37 kg/kg nutrient applied during 2012 - 13. The agronomic use efficiency significantly decreased with lower irrigation regime. The lower value of agronomic use efficiency (9.23 and 8.09 kg/kg nutrient applied) was recorded under surface irrigation with conventional method of fertilizer application during both the years of study. Agronomic efficiency (AE) means crop yield (kg) increase per kg of nutrient applied. In this experiment, two forms of fertilizer i.e., water soluble fertilizer and conventional fertilizers were used (Table 2). Among the different irrigation and fertigation levels, fertigation with water soluble fertilizer recorded higher AE compared to

conventional fertilizers. Decrease in irrigation regimes shows decreased in agronomic efficiency. Similar findings are in accordance with Ramah *et al*. (2008).

Table 2. Effect of drip irrigation and fertigation levels on agronomic efficiency of pigeonpea.

Treatments	Agronomic efficiency (kg/kg nutrient)		Partial factor productivity (kg/kg nutrient applied)	
	2011-12	2012-13	2011-12	2012-13
T_1 - 50 % WRc + Drip fertigation at 75 % RDF (WSF)	14.00	13.53	27.22	26.75
T_2 - 75 % WRc + Drip fertigation at 75 % RDF (WSF)	16.27	14.91	29.49	28.13
T_3 - 100 % WRc + Drip fertigation at 75 % RDF (WSF)	16.38	15.37	29.60	28.59
T_4 - 50 % WRc + Drip fertigation at 100 % RDF (WSF)	12.46	11.44	22.31	21.29
T_5 - 75 % WRc + Drip fertigation at 100 % RDF (WSF)	14.62	12.98	24.47	22.83
T_6 - 100 % WRc + Drip fertigation at 100 % RDF (WSF)	16.58	15.13	26.43	24.98
T_7 - 50 % WRc + Drip fertigation at 125 % RDF (WSF)	10.57	9.50	18.45	17.38
T_8 - 75 % WRc + Drip fertigation at 125 % RDF (WSF)	12.28	10.61	20.16	18.49
T_9 - 100 % WRc + Drip fertigation at 125 % RDF (WSF)	14.62	12.81	22.50	20.69
T_{10} - 50 % WRc + Drip fertigation at 100 % RDF (CF*)	9.35	8.31	19.20	18.16
T_{11} - 75 % WRc + Drip fertigation at 100 % RDF (CF*)	9.98	8.88	19.83	18.73
T_{12} - 100 % WRc + Drip fertigation at 100 % RDF (CF*)	11.75	9.93	21.60	19.78
T_{13} - Drip irrigation at 100 % WRc + 100 % RDF (CF- all basal)	10.85	8.59	20.70	18.44
T_{14} - SI +100 % RDF (CF- all basal)	9.23	8.09	19.08	17.94
SEd	0.70	0.59	1.15	1.11
CD(P = 0.05)	1.44	1.24	2.40	2.31

*P as basal; N and K through drip fertigation; WRc - Computed water requirement of crop; RDF - recommended dose of fertilizers (25 : 50 : 25 NPK kg/ha); CF- Conventional fertilizers.

The partial factor productivity significantly decreased with lower drip irrigation regime which is presented in Table 2. Drip irrigation at 100 per cent WRc along with fertigation at 75 per cent RDF through WSF recorded higher values of 29.60 and 28.59 kg/kg nutrient applied during 2011 - 12 and 2012 - 13 and was on par with drip irrigation at 75 per cent WRc along with fertigation at 75 per cent RDF through WSF. The partial factor productivity of nutrient decreased significantly with increased level of recommended fertilizers dose. The lesser PFP values of 18.45 and 17.38 kg/kg nutrient applied was noticed under drip irrigation at 50 per cent WRc along with fertigation at 125 per cent RDF through WSF during both the years of study. The agronomic use efficiency was lower under drip fertigation with higher dose of fertilizers. The reason might be that the crop uptake increased as the dosage increases and then slows down or declines after a critical limit. Efficiency of nutrients was decreased with increased level of nutrients. Partial factor productivity **(**PFP) decreased with increasing rates of fertigation. The favourable effect on nutrient use efficiency was well pronounced under drip fertigation when compared to surface irrigation. Drip fertigation with water soluble fertilizer resulted in increased nutrient use efficiency than conventional fertilizer application under surface irrigation. This might be due to the greater mobility and availability of nutrients to the root zone of the crops under drip fertigation, since water soluble fertilizer contained readily available form of nutrients. Scheduling fertilizer application based on the need of the crop once in seven days offered the possibility of reducing nutrient losses, thereby increased the nutrient use efficiency when compared to conventional fertilizer application methods, wherein large quantity of fertilizers were applied as basal during sowing which led to greater loss of applied nutrients. During later growth stage, the uptake of

nutrients was low due to limited availability of nutrients under surface irrigation resulting in poor nutrient use efficiency for all the major nutrients of NPK. In fertigation, nutrient use efficiency could be as high as 90 per cent compared to 40 - 60 per cent in conventional methods. The amount of fertilizer lost through leaching can be as low as 10 per cent in fertigation whereas it is 50 per cent in the traditional system (Solaimalai *et al*. 2005).

From this experiment it is recommended that application of 100 per cent WRc along with 125 per cent RDF through WSF in drip fertigation system enhanced the seed yield upto 45 per cent whereas the agronomic efficiency was higher irrespective of irrigation regimes during first year 100 per cent RDF through WSF and 75 per cent RDF through WSF during second year. The highest partial factor productivity was recorded in 100 % WRc + 75 % RDF through WSF irrespective of the years.

References

Cassmen KU, Gines G C, Dizon MA, Samson MI and Alcantace J M 1996. Nitrogen use efficiency in tropical low land rice system. Contribution from indigenous and applied nitrogen. Field Crop Res. **47**: 1-12.

Hebbar SS, Ramachandrappa BK, Nanjappa HV and Prabhakar M 2004. Studies on NPK drip fertigation in field grown tomato (*Lycopersicon esculentum* Millsp.). Europ. J. Agron. **21**: 117-127.

Ramah K 2008. Study on drip irrigation in maize (*Zea mays* L.) based cropping system. Ph. D. Thesis, TNAU, Coimbatore.

Rolf Hardter and Thomas Fairhurst 2004. Nutrient use efficiency in upland cropping system of Asia.www.kaligmbh.com/duengemittal_en/service/publications.cfm?artikelied=17.

Singh AK, Chakraborty D, Mishra D and Singh DK 2002. Nitrogen and Potassium dynamics in fertigation system. 17th WCSS, 14-21 August in Thailand.

Solaimalai A, Baskar M, Sadasakthi A and Subburamu K 2005. Fertigation in high value crops - A review. Agric. Rev. **26**(1): 1-13.

Zhang TQ, Liu K, Tan CS, Hong JP and Warner. J 2010. Evaluation of agronomic and economic effects of nitrogen and phosphorus additions to green pepper with drip fertigation. Agronomy Journal **102**(5): 1434-1440.

Gomez KA and Gomez AA 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons, New York.

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