Influence of Subsurface Drip Irrigation System on Growth and Yield of Sunflower (*Helianthus annuus* L.) in Scarce Rainfall Zone of Andhra Pradesh in Subtropical India

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Citation Information: Helia. Volume 37, Issue 60, Pages 69–75, ISSN (Online) 2197-0483, ISSN (Print) 1018-1806,DOI: 10.1515/helia-2014-0005, June 2014

Publication History

Received:
2013-12-24
Accepted:
2014-05-20
Published Online:
2014-06-24

Abstract

This study was conducted during 2009 and 2010 at Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India to evaluate the feasibility of subsurface drip irrigation (SDI) in vertisols and its influence on sunflower crop under two lateral spacings with two lengths of lateral and two levels of nitrogen. The experimental design was a split split plot with three replications. Laterals, buried at 30 cm depth in the soil, were set as per treatments, and emitters are spaced 40 cm apart. The experimental results indicated that the SDI with lateral spacing of 150 cm is feasible in vertisols with 75 kg N/ha can be adopted, and length of lateral can be adjusted depending on the layout of the SDI system in the field.

Keywords: sunflower; subsurface drip irrigation; nitrogen fertilization; vertisols

Introduction

Depleting ground water supplies and increased competition for available sources in scarce rainfall zone of Andhra Pradesh in India have resulted in an increased need for efficient irrigation systems. Numerous studies have shown that drip irrigation can increase the water use efficiency of crop production. Subsurface drip irrigation (SDI) is a variation of the conventional surface drip irrigation. Camp *et al*. (1989) found that SDI required less water than surface drip irrigation and is different from surface method only in the way that the lateral pipes are buried below the ground surface unlike the same laid on the surface and has many benefits over conventional drip irrigation (Singh and Rajput, 2007). It is a highly efficient method of water application, with minimum of water losses through evaporation and deep percolation, thus assisting water and nutrient conservation. Lamm *et al*. (1995) evaluated the water requirement of subsurface drip irrigated for corn and found water savings of ~25% which were achieved primarily through reductions in deep percolation and evaporation from the soil surface.

The laterals are buried in a depth below the soil surface depending mostly on the tillage practices and the crop to be irrigated. Also, the biophysical advantages are the lower canopy humidity and fewer diseases and weeds (Camp and Lamm, 2003). Subsurface drip has proven to be an efficient irrigation method with potential advantages of high water use efficiency, fewer weed and disease problems, less soil erosion, efficient fertilizer application, maintenance of dry areas for tractor movement at any time, flexibility in design, and lower labor costs than in a conventional drip irrigation system. However, there are also some disadvantages with SDI, which mainly relate to poor or uneven surface wetting and risky crop establishment (Lamm, 2002).

An overview of published studies shows that lateral spacing ranges from 0.25 to 5 m for SDI, as determined by crop behavior, cultural practices, and soil properties. Wider lateral spacing is practiced in heavy textured soil (Camp, 1998) while closer spacing is recommended for sandy soil (Phene and Sanders, 1976). Lateral spacing is generally one drip line per row/bed or an alternative row/bed with one drip line per bed or between two rows (Lamm and Camp, 2007). Lateral spacing of 1.5 m in subsurface drip-irrigated corn was successful in a silt loam soil (Darusman *et al*., 1997). Lateral spacing of 2 m intervals on a 1:2 drip tape: crop row has been successful in Queensland for cotton (Raine *et al*., 2000). Further, lateral diameter and length influence water application uniformity (Kang *et al*., 1999). In Greece, 17 mm polyethylene pipe was used at the shorter row length of 30 m for sugar beet (*Beta vulgaris* L.) research using subsurface drip (Sakellariou-Makrantonaki *et al*., 2002). As the installation costs for SDI are high and it has not been considered a viable economic option for oilseed crops such as sunflower. However, the use of SDI in row-crop agriculture is increasing because of potential increase in water and nutrient use efficiency. Increasing the spacing of drip line laterals would be one of the most significant factors for reducing the overall investment costs of SDI.

Hence, the present investigation was taken up to study the feasibility of SDI system and its influence on growth and seed yield of sunflower under varied spacings of laterals and nitrogen fertilization in vertisols of scarce rainfall zone of Andhra Pradesh in India.

Materials and methods

A field experiment was conducted at Regional Agricultural Research Station, Nandyal, Andhra Pradesh, India during 2009 and 2010. The soils were vertisols (deep black cotton soils) and slightly alkaline in nature with pH of 8.4 with a texture of clay loam. The soil of the experimental site was low in available N (198 kg/ha), high in available P_2O_5 (58 kg/ha) and K_2O (412 kg/ha) (Arora, 2002). The treatments comprised two lateral spacings (120 and 150 cm), two lengths of laterals (20 and 30 m) and two levels of nitrogen (100 and 125% recommended dose of nitrogen accounting to 75 and 94 kg N/ha, respectively) and the test hybrid was NDSH-1. The treatments were arranged in Split split plot design with lateral spacing as main plots, length of laterals as subplots, and nitrogen levels as sub-subplots and replicated thrice. The recommended levels of fertilizers were 75:90:30 kg N, P_2O_5 and K_2O/ha. The crop was sown in January and December during 2009 and 2010, respectively. A spacing of 60 cm × 30 cm was adopted. There were 10 rows per elementary plot. The size of main plot, subplot and sub-subplot was 720, 360 and 180 m^2, respectively. There were ten rows per elementary plot. Full dose of P and K along with half of N as per the treatment was applied as basal, and the remaining half of N was top dressed by point placement method in two splits at 35 and 55 days after sowing. Standard package of practices were followed in raising the crop. A total rainfall of 692.0 and 1,118.0 mm was received during 2009 and 2010, respectively, and no rainfall was received during crop growth period. The size of elementary plot for harvesting was 4.8 × 5.0 m. Data on plant height and head diameter were recorded at harvesting stage, and 100 seed weight and seed yield were recorded after harvest and expressed on air dry basis. The data thus obtained were subjected to statistical analysis as per the recommended methods (Gomez and Gomez, 1984), and critical difference at 5% level was used for testing the significant difference among the treatment means.

Details of SDI system

The headwork of SDI system used for conducting the field experiment consisted of a 7.5 HP motor to develop required pressure in system and to lift water from a farm pond adjacent to the experimental site and deliver water to main pipeline, laterals and emitters after filtering through sand and screen filter. One by-pass, control valve, and pressure gauge were also provided after the pump to adjust flow and monitor system pressure. Also, a water meter was connected to the pipe line system to record the amount of water given to field during each irrigation. The main line delivered water to three sub-mains each fitted with a valve and a pressure gauge. Main and sub-main lines were buried at a depth of 30 cm from soil surface. Laterals were connected with sub-mains. Laterals with diameter 16 mm having inbuilt emitters of 2.4 L/h and inline emitters spaced at 40 cm apart were used in the study. The crop was established by giving a pre-sowing irrigation of 60 mm, and later the crop was irrigated at critical stages*i.e*. vegetative stage, star bud stage, and flowering and grain filling stages. Water applied to crop by SDI was 125 and 115 mm during 2009 and 2010, respectively.

Results and discussion

Plant height

A numerical increase in plant height was noticed with lateral spacing of 120 cm (141.4 and 138.6 cm during 2009 and 2010, respectively) and lateral length of 20 m (146.1 and 143.2 cm during 2009 and 2010, respectively), but was found to be statistically on par with that of recorded with lateral spacing of 150 cm (141.3 and 132.5 cm during 2009 and 2010, respectively) and lateral length of 30 m (136.6 and 127.9 cm during 2009 and 2010, respectively). However, significantly higher plant height was observed with application of 94 kg N/ha (148.5 and 142.4 cm during 2009 and 2010, respectively) over 75 kg N/ha (134.2 and 128.6 cm during 2009 and 2010, respectively).

Yield parameters

Head diameter recorded with varying lateral spacings of 120 and 150 cm and length of laterals (20 and 30 m) during both the years of study did not differ significantly. However, during 2010, application of 94 kg N/ha resulted in significantly higher head diameter (15.6 cm) over 75 kg N/ha (13.6 cm) where as in 2009, different levels of nitrogen fertilization could not significantly influence head diameter. A similar trend was noticed with 100 seed weight which was not influenced significantly either due to lateral spacings (120 and 150 cm) or length of laterals (20 and 30 m) or nitrogen fertilization (75 and 94 kg/ha) treatments during both the years of study.

Seed yield

A mean seed yield of 1,457 kg/ha was realized with lateral spacing of 120 cm over 150 cm (1,390 kg/ha), 1,452 kg/ha with lateral length of 20 m over 30 m (1,395 kg/ha), and 1,474 kg/ha with 94 kg N/ha over 75 kg N/ha (1,374 kg/ha). It is clearly indicated in Table 1 that seed yields during 2009 and 2010 due to different treatments under study did not vary significantly. Spurgeon and Manges (1990) reported no significant differences in corn yields among drip line spacings ranging from 0.75 to 3.0 m in a wet season.

Tab.
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Table 1:

Effect of SDI on yield attributes, seed yield and water use efficiency (WUE) of sunflower during 2009–2010 and 2010–2011

The possible double interaction effects *i.e*. lateral spacings and length of laterals, lateral spacings and nitrogen levels, and length of laterals and nitrogen levels and triple interaction effect *i.e*. lateral spacing and length of laterals and nitrogen levels were non-significant effect.

Water use efficiency

During both the years of study, higher WUE was recorded with a lateral spacing of 120 cm, 20 m lateral length, and 94 kg N/ha, and this was due to better performance of crop resulting in increased seed yield.

Conclusions

On the basis of present study, it can be concluded that response of SDI method in deep vertisols on sunflower is positive with respect to its growth, yield, and water use efficiency. As the variation in seed yield of sunflower due to lateral spacings of 120 and 150 cm did not vary significantly, a lateral spacing of 150 cm could be preferred to reduce the installation cost of SDI system. Similarly, Powell and Wright (1993) recommended that subsurface drip lines installed in alternate corn row middles (1.83 m) or under every third row (2.74 m) would be the most cost effective of the drip line spacings evaluated. Also, either 20 or 30 m lateral length can be opted depending on the layout of the SDI system in the field. With regard to nitrogen fertilization, existing recommended dose of nitrogen *i.e*. 75 kg N/ha for irrigated sunflower in scarce rainfall zone of Andhra Pradesh holds good for SDI system also.

Acknowledgments

All type of help rendered by Acharya N.G. Ranga Agricultural University, Rajendranagar Hyderabad, Andhra Pradesh, India during course of study to the authors is gratefully acknowledged.

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