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Effect of Drip Fertigation and Mulching on Yield Parameter and Water Productivity of Pigeonpea (*Cajanus cajan* L.)

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ABSTRACT

Background: Pigeonpea is second most important pulse crop grown after chickpea in India. Pigeonpea is versatile crop can be grown in vast agro climatic condition with low input. Although the yield is very less as compare to the potential yield, so we need to increase the yield of pigeonpea using modern techniques such as drip fertigation and mulching. Both these techniques are resource saving and realized maximum yield as compare to conventional practices.

Methods: The experiment was laid out in factorial complete randomized block design with three replications. The experiment consisted of two levels of irrigation (0.50 CPE and 0.75 CPE) as one factor and three fertility levels (100% RDF,75% RDF and 50% RDF) as second factor and two levels of mulching (without mulching and with plastic mulching 25 micron) as third factor.

Result: The results revealed that the combination of higher level of irrigation with 100 per cent RDF and with plastic mulching recorded significantly higher seed yield, water productivity and B.C ratio compared to the rest of the treatment combination.

Key words: Drip fertigation, Growth, Mulching, Pigeonpea, Yield.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] also known as red gram, tur or arhar is the fifth major pulse crop grown throughout the world and second prominent pulse crop in India after chickpea. According to the FAO statistics, global pigeonpea cultivation increased at an annual rate of 1.3% from about 2.7 million hectares in 1961 to about 4.6 million hectares in 2007 (FAO, 2008). Globally pigeonpea production grew at an annual rate of 2.5% from about 2.2 million tons in 1961 to about 3.4 million tons in 2007 representing an increase of about 54% (FAO, 2008). In the tropics and sub-tropics of India, South-East Asia and Africa, it is mainly known as subsistence crop while in West Indies as important cash crop. Pigeonpea grown as hedge row, vegetable in kitchen gardens and also act as wind break. Pigeonpea remained at second position in total pulse production with 4.25 m t recorded in an area of 4.45 m ha with average productivity of 960 kg ha^{-1} (Anonymous, 2018). Pigeonpea has good yield potential but production and productivity is very low because in most of the region it is cultivated as rainfed crop.

Drip irrigation has significant impact on resource saving, crop yield and profitability of farm compared to other means of irrigation methods. Drip fertigation is a highly efficient method for fertilizer application, minimize losses and adverse environment impact on crop production. Both water and nutrient uptake by the plant and realized maximum dry matter and yield (Ramana Rao *et al*. 2018). The nutrient and water losses from the soil is minimized through mulching and utilized to a greater extent. Among the different production factor like irrigation and nutrient management has immense importance. Although soil moisture conservation can be achieved through different practices. Mulching is one of the most promising practice to conserve the moisture and other resources. Mulching helps to reduce the losses of water from soil, preventing the soil particles from direct contact of rain drops which helps to control the soil erosion and check the run-off losses. Application of mulching on soil surface helps to maintain the optimum soil temperature which favored the plant growth, suppress the weed population and prevent the losses of nutrients from the soil (Kamar *et al.* 2018). Drip fertigation and mulching and their combined effects was significant with respect to overall growth parameters (plant height, leaf area and number of branches), yield attribute and final yield of pigeonpea (Solanki *et al.,* 2019).

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MATERIALS AND METHODS

A field experiment was conducted during *Kharif 2019* at University of Agricultural Science Bangalore, GKVK, ZARS in red sandy loam soil. The experiment consisted of two levels of irrigation (0.50 CPE and 0.75 CPE) as one factor and three fertility levels (100% RDF, 75% RDF and 50% RDF) as second factor and two levels of mulching (without mulching and with plastic mulching 25 micron) as third factor.

The soil was low in available nitrogen (262.08 kg ha^{-1}), medium in available phosphorus (20 kg ha^{-1}), medium in available potassium (269.7 kg ha^{-1}), The soil was acidic in nature (5.87) with electrical conductivity in the safer range.

The recommended dose of fertilizer (RDF) 25:50:25 N, P_2O_5 and K_2O kg ha^{-1} respectively. The sources of fertilizer were urea, DAP and MOP for NPK respectively. Cultivar BRG-5 was sown with spacing of 180/60 cm x 30 cm (180 cm between lateral and 40 cm between emitter). Drip irrigation was schedule once in seven days up to flowering and then once in three days after flowering based on CPE value.

RESULTS AND DISCUSSION

Effect of drip fertigation and mulching on yield of pigeonpea

Seed yield of pigeonpea affected significantly due to various levels of irrigation, fertility and mulching were presented (Table 1). The crop irrigated with drip system at 0.75 CPE recorded highest seed yield (1364 kg ha^{-1}) compared to lower irrigation at 0.50 CPE (1166 kg ha^{-1}). The highest seed yield was obtained with higher levels of fertigation with 100 per cent RDF (1509 kg ha^{-1}) followed by 75 and 50 per cent RDF (1197 and 1089 kg ha^{-1}, respectively). Significantly highest seed yield was recorded with plastic mulching (1423 kg ha^{-1}) as compared to without mulching (1107 kg ha^{-1}). Seed yield of pigeonpea was significantly higher due to individual factors and their interaction effects also. This was because of higher levels of irrigation provide optimum moisture to plant and higher fertility levels provides more nutrients to plant in available form and reduce the losses of nutrients because they are supplied through drip irrigation which helps to match the supply and demand of crops. Mulching also helps to reduce the evaporation losses of moisture from the soil and maintains optimum temperature and also reduce the weeds which helps to provide weed free condition and crop growth is good and gives higher yield. Similar finding was reported by Savani *et al*. (2017) and Kamar *et al.* (2018).

Kumar and Sharma (2017) reported that black plastic mulch and 125 per cent NPK application increased plant growth, yield and quality of cauliflower and recorded 88.7 per cent higher curd yield *i.e.* 266.8 q ha^{-1} over control. Kamar *et al*. (2018) opined that the biological yield varied significantly due to the interaction effect of irrigation and mulch. The highest biological yield of 22.24 t ha^{-1} was recorded from1_3M_3 (I_3: Two irrigations each at 4 leaf stage and 8-10 leaf stage and M_3: Mulch with 2 cm thickness) and the lowest of 17.04 t ha^{-1} from 1_1M_4 (I_1 Farmer practice, M_4: Mulch with 3 cm thickness).

The interaction effect of drip fertigation and mulching on yield and water productivity of pigeonpea (Table 1.1). In all the treatment combinations $I_2F_1M_1$ (0.75 CPE, 100 % RDF and with plastic mulching) recorded significantly higher yield (2091 kg ha^{-1}) compared to rest of treatment combinations.

The stalk yield of pigeonpea was affected significantly due to different levels of irrigation, fertigation and mulching. The crop irrigated with drip at 0.75 CPE recorded higher stalk yield (3777 kg ha^{-1}) compared to the lower level of irrigation with 0.50 CPE (3464 kg ha^{-1}). The highest stalk yield ha^{-1} was obtained with 100 per cent RDF (3815 kg ha^{-1}) followed by 75 per cent and 50 per cent RDF (3620 and 3426 kg ha^{-1}, respectively). Higher stalk yield ha^{-1} was recorded with mulching (3923 kg ha^{-1}) as compared to without mulching (3318 kg ha^{-1}). Similar results have been found by Patel *et al*. (2015) and Mathukia *et al.* (2015). This might be due to optimum moisture available during entire crop growth period and fertilizers are applied through drip which reduce losses and efficiently uptake of nutrients led to taller plant, maximum number of branches, more leaf area plant^{-1} and finally more dry matter or stalk yield. Further mulching reduces the competition for nutrients and space by suppressing the weeds which helps to increase plant canopy vigorously and produce more stalk yield. Reddy *et al.* (2010) studied that the response of French bean (rajmash) to irrigation schedules and nitrogen levels. Scheduling of irrigation at 1.0 IW: CPE was significantly better than 0.8 or 0.6 IW: CPE ratios or irrigating the crop at pre flowering and pod development stages in terms of yield and yield attributes. Mahalakshmi *et al.* (2011) reported that pigeonpea seed yield and dry matter yield were higher when irrigations scheduled by drip at 0.8 E pan throughout crop life. The increase in yield was 36.2 per cent more when irrigation was scheduled by drip at 0.8 E pan throughout crop life compared to surface furrow irrigation at 0.8 IW: CPE ratio.

Effect of drip fertigation and mulching on water productivity of pigeonpea

The water productivity of different irrigation levels (0.50 CPE) and (0.75 CPE) was obtained 67.3 and 59.4 kg ha-cm^{-1}, respectively which indicates that water productivity at 0.50 CPE was significantly higher than 0.75 CPE. Highest water productivity was recorded in higher fertigation level of 100 per cent RDF (75.3 kg ha-cm^{-1}) followed by 75 per cent RDF and 50 per cent RDF (59.8 and 55.0 kg ha-cm^{-1}, respectively). The mulching recorded higher water productivity (71.1 kg ha-cm^{-1}) than without mulching (55.7 kg ha-cm^{-1}). The similar finding was reported by Kumar *et al*. (2016) and Savani *et al*. (2017).

The interaction effect of irrigation, fertigation and mulching on water productivity was found to be significant. Highest water productivity 91.2 kg ha-cm^{-1} was recorded with $I_2F_1M_1$ (0.75 CPE, 100 % RDF and with mulching) than rest of the treatment combinations, but on par with $I_1F_1M_1$ *i.e.* (0.50 CPE, 100 % RDF and with mulching) 84.1 kg ha-cm^{-1}. Similar finding was reported by Solanki *et al.* (2019).

These results indicated that lower levels of irrigation gives higher water productivity because of more yield is produced with less amount of water. Higher water productivity was observed with interaction effect because of more yield is obtained and less losses of water through

Table 1: Effect of drip fertigation and mulching on yield and water productivity of pigeonpea.

Treatments	Seed yield(kg ha^{-1})	Stalk yield(kg ha^{-1})	Water productivity (kg ha-cm^{-1})
Irrigation levels (I)			
I_1: 0.50 CPE	1166	3464	67.3
I_2: 0.75 CPE	1364	3777	59.4
SEm(.±)	29.5	75.8	1.5
C.D (5%)	86.5	222.3	4.4
Fertilizer levels (F)			
F_1 : 100 % RDF	1509	3815	75.3
F_2 : 75% RDF	1197	3620	59.8
F_3 : 50% RDF	1089	3426	55.0
SEm(.±)	36.1	92.8	1.8
C.D (5%)	106.0	272.3	5.45
Mulching levels (M)			
M_0 : Without mulching	1107	3318	55.7
M_1 : With Mulching	1423	3923	71.1
SEm(.±)	29.5	75.8	1.5
C.D (5%)	86.5	222.3	4.4

Table 1.1: Interaction effect of drip fertigation and mulching on yield and water productivity of pigeonpea.

Treatment combinations	IxFxM		
	Seed yield(kg ha^{-1})	Stalk yield(kg ha^{-1})	Water productivity (kg ha-cm^{-1})
$I_1 F_1 M_0$	1238	3204	71.5
$I_1 F_1 M_1$	1457	4133	84.1
$I_1 F_2 M_0$	936	3129	54.1
$I_1 F_2 M_1$	1227	3726	70.9
$I_1 F_3 M_0$	985	3116	56.9
$I_1 F_3 M_1$	1152	3476	66.5
$I_2 F_1 M_0$	1249	3602	54.5
$I_2 F_1 M_1$	2091	4323	91.2
$I_2 F_2 M_0$	1219	3526	53.1
$I_2 F_2 M_1$	1407	4098	61.4
$I_2 F_3 M_0$	1013	3332	44.2
$I_2 F_3 M_1$	1206	3781	52.6
SEm(.±)	72.2	185.7	3.7
C.D (5%)	212.0	NS	10.9

evaporation from soil surface (Solanki *et al*. 2019). Datta and Chatterjee (2006) observed that irrigation influenced the moisture extraction pattern of the fenugreek and higher amount of moisture was extracted from the surface layer irrespective of irrigation treatment and depletion of soil moisture increased with increasing level of irrigation. Seed yield and water use efficiency were influenced by different levels of irrigation. The highest water use efficiency was recorded in no irrigation and it was lowest in highest level of irrigation at 1.0 IW: CPE. The highest seed yield, gross return, net return and B: C ratio were recorded at 1.0 IW: CPE ratio. Scheduling of irrigation at 1.0 IW: CPE ratio was most beneficial followed by 0.8 IW: CPE ratio and irrigation at branching + flowering + seed development stages in terms of yield and return. Savani *et al*. (2017) reported that the water use efficiency obtained under irrigation levels of 0.4, 0.6 and 0.8 CPE through drip and surface irrigation were 3.65, 3.02, 2.45 and 1.90 kg ha-mm-1 of water used, respectively. This indicated that WUE decreased with increase in level of irrigation. Drip irrigation scheduled at lower level (0.4 CPE) recorded higher WUE of 3.65 kg ha-mm-1 with 49 per cent water saving.

Effect of drip fertigation and mulching on soil moisture content at different soil depth

Average soil moisture up to 15 cm and 30 cm depth of soil

The data pertaining to soil moisture content at different depth as influenced by different levels of drip fertigation and mulching is presented in Table 2 and Table 2.1. Higher soil moisture content was obtained in the field with higher levels of irrigation at 0.75 CPE (12.7 and 12.1 %, respectively) compare to lower levels of irrigation at 0.50 CPE (11.5 and 11.1 %, respectively) up to 15 and 30 cm of soil depth which

Table 2: Effect of different levels of drip fertigation and mulching on soil moisture content at different depth of soil during crop growth.

Treatments	Soil moisture at 0-15 cm (%)	Soil moisture at 15-30 cm (%)	Soil moisture at 30-60 cm (%)
Irrigation levels (I)			
I_1: 0.50 CPE	11.5	11.1	10.1
I_2: 0.75 CPE	12.7	12.1	11.3
SEm(.±)	0.2	0.2	0.3
C.D (5%)	0.6	0.6	0.9
Fertilizer levels (F)			
F_1 : 100 % RDF	12.1	11.7	11.1
F_2 : 75% RDF	11.5	11.6	10.6
F_3 : 50% RDF	11.8	11.3	10.4
SEm(.±)	0.2	0.26	0.4
C.D (5%)	NS	NS	NS
Mulching levels (M)			
M_0 : Without mulching	11.4	11.2	10.2
M_1 : With Mulching	12.2	11.9	11.2
SEm(.±)	0.2	0.2	0.3
C.D (5%)	0.6	0.6	0.9

Table 2.1: Interaction effect of different levels of drip fertigation and mulching on soil moisture content at different depth of soil during crop growth.

Treatment combinations	IxFxM		
	Soil moisture at 0-15 cm (%)	Soil moisture at 15-30 cm (%)	Soil moisture at 30-60 cm (%)
$I_1 F_1 M_0$	11.4	11.6	9.9
$I_1 F_1 M_1$	12.4	11.2	10.9
$I_1 F_2 M_0$	11.0	11.5	9.8
$I_1 F_2 M_1$	11.6	11.3	10.6
$I_1 F_3 M_0$	11.0	9.6	9.2
$I_1 F_3 M_1$	11.9	11.7	10.3
$I_2 F_1 M_0$	12.3	11.7	11.2
$I_2 F_1 M_1$	12.6	12.6	12.5
$I_2 F_2 M_0$	11.4	11.7	10.7
$I_2 F_2 M_1$	12.3	12.3	11.5
$I_2 F_3 M_0$	11.5	11.5	10.8
$I_2 F_3 M_1$	13.0	12.7	11.5
SEm(.±)	0.5	0.5	0.8
C.D (5%)	NS	NS	NS

was significantly differed. Soil moisture with mulching was significantly higher in both 15 cm and 30 cm in depth (12.2 and 11.9 %, respectively) as compared to without mulching (11.4 and 11.26 %, respectively). The similar finding was reported by Datta and Chatterjee (2006)

Average soil moisture at 60 cm depth of soil

The soil moisture content at 60 cm soil depth was higher when irrigation was applied at 0.75 CPE (11.3 %) than at 0.50 CPE (10.1 %). The higher soil moisture content was recorded with mulching (11.2 %) as compared with non-mulching (10.2 %) (Patel *et al.,* 2008). The interaction effect of different levels of irrigation, fertigation and mulching are recorded non-significant results on soil moisture at different depths.

The water is applied through drip irrigation which maintain the soil moisture at field capacity by application of water less than infiltration rate of the soil. At 15 cm of soil depth maximum moisture is obtained in lower irrigation level because of less infiltration rate and water accumulation in upper layer of soil. But at 30 cm soil depth, higher moisture was observed because of higher irrigation levels due to more supply of water and more infiltration which accumulate more water at deeper layer of soil (Gulati *et al.* 2009). At 60 cm of soil depth more moisture was found in higher irrigation levels because of mulching which conserved moisture and reduces the evaporation losses from the soil and more water is stored in deeper layer. Similar finding has been reported by Patel *et al.,* (2008).

The data pertaining to water saving through various levels of drip fertigation and mulching is presented in Table 3.

Table 3: Effect of different levels of drip irrigation and mulching on water saving in pigeonpea.

Treatments	Yield (kg ha^{-1})	Water applied (ha-cm)	Water productivity (kg ha-cm^{-1})	Water saving (%)
		Irrigation levels (I)		
I_1: 0.50 CPE	1166.4	17.3	67.3	24.4
I_2: 0.75 CPE	1364.6	22.9	59.4	

Table 4: Effect of different levels of drip fertigation and mulching on economics of pigeonpea cultivation.

Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Irrigation levels (I)				
I_1: 0.50 CPE	41293	81648	40354	1.97
I_2: 0.75 CPE	41293	95521	54228	2.30
Fertilizer levels (F)				
F_1 : 100 % RDF	42165	105654	63488	2.49
F_2 : 75% RDF	41330	83838	42508	2.02
F_3 : 50% RDF	40385	76262	35877	1.89
Mulching levels (M)				
M_0 : Without mulching	38836	77497	38660	1.99
M_1 : With mulching	43750	99672	55922	2.27

Drip irrigation scheduled at lower level *i.e.* 0.50 CPE saves 24.4 per cent of water as compared to higher level *i.e.* 0.75 CPE. This was because of lower irrigation levels give much higher yield with less amount of water compare to higher amount of water. Similar finding was reported by Biswas *et al.* (2015) and Savani *et al*. (2017).

Effect of different levels of drip fertigation and mulching on economics of pigeonpea

The data pertaining to economics of pigeonpea cultivation as influenced by different levels of irrigation, fertigation and mulching are presented in Table 4. The higher gross returns (Rs. ha^{-1}) and benefit-cost ratio of pigeonpea was obtained with 0.75 CPE, 100 per cent RDF and mulching (Rs. 95521, Rs.105654, Rs.99672 ha^{-1} and 2.30, 2.49 and 2.27, respectively) and lowest in 0.50 CPE, 50 per cent RDF and without mulching (Rs. 81648, Rs. 76262, Rs. 77497 ha^{-1} and 1.97, 1.89 and 1.99, respectively).

The highest net returns were obtained with 0.75 CPE, 100 per cent RDF and mulching (Rs. 54228, Rs. 63488 and Rs. 55228 ha^{-1}, respectively) and lowest with 0.50 CPE, 50 per cent RDF and without mulching (Rs. 40354, Rs. 35877 and Rs. 38660 ha^{-1}, respectively).

The gross returns, net returns and B: C ratio higher due to more seed yield kg ha^{-1} is obtained because of optimum moisture in higher irrigation levels, adequate supply of fertilizer through drip irrigation and favarouble environmental condition maintain by mulching leads to more seed and stalk yield. Similar finding was reported by Meena *et al*. (2012), Vishwanatha *et al.* (2012) and Solanki *et al.* (2019).

CONCLUSION

Based on the above experiment it can be concluded that application of water at 0.75 CPE + 100 per cent RDF with mulching gives higher yield, water productivity, gross and net return as well as higher B: C ratio compared to rest of the treatment combinations. Irrigation at 0.50 CPE gives higher water productivity as compared to higher irrigation level (0.75 CPE). This study help farmer to increase their production with less use of inputs and conserve the natural resource for future needs

REFERENCES

Anonymous, (2018). Annual Report Directorate of Pulse Development, Ministry of Agriculture and Family Welfare, Government of India, pp. 38-39.

Biswas, S.K., Akanda, A.R., Rahman, M.S. and Hossain, M.A., (2015). Effect of drip irrigation and mulching on yield, water-use efficiency and economics of tomato. Plant Soil Environ. 61(3): 97-102.

Datta, S. and Chatterjee, R., (2006). Effect of irrigation regimes on moisture extraction pattern, evapotranspiration and yield of fenugreek (*Trigonella foenum-graecum* L.). J. Spices and Aromatic Crops. 15(2): 125-129.

FAOSTAT, (2008). Online agricultural statistics. www.faostat.org

Gulati, J.M.L., Mishra, M.M., Patra, A.K. and Singh, D.N. (2009). Influence of irrigation and nitrogen levels on bulb yield, water use efficiency and moisture extraction pattern and ET/EPan ratio in onion (*Allium cepa).* Environ. Eco. 27(2): 659-662.

Kamar, S.S.A., Khan, M.H. and Uddin, M.S. (2018). Effect of irrigation and mulch on maize yield (*Zea mays*) in southern areas of Bangladesh. J. Agri. Crop Res. 6(2): 28-37.

Kumar R., Pal, R., Kumar, R., Sagar, S. and Ankur, S.B. (2016). Response of water use efficiency through fertigation on growth and yield of chilli crop. Inter. J. Engi. Sci. and Res. Tech. 5(12):

Kumar, V. and Sharma, J.C. (2017). Soil and plant nutrient status as modified by different types of mulching in cauliflower. Curr. J. Appl. Sci. Tech. 24(1): 1-8.

Mahalakshmi, K., Kumar, K.A., Reddy, M.D. and Devi, M.U. (2011). Response of *rabi* pigeonpea [*Cajanus cajan* (L.)] to different levels of drip irrigation. J. Res. ANGRAU. 39(4): 101-103.

Mathukia, R.K., Mathukia, P.R. and Polara, A.M. (2015). Effect of preparatory tillage and mulch on productivity of rainfed pigeonpea [*Cajanus cajan* (L.) Millsp.]. Ind. J. Dryland Agric. Res. and Dev. 30(2): 58-61.

Meena, M.C., Dwivedi, B.S., Singh, D., Sharma, B.M., Kumar, K. and Rana, D.S. (2012). Effect of integrated nutrient management on productivity and soil health in pigeonpea (*Cajanus cajan*)- wheat (*Triticum aestivum*) cropping system. Ind. J. Agron. 57(4): 333-337.

Patel, A.R., Gohel, T.J., Davara, D.K. and Solanki, M.H. (2015). Effect of drip irrigation and mulching on growth, yield and water use efficiency of *rabi* pigeonpea (*Cajanus cajan* L.). Trends in Biosciences. 8(16): 4275-4279.

Patel, I.C., Patel, B.S., Patel, M.M., Patel, A.G. and Tikka, S.B.S. (2008). Effect of irrigation schedule, dates of sowing and genotypes on yield, water use efficiency, water expense efficiency and water extraction pattern of cowpea. J. Food Leg. *2*1(3): 175-177.

Ramana, Rao, K.V., Aherwar Pushplata, Gangwar, S., Kumar, S. and Yadav, D. (2018). Growth, yield, economics, water use efficiency and microbial functions of pigeonpea crop influenced by drip irrigation with plastic mulch. Inter. J. Curr. Microbiol. App. Sci. 7(12): 2284-2290.

Reddy, M.M., Padmaja, B. and Reddy, D.R.R. (2010). Response of French bean to irrigation schedules and nitrogen levels in Telangana region of Andhra Pradesh. J. Food Leg. 23(1): 38-40.

Solanki, M.A., Chalodia, A.L., Fadadu, M.H. and Dabhi, P.V. (2019). Response of pigeonpea to drip irrigation and mulching. Inter. J. Curr. Microbiol. App. Sci. 8(2): 91-97.

Savani, N.G., Patel, R.B. Solia, B.M., Patel, J.M. and Usadadiya, V.P. (2017). Productivity and profitability of *rabi* pigeonpea increased through drip irrigation with mulch under south Gujarat condition. Inter. J. Agri. Innov. Res. 5(5) 2319-1473.

Vishwanatha, S., Anilkumar, S.N., Koppalkar, B.G., Pujari, B.T. and Desai, B.K. (2012). Effect of fertilizer management on economics and yield advantages of pigeonpea and sunflower intercropping system. Inter. J. Fore. Crop Imp. 3: 76-79.