Development of safflower as a new winter crop for the Texas High Plains

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Abstract
Energy and water are the two most important commodities that keep our economy operating at optimum performance and efficiency. A need for crops that produce vegetable oil for biofuels, as well as a crop that is water use efficient is imperative, especially if that crop could be grown during winter months to reduce demand on the Ogallala aquifer during peak summer months. The purpose of this research is to evaluate eight accessions of safflower exhibiting winter hardiness for water use efficiency under variable irrigation rates, while determining oil yield and quality potential for biofuel production, data used to establish safflower as a new winter crop for the Texas High Plains. On September 15, 2007, eight accessions of safflower from the USDA germplasm collection were planted in a randomized split block design. Irrigation rates were established using PET. The trials were planted on subsurface drip irrigation, with tape injected 20-25 centimeters below root zone on one meter centers. Each irrigation regime ranged from 2.65 (67 mm), 3.23 (82 mm), 3.68 (94 mm), 4.16 (106 mm), and 5.48 inches (139 mm) of supplemental irrigation above the 11.8 inches (300 mm) of rainfall during the growing season. The purpose of the irrigation regimes was to determine water use efficiency as a function of seed yield, which demonstrated maximum average yield of 1610 lbs/acre (1771 kg/hectare) occurred at 3.68 inches (94 mm), which was the mid range irrigation treatment. Also, each accession was evaluated for winter survivability, maturity date, seed yield, oil content, and fatty acid profile for each irrigation treatment. The selected safflower accessions demonstrated high water use efficiency as well as significant winter survivability, with maturity comparable to winter wheat, harvest occurring in late June and early July. Seed yields were significantly higher, as much as three times the yield, than summer safflower grown under similar irrigation rates in summer. Oil content demonstrated lower oil percentages than summer grown safflower, with comparable fatty acid profiles. This research will allow farmers to incorporate a new winter crop into their crop rotation strategy that is profitable as well as high in water use efficiency.

Keywords: Safflower - water use efficiency - winter hardiness - biofuels

Introduction

Energy and water are the two most important commodities that keep mechanized agriculture operating at optimum performance and efficiency. Therefore, there is an inherent need for crops that produce oil for use as an energy crop that can produce economical yields while being water use efficient. An added benefit to such a crop would be sufficient cold tolerance to survive the winters on the Texas High Plains and other comparable climates world wide. Winter safflower is a crop that can fulfill these requirements. Winter safflower is a crop that produces high quality oil for edible purposes or biofuel production while being highly water use efficient. Winter Safflower can produce higher yields with less water in the winter months when compared to spring safflower grown during the warmer summer months when potential evapotranspiration is higher (Johnson and Li, 2008). The purpose of this research was to evaluate eight accessions of safflower exhibiting winter hardiness for water use efficiency under variable irrigation rates to determine seed and oil yield for biofuel production.

Materials and Methods

Eight accessions of safflower from the USDA germplasm collection were planted on September 15, 2007 in a randomized split block design. Irrigation rates were determined by PET, potential evapotranspiration, even though true PET rates have not been determined for the Texas High Plains for winter safflower, an irrigation regiment was incorporated using estimated PET during peek crop water usage, for plant dormancy occurs during the coldest winter months. The soil profile was at field capacity at the time of planting due to summer fallow. The trials were planted on subsurface drip irrigation, with tape placed 20-25 centimeters below root zone on one meter centers. The five irrigation regimes were 67mm, 82mm, 94mm, 106mm, and 139mm additional irrigation above natural rainfall which was 300mm for the entire growing season. The purpose of the irrigation regimes was to determine optimum water use efficiency as a function of seed yield. Harvest date was June 27 for the earlier maturing accessions and July 8 for the longer maturing accessions.

Results

All eight accessions exhibited at least 80 percent stand survival for the winter of 2006-2007 in West Texas. The winter of 2007-2008 was extremely dry and windy as well as initial plant growth produced prior to first freeze was completely grazed to the ground by migrating Canadian Geese. All accessions exhibited cessation of dormancy by January 20, as vegetative growth resumed. Temperatures of minus 15 ^{0}C were recorded in early February resulting in no stand loss. Maximum yield for all accessions was 1771 kg/hectare (Figure 1.) of cleaned seed. This yield occurred at the irrigation rate of 94mm, which was the mid range irrigation treatment. Each accession was also evaluated for winter survivability, maturity date, oil content, and fatty acid profile under each irrigation treatment. The winter safflower accessions demonstrated superior water use efficiency, winter survivability, and early maturity compared to winter wheat grown under similar conditions. Seed yields of winter safflower were approximately three times higher than any cultivars of spring safflower we have evaluated on the Texas High Plains, when grown under similar irrigation rates. Oil content of the selected winter accessions was in the range of 24-28% (Table 1.), significantly lower than the oil levels observed in spring planted safflower (35-40%). However, the increased seed yield per hectare of the winter accessions allowed for higher oil production per hectare. Fatty acid analysis showed all eight accessions had high levels of linoleic acid content and lower oleic acid content than spring varieties selected for high oleic acid and oil content. This oil is still well suited for biofuel production, as well as use in the edible oil industry. This research will allow U.S. farmers to incorporate a new winter crop into their crop rotations that is profitable as well as highly water use efficient

Figure 1. Effect of supplemental irrigation applications on seed yield of eight accessions of winter safflower grown at Lubbock, TX in 2007-2008.

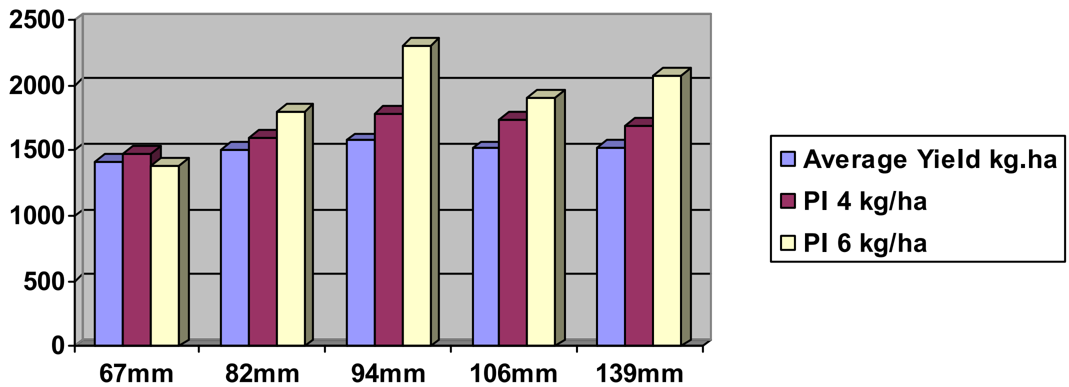

Table 1. Fatty acid composition and oil content of eight accessions of winter safflower grown at Lubbock, TX in 2007-2008.

	16:0	18:0	18:1	18:2	Oil%
PI 388901	5.1	2.0	17.2	73.6	28.7
PI 406002	5.6	2.2	17.3	72.6	27.7
PI 405984	6.2	2.3	14.5	75.2	24.0
PI 388903	5.7	2.1	13.2	76.5	26.9
PI 544017	5.1	1.6	13.8	76.2	23.5
PI 544016	5.0	1.6	15.4	74.2	22.7
PI 405985	5.5	2.1	14.5	74.6	25.8
PI 543985	5.1	1.6	14.3	76.0	22.4
Mean	**5.4**	**1.9**	**15.0**	**74.9**	**25.3**

References

Johnson, R.C. and Dajue Li. 2008. Registration of WSRC01, WSCRC02, and WSRC03 Winter Hardy Safflower Germplasm. Journal of Plant Registrations 2:140-142.