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Impact of climate change on safflower (*Carthamus tinctorius* L) in India and Mexico

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ABSTRACT

Twenty years (1990-2010) of climatic data of safflower growing region of India (Indore and Solapur) and Mexico (Hermosillo and Ciudad Oberagon) were used to tind out the trend and were related to productivity in the respective countries. The safflower growing environment were characterised and adapation measures are suggested under changing climatic condition in both the countries.

Key words : Safflower, climate change, production, productivity

Safflower (*Carthamus tinctorius* L) can be grown in most cropping regions in the world between the latitudes of 50° and 23° in both the northern and southern hemispheres. Safflower's ability to forage for subsoil moisture with its vigorous tap root, improved oil content and its versatility to produce linoleic and oleic oils makes it an obvious alternative to current crops grown in more marginal cropping areas around the world. Safflower is grown in about 60 countries. Although safflower is considered a minor crop with less than 1 m. ha planted, produces 500,000 t seed each year, it plays an important role in the oilseed economy of the world.

Currently safflower is grown primarily for oil and poultry feed. In the world, safflower is grown in 752,000 ha and the total production in 2009 was 646,000 tons. India, Kazakhstan, Argentina, the United States, and Mexico are the leading producers of safflower grown for both seed and oil. India occupies first position in terms of area (40%) and production (29%) of all safflower grown in the world. Kazakhstan occupied second position in area and fifth position in production due to low productivity of the crop (568 kg ha^{-1}). Though, China occupies 7th position in terms of area and occupies 6th position in terms of production, productivity of crop is high (1478 kg ha^{-1}). High productivity is observed in Mexico, USA, China, Canada and Ethiopia. The other safflower producing countries are Tanzania, Turkey, Kyrgystan, Australia, Uzbekistan, Ethiopia, Tajikistan, Canada and Iran (FAOSTAT, 2012).

Safflower is a major oilseed crop grown in peninsular India, particularly on Vertisol and associated soils over an area of 300,000 ha. The average productivity of the crop is 630 kg ha^{-1}. However, the productivity of the crop is low when compared to world productivity (859 kg ha^{-1}). India, however, accounts for almost half of the area sown to the crop world-wide, and its productivity is comparable to most of the developing countries. Within India, the crop is largely grown in Maharashtra (188,000 ha; productivity 580 kg ha^{-1}), Karnataka (68,000 ha; productivity 735 kg ha^{-1},), Gujarat (14,000 ha; productivity 857 kg ha^{-1}). Other states, where safflower is grown are Andhra Pradesh, Orissa, Chattisgarh, Jharkhand and Madhya Pradesh have much smaller area under the crop. Maharashtra and Karnataka states produce almost two thirds of the total India's production of 159,000 t (Anonymous 2011).

MATERIALS AND METHODS

Weather data of Indore and Solapur (1990-2010) was collected from All India Coordinated Research Project on Agrometeorology, CRIDA, Hyderabad while that of Hermosillo (Mexico) was browsed from the website: http://www.tutiempo.net/en/Climate/north_america.htm. The values given in the Table 1 (temperature, RH and rainfall/ precipitation) are mean of 20 years. Annual data for one year (2011-12) was used to depict the weather condition at Ciudad Oberagon, Mexico. Other details (time of sowing, harvest, crop duration) are approximated values collected from the literature. Comparison of growing conditions of safflower between India and Mexico are also presented.

RESULTS AND DISCUSSION

Growing environment of safflower in India and Mexico

Perusal of data presented in Table 1 reveals that safflower is grown during winter season in both the countries. It is sown during October to January and

Table 1: Comparison of growing conditions of safflower in India and Mexico

Particulars	Indore, India	Solapur, India	Hermosillo, Mexico	Ciudad Oberagon, Mexico
Latitude	22° 44' N	17° 41' N	29° 08' N	27° 48' N
Longitude	75° 50' E	73° 55' E	110° 95' W	109° 93' W
Altitude (m)	553	457	211	30
Sowing (month)	Nov.	Sept./Oct.	Dec./ Jan.	Dec./ Jan.
Harvesting (month)	Apr.	Jan./ Feb.	Apr./May	May/June
Tmin. during vegetative stage (°C)	12.7	20.2	8.6	6.4
Tmax. during reproductive stage (°C)	36.1	31.8	33.2	31.6
Mean RH during reproductive stage (%)	40	53	30	52
Annual rainfall (mm)	930	680	435	235
Seasonal rainfall (mm)	50	120	109	8
Crop duration (days)	140-150	110 – 120	140-150	140 - 150
Productivity (kg ha^{-1})	286	580	1675	1675
Crop growing conditions	Irrigated	Rainfed	Irrigated	Irrigated

harvested during February to May. Under rainfed condition its life cycle completes in 110-120 days. While under irrigated condition its duration extend upto 140-150 days. Rainfall in Indian regiones are higher than that of Mexico, where as temperate and humidity are more or less similar in both the countries. Hawever the productivity in Mexico is quite high (1675 kg ha^{-1}) than the Indian averages. (Table 1)

Climate change in Mexico

The annual maximum temperatures at hermosillo approximately increased by 1°C from 32.5° to 33.5°C in 20 years period while, minimum temperature has increased by 1°C from 16.5° to 17.5°C and annual precipitation has decreased from 450 mm to 200 mm at Hermosillo, Sonora, Mexico (Fig. 1).

Change in temperature, rainfall and safflower production in India

A comparative analysis of the annual rainfall data for the past 40 years (1971-2010) for Solapur revealed a decrease from an average of 800 mm during 1971-1990 to about 680 mm during the 20 year period 1991-2010 (Anon. 2011a). Another major change for safflower is the shift in the rain recorded in the month of September-October. As stated earlier the crop is sown in October and this shift is particularly damaging. The ambient temperatures are high during September, the crop can't be planted, when temperatures are suitable for planting safflower, the soil moisture in the seeding zone dries up by the month of October. Such a climate change in the rainfall pattern, therefore results in a poor stand of the crop in the core safflower production area of Maharashtra. A somewhat similar pattern of rainfall shift is observed in Padegaon (Anon 2011a). Further, analysis of monthly rainfall also shows that October rainfall has shifted. The rain recorded during the past decade (2001-2009) has shown a considerable reduction in the month of October. These data clearly demonstrate that climate-led variability of safflower production and productivity will be seriously dented in the core dryland crop growing areas of the Maharashtra state.

Observations of temperatures recorded at Solapur clearly demonstrated that average temperature regime is on an increase (As on 2011 a). This for safflower production

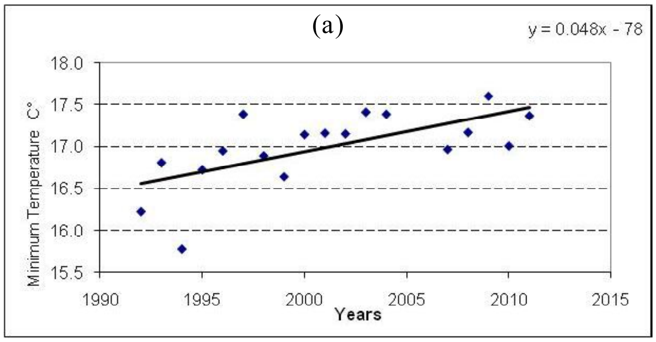

Fig. 1 : Trend of (a) annual maximum temperature

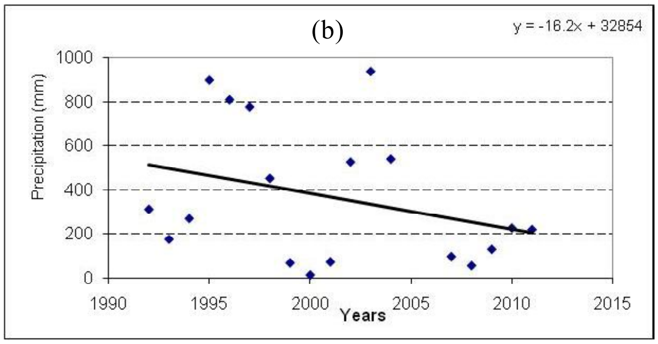

Fig. 2 : (B) Minimum temperature

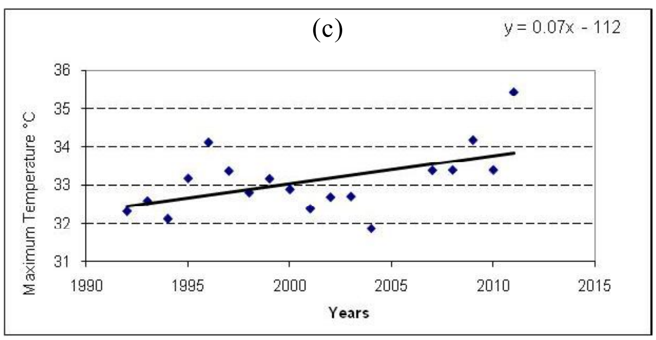

Fig. 3 : (C) Precipitation (mm) at Hermosillo, Sonora, Mexico

means that the crop ET will show an increase, thus the stored soil moisture will be utilized in a shorter time span, thus reducing the length of the crop growing period. Further, the crop in the climate change era will be exposed to a severe moisture deficit (abiotic stress) at the flowering and seed formation stages (GS 3). It will obviously reduce the quality and quantity of safflower flower production, its seed production and the composition of oil: protein: fiber ratios. There may be quality reduction of the crop due to the impacts of the climate change.

Biotic and soil related abiotic stresses and soil quality degradation

Elevated thermal regimes, change in the intensity of rainfall, short and long term wet and dry periods (droughts) are likely increase crop losses due to leaf feeding pests. In some instances of the severe incidence of *Spodoptera litura*, a serious defoliator in Maharashtra has been noted. The National Bureau of Soil Survey and Land Use Planning (NBSS and LUP) has observed that large areas of vertisols (>90 cms deep) in the black soil region of Peninsular India, have been reduced to vertic inceptisols (<90 cms depth). Such soils are either medium deep or shallow (<30 cms) soils. Their water holding capacity in the root profile has been greatly reduced, so much so, that these soil have now become increasingly unsustainable for production of winter crops production under dryland conditions. Such a situation has occurred due to the accelerated soil erosion of the top soil. Carbon reserves in the soil have also been reduced and thus quality of the soils has suffered a serious deterioration. (Virmani 1989;, Mathew and Rodomiro, 2010)

CONCLUSIONS

Owing to projected 2°C rise in average ambient temperature the crop growing cycle of the present day cultivars will be compressed in the areas where the crop is currently grown, it may lead to a 15 to 20% yield decreases. Thus, makes its production unviable. Owing to the shift in the rainfall pattern, the sowing of safflower will have to be completed in the month of September. Identification of cultivars which can stand to relatively high thermal stress at seedling and juvenile stages will have to be identified from the available germplasm.

Higher ambient temperatures would mean higher moisture carrying capacity of the air thus, the RH would increase and the number of foggy days would be more. The incidence of biotic stresses is likely to increase.

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