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Effect of methods of irrigation and sulphur nutrition on seed yield, economic and bio-physical water productivity of two sunflower (*Helianthus annuus* L.) hybrids

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ABSTRACT

A field experiment was conducted to find out the effect of methods of irrigation and sulphur nutrition on productivity of sunflower hybrids at Punjab Agricultural University, Ludhiana during spring season of 2016 and 2017. The experiment was laid out in randomized complete block design and treatments comprises combination of two hybrids (PSH 1962 and PSH 996), two methods of irrigation (drip and furrow irrigation) and four sulphur levels (0, 20, 40 and 60 kg S ha^{-1}). PSH 1962 recorded 12.9% higher seed yield with 27.3% higher economic water productivity because of significantly superior yield attributing characters viz. capitulum diameter, capitulum weight, seeds per capitulum and 1000 seed weight than PSH-996. PSH 1962 recorded Rs 9393 ha^{-1} higher net returns along with 10.8 and 3.5% higher bio-physical water productivity (BPWP) and oil content than PSH 996, respectively. Drip irrigated crop produced significantly higher seed yield along with saving of 38.0% irrigation water and 32.6% higher water use efficiency as compared to furrow irrigated crop. Net returns, bio-physical and economic water productivity were also 32.7, 5.3 and 20.9% higher in drip than furrow irrigation, respectively. Seed yield increased successively and significantly with each increment in sulphur from 0 to 60 kg S ha^{-1}. Sulphur nutrition with 60 kg ha^{-1} recorded 31.1, 18.8 and 8.0% higher seed yield than 0, 20 and 40 kg ha^{-1}, respectively. Oil content increased to the tune of 3.2, 1.9 and 0.8% with 60 kg S ha^{-1} than 0, 20 and 40 kg S ha^{-1}, respectively. Net returns were Rs 11,185 ha^{-1} higher from 60 kg S ha^{-1} than control (0 kg S ha^{-1}) with 23.3% higher benefit: cost. Economic water productivity improved to the tune of Rs 2.32 with 60 kg S ha^{-1} over control (0 kg S ha^{-1}) with each cubic metre of consumptive use (actual evapotranspiration). Drip irrigated crop produced 18.8, 12.2 and 11.3% higher seed yield than furrow irrigated with 20, 40 and 60 kg S ha^{-1}. Drip irrigation also resulted in Rs 4.01, 2.49, 1.18 and 0.02 higher net returns with each cubic metre of consumptive use than furrow irrigation with 0, 20, 40, and 60 kg S ha^{-1}, respectively.

1. Introduction

Sunflower (*Helianthus annuus* L.) commonly known as '*surajmukhi*' belongs to family compositae and is a native of North America. In India, sunflower is cultivated on 0.59 million hectare, with total production of 0.43 million tonnes at productivity levels of 736 kg ha^{-1} (Anon., 2015). In Punjab, sunflower was grown on 6400 ha with total production of 11,500 tonnes at productivity levels of 1792 kg ha^{-1} (Anon., 2016a). Sunflower seed contains 40–45 % oil and 30% protein. The crude sunflower oil has light amber color, but in other hand refined oil has pale yellow with oleic acid 42–57 % and linoleic acid 33–48 %. Sunflower oil is a rich source of vitamin B_1 and B_2 complexes than other oilseed (Caldinin, 1958) and consists of high amount of monounsaturated and poly-unsaturated fatty acids as well as high vitamin E content, which competes with soybean, rapeseed, palm oil and cotton seed in world oilseed complex (Kleingartner, 1997). Hence, sunflower oil is considered as premium oil because of good nutritional value and high smoke point (252–255 °F).

India has imported edible oil of worth rupees 68,676.62 crores during 2015–16 (Anon., 2016b), which is a big drain on Indian economy. In India sunflower oil being imported mainly from Ukraine, Russia and Argentina to meet edible oil demand. But on the other hand India exports sunflower cake to other countries as animal feed (Nayak et al., 2013). Sunflower being a prospective and versatile oilseed crop can help to meet the increasing demands of edible oils and also check country's import exchanges.

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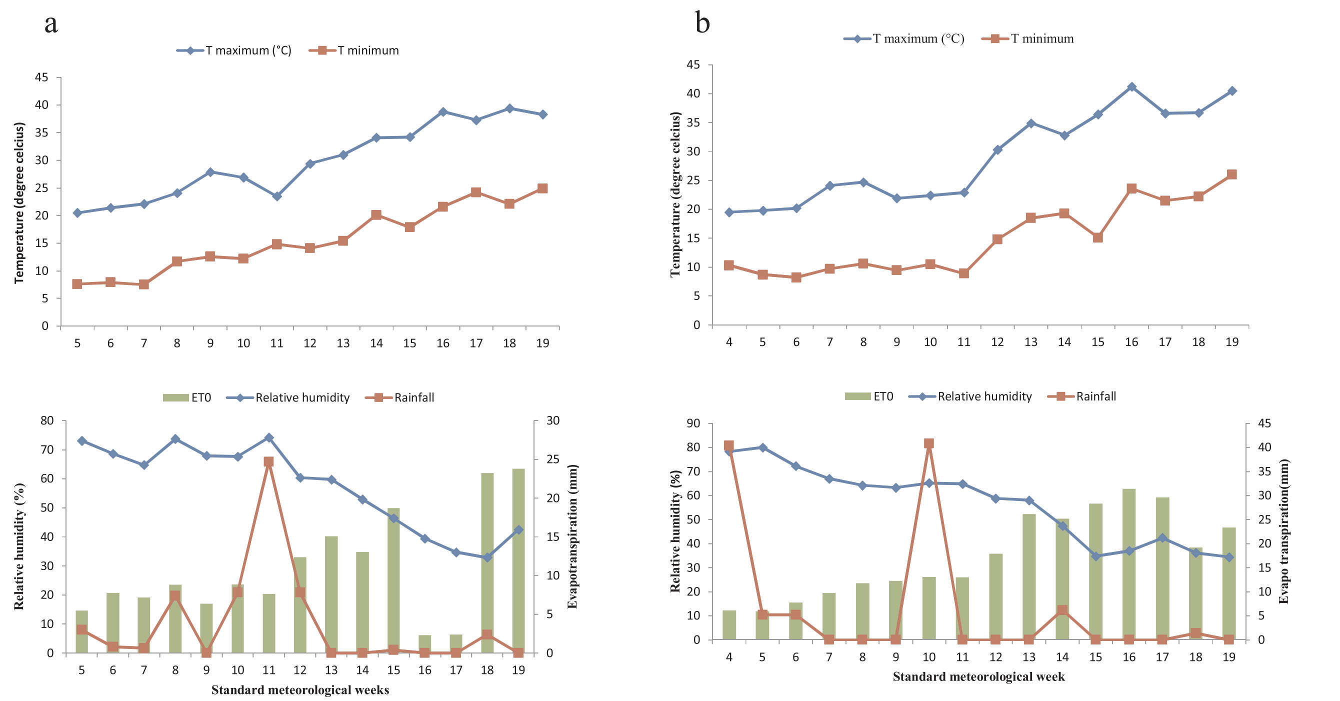

Fig. 1. (a) Weekly mean meteorological data recorded during the crop season of 2016. (b) Weekly mean meteorological data recorded during the crop season 2017.

In Punjab, rice-wheat is the predominant cropping system and the state contributes about 27.3 and 46.4% rice and wheat to central pool, respectively (Anon, 2016b). Rising production cost, degradation of natural resources and monoculture problems lead to declining of water table and forced policy makers to diversify this cropping system in the state. Sunflower fits well in high intensity cropping system like maize-potato-sunflower to diversify some area from rice-wheat in the state of Punjab. This system not only increases the cropping intensity but also increases the profit of the farmers. Secondly sunflower is a short duration, thermo and photo insensitive plant with wide range of climatic adaptability. In Punjab, sunflower is being cultivated in spring season (end of January to first week of February) during high evaporative demand period which makes its water requirement quite high despite a short duration crop. Yield of sunflower is greatly influenced by inputs (fertilizer and irrigation practices) and potential yield can be achieved by adopting optimum input schedules.

Optimum soil moisture is an important pre-requisite to obtain a good yield of sunflower. But, in Indian Punjab irrigation is a sole source of soil moisture because of scanty rainfall during spring season (February to mid June). Secondly, water resources of Punjab are depleting day by day (Brar et al., 2012) because of more acreage under rice cultivation and efficient utilization of available water resources is the need of the hour to achieve higher level of production per unit of water use. Drip irrigation, in which water is applied beneath the root zone of plant in small quantities at frequent interval, not only reduces or eliminates runoff, deep percolation, evaporation, minimizes the weed growth but also enhances crop productivity per unit of water use. Drip irrigation improves water use efficiency, nutrient uptake and quality of the produce (Kaur and Brar, 2016). Therefore, water use efficiency and productivity of crops can be improved greatly by using drip irrigation, under limited water applications (El-Hendawy et al., 2008).

Recently, Punjab Agricultural University, Ludhiana has developed a new sunflower hybrid PSH 1962, which has 6.1% higher oil content than earlier recommended hybrid PSH 996 (Anon., 2016a). Hence, there is a need for investigation on the nutritional requirement of sunflower in the state. Sulphur is an essential nutrient in oilseed production and plants require sulphur in equal amount to phosphorous (Kumar et al., 2011). Sulphur also called as quality element, because it improves odor and flavor of oil apart from being a component of amino acids i.e. cystine, cysteine and methionine (Hassan et al., 2007). Sulphur involves in the synthesis of chlorophyll, synthesis of oil (Marschner, 1986) and plays a major role in increasing the oil content of the seed (Chaudhary et al., 1992). Sulphur deficiency symptoms are more often observed at early stage of crop because it is easily leached down beneath the root zone (Hitsuda et al., 2005). Secondly, in the absence of sulphur, carbohydrates are not fully utilized for the synthesis of oil (Rani et al., 2009). Hence, application of sulphur in sunflower can show a great promise in promoting seed yield and oil content. Therefore, the present investigation was planned with the hypothesis whether fertigation of element sulphur along with drip will enhance the oil synthesis capability of sunflower hybrids having genetically higher and lower oil content.

2. Materials and methods

2.1. Location and weather

An experiment was conducted at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana during spring seasons of 2016 and 2017. The experimental site is situated at an altitude of 247 m above mean sea level in the central plain region of Punjab state under trans-gangetic agro-climatic zone of India, with latitude of 30° 54′ N and longitude of 75° 48′ E. The climate of this region is characterized as sub-tropical and semi-arid with very hot and dry summer from April to June, hot and humid conditions from July to September, cold winter from November to January and mild climate during February and March. Mean minimum and maximum temperature shows considerable fluctuation during summer and winter. The average annual rainfall of Ludhiana is 755 mm and greater portion (> 75%) of that is received from July to September as summer monsoon. During winter, the rains are scanty but a few showers of cyclonic rains are received during December-January or late spring. Spring season is marked by low temperature during early (sowing) and bright sunshine hours during mid and late (flowering or maturity) period of spring season.