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RESEARCH ARTICLE

Impact of abiotic factors on foraging behaviour of major pollinators in sunflower ecosystem

■ **AMIT JADHAV AND K. SREEDEVI**

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ABSTRACT : Sunflower being a rich oilseed crop in India is widely grown in Karnataka and Andhra Pradesh. It is a highly cross pollinated crop dependent on pollinators for good seed set. Lack of adequate pollinators results in chaffy and partially filled seeds reducing the yield. The pollination in sunflower is carried out mainly by insects both *Apis* and non *Apis* sp. whose behaviour and efficiency is largely dependent on weather parameters. The sunflower hybrid was sown and the different pollinators' activity was observed on randomly tagged ten plants for five minutes at hourly interval daily from 06:00h to 19:00h throughout the flowering period during *Rabi* season of 2009-2010. The meteorological data for the observational period was obtained from Regional Agricultural Research Station located nearby and documented for further correlation studies with pollinators' foraging activity. The studies revealed that the pollinators were foraging maximum during early hours of the day except *A. cerana* whose activity was maximum in the late hours of the day. The correlation analysis between pollinators' activity and weather parameters revealed that the former was positively correlated with maximum temperature and sunshine hours and negatively correlated with relative humidity, rainfall and wind velocity. Each bee species is guided by specific ecological threshold for normal foraging activity whose maintenance differ intra and interspecifically according to their adaptability.

Key Words :
Abiotic factors, Correlation, Pollinators, Foraging behaviour

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Author for correspondence :
AMIT JADHAV
Regional Plant Quarantine Station, Sewri (E), MUMBAI (M.S.) INDIA
Email: amitjadhav1181@yahoo.com
See end of the article for **Coopted authors'**

Pollination is one of the important factors in increasing crop productivity. Lack of natural pollination may prevent increase in productivity of most crops (D'Avilla and Marchini, 2007). Sunflower (*Helianthus annuus* L. Fam : Compositae) popularly known as 'Surajmukhi' (Sobard, 1996) occupies 4th place among different oilseed crops in terms of acreage and production in India. Andhra Pradesh is at 2nd place followed by Karnataka with an annual production of 437.0 tonnes per ha (Ministry of Agriculture, Govt. of India, 2010). It is valued for its nutritive value as vegetable oil (48-53 % edible oil). Cross pollination in sunflower is profoundly aided by honey bees and their efficiency to do so is mostly regulated by certain environmental factors.All those factors which controls the bee activity in sunflower ecosystem is studied by different workers (Abrol, 1985; Bish and Pant, 1968; Choi, 1987; Kapil and Jain, 1986; Kumar *et al.*, 2002; Puskadija *et al.*, 2007; Sihag and Khatkar, 1999 and Sinha and Vaishampayan, 1995) found that temperature and humidity plays a vital role in foraging activity of honey bee. To check the previous findings, present study was undertaken as weather parameters *viz.*, temperature (maximum and minimum), relative humidity (morning and evening), rainfall, sunshine hours and wind velocity prevailed during entire flowering period were correlated with normal honey bee activity. The materials used for experiment and results obtained are discussed hereunder.

EXPERIMENTAL METHODOLOGY

To assess the relation between weather factors and bee activity, the experiment was carried out with hybrid seeds of sunflower variety NDSH-1 at the Insectary, Department of Entomology, S.V. Agricultural College, Tirupati (79° 36' North latitude and 13° 37' East longitude; 182.9 MSL).

The weather parameters *viz.*, temperature (maximum and minimum), relative humidity (morning and evening), rainfall, sunshine hours and wind velocity prevailed during entire flowering period were obtained from nearby meteorological observatory of the college. The mean number of pollinators per ten capitulum were calculated for different bee species and subjected to correlation analysis with the average maximum and minimum temperature, relative humidity, sunshine hours, wind velocity and total rainfall of the day.

Statistical analysis :

For different parameters, prescribed tools of statistical analyses were applied separately which are elaborated here.

Pearson correlation co-efficient (r) :

This was used to find out the extent of the relationship between the scores of independent variable and the scores of dependent variables of the study :

$$r = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sqrt{\left[\sum x^2 - \frac{(\sum x)^2}{n}\right]\left[\sum y^2 - \frac{(\sum y)^2}{n}\right]}}$$

where,

r = Correlation co-efficient

n = Number of respondents

x = Sum of the squares of variable X

y = Sum of the squares of variable Y

x^2 = Sum of the squares of X variable

y^2 = Sum of the squares of Y variable

xy = Variables sum of the product of X and Y.

The computed 'r' values are then compared with the tabulated values at 1 and 5 per cent level of significance.

Regression co-efficient :

Simple linear regression provides amount of relation between a predicted variable and the single criterion variable. The factors showing significance relation at P = 0.05 were further subjected to linear and non-linear models using scatter plot and trend line.

This was calculated for a line represented by y = a + bx, where y = the predicted mean population, x the factor, a the intercept and b the slope (a = y – bx), where 'y' is the dependent array of means and 'x' is the independent array of factor identified.

The following models were computed to arrive at the best fit.

Logarithmic model :

This model calculates the least square fit through points using the following equation :

$$\mathbf{y = C\ln x + b}$$

where, C and b are constants and ln is the natural logarithm function.

Exponential model :

This model calculates the least square fit through points using the following equation :

$$\mathbf{y = Ce^{bx}}$$

where, C and b are constants and e is the base of the natural logarithm.

Power model :

This model calculates the least square fit through points using the following equation

$$\mathbf{y = Cx^{b}}$$

where, c and b are constants.

Polynomial model :

Calculates the least fit square fit through points using the following equation :

$$\mathbf{y = b + C_1x + C_2x^2 + C_3x^3 \ldots\ldots\ldots\ldots C_nr^n}$$

where, b and C_1 …………..C_n are constants,

R = square (r) or co-efficient of determination (CD).

After working out different models, the relevant models were plotted for different variables.

Statistical analysis :

The obtained data was analyzed by statistical significant at P<0.05 level, S.E. and C.D. at 5 per cent level by the procedure given by (Gomez and Gomez, 1984).

Experimental Findings and Discussion

The abundance of *Apis dorsata* showed significant positive correlation with maximum temperature (r = 0.578) and sunshine hours (r = 0.612*) whereas, it showed significant negative correlation with relative humidity (r = -0.678). There was no significant correlation between *A. dorsata* abundance and rainfall and wind velocity (Table 1).

Similarly, *Trigona irridipenis*, showed significant negative correlation between itsabundance and relative humidity (r = -0.731) whereas significant positive correlation with maximum temperature (r = 0.584) and sunshine hours (r = 0.614). Rest all the factors *viz.*, rainfall and wind velocity showed no significant correlation with its abundance (Table 1).

Apis cerana had significant negative association with relative humidity (r = -0.758) and positive association with maximum temperature (r = 0.591). The abundance of *A. cerana* did not show correlation with sunshine hours, rainfall and wind velocity (Table 1).

Xylocopa fenestrata showed negative association with relative humidity (r = -0.611) and wind velocity (r = -0.612). But, it did not show correlation with temperature, rainfall and sunshine hours (Table 1).

In case of *Ceratina unimaculata*, there was significant negative correlation between its abundance and relative humidity (r = -0.728) and rainfall (r = -0.766) and positive association with maximum temperature (r = 0.733) (Table 1).

Regression co-efficient between the abundance of *A. dorsata* and abiotic factors :

The most significant abiotic factors in relation to *A. dorsata* foraging activity were taken and regressed to quantify the extent of variability in *A. dorsata* that could be explained by these factors.

Apis dorsata versus maximum temperature (°c) :

The parameters, Rock bee, *A. dorsata* activity and maximum temperature were regressed to know the variability in Rock bee activity due to maximum temperature, which will be explained by different models. The linear model (y = 0.6472x - 10.983) could explain to the extent of 77 per cent. The polynomial model ($y = -0.0781x^2 + 5.1183x - 74.42$) was found to be the best fit, as it could explain variability in Rock bee activity to the extent of 85 per cent due to maximum temperature (Table 2, Fig. 1).

Apis dorsata versus relative humidity (%) :

When the scores of the Rock bee activity were regressed against the relative humidity, it revealed that linear (y = -0.1409x + 17.235) and polynomial model could

Table 1 : Correlation of different pollinator species abundance with abiotic factors on hybrid, NDSH-1

Pollinator species	'r' values						
	Temperature (°C)		Relative humidity (%)		Sunshine hr	Rainfall (mm)	Wind velocity (kmph)
	Max	Min	Morn	Eve			
A. dorsata	0.578*	-0.588*	-0.236	-0.678*	0.612*	-0.423	-0.348
T. irridipenis	0.584*	-0.547	-0.433	-0.731**	0.614*	-0.311	-0.088
A. cerana	0.591*	-0.624*	-0.059*	-0.758**	0.439	-0.095	-0.217
X. fenestrate	0.207	-0.610*	-0.019	-0.611*	0.125	-0.188	-0.612*
C. unimaculata	0.733**	-0.735**	-0.625*	-0.728**	0.138	-0.766**	0.144

* and ** indicate significance of values at P=0.05 and P=0.01, respectively

Table 2: Regression co-efficients of *A. dorsata* with maximum temperature (Hybrid, NDSH-1)

Sr. No.	Type of model	Regression co-efficient	R^2	CD
1.	Linear	y = 0.6472x - 10.983	0.77	77
2.	Logarithmic	y = 18.673Ln(x) - 55.007	0.7934	79.34
3.	Polynomial	$y = -0.0781x^2 + 5.1183x - 74.42$	0.8531	85.31
4.	Power	$y = 0.0002x^{3.11}$	0.661	66.1
5.	Exponential	$y = 0.3386e^{0.1067x}$	0.6288	62.88

explain the variability in Rock bee foraging activity due to relative humidity to the extent of 46 and 91 per cent, respectively. The polynomial model ($y = -0.0093x^2 + 1.1361x - 24.85$) was found to be better fit as it showed co-efficient of determination up to 91 per cent (Table 3, Fig. 2).

Apis dorsata versus sunshine hours (hr) :

The foraging activity of *A. dorsata* when regressed against total sunshine hours of the day revealed that linear ($y = 0.9744x + 1.4854$) and polynomial ($y = -0.054x^2 + 1.4168x + 1.108$) models could explain the foraging activity of *A. dorsata* to the tune of 66 and 67 per cent, respectively. The polynomial model was found to be the best fit to explain the foraging activity of *A. dorsata* (Table 4, Fig. 3).

Correlation co-efficients between activity of different bee species and five environmental factors *viz.*,

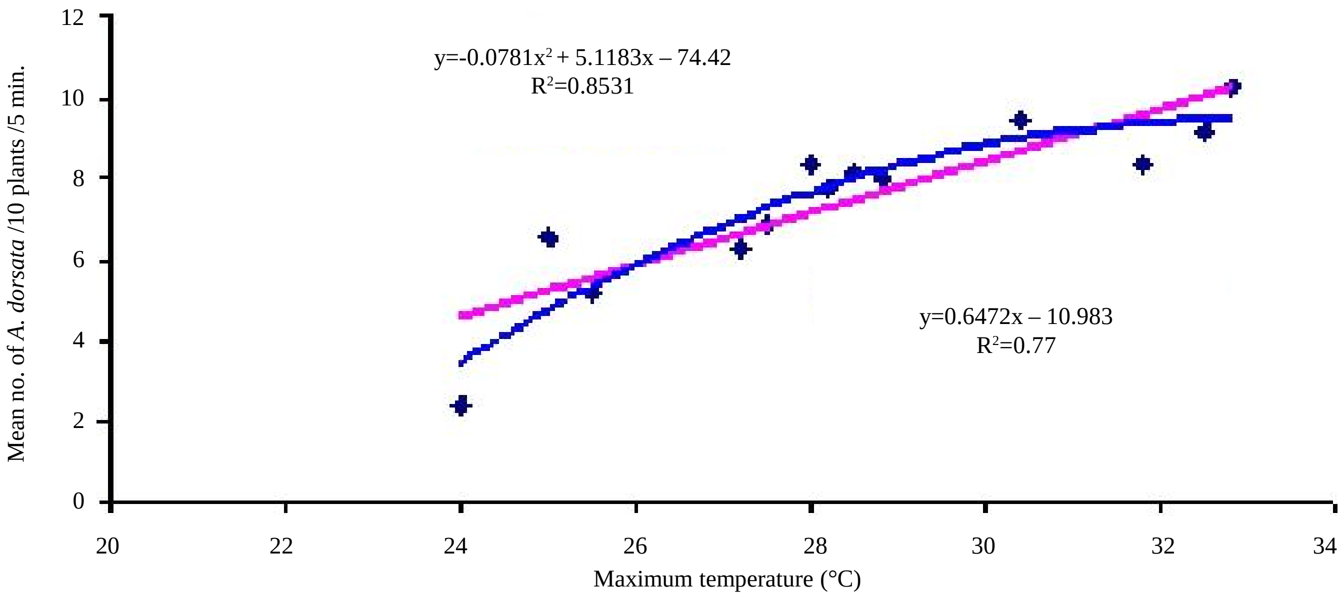

Fig. 1 : Regression co-efficients between *A. dorsata* and maximum temperature (°C)

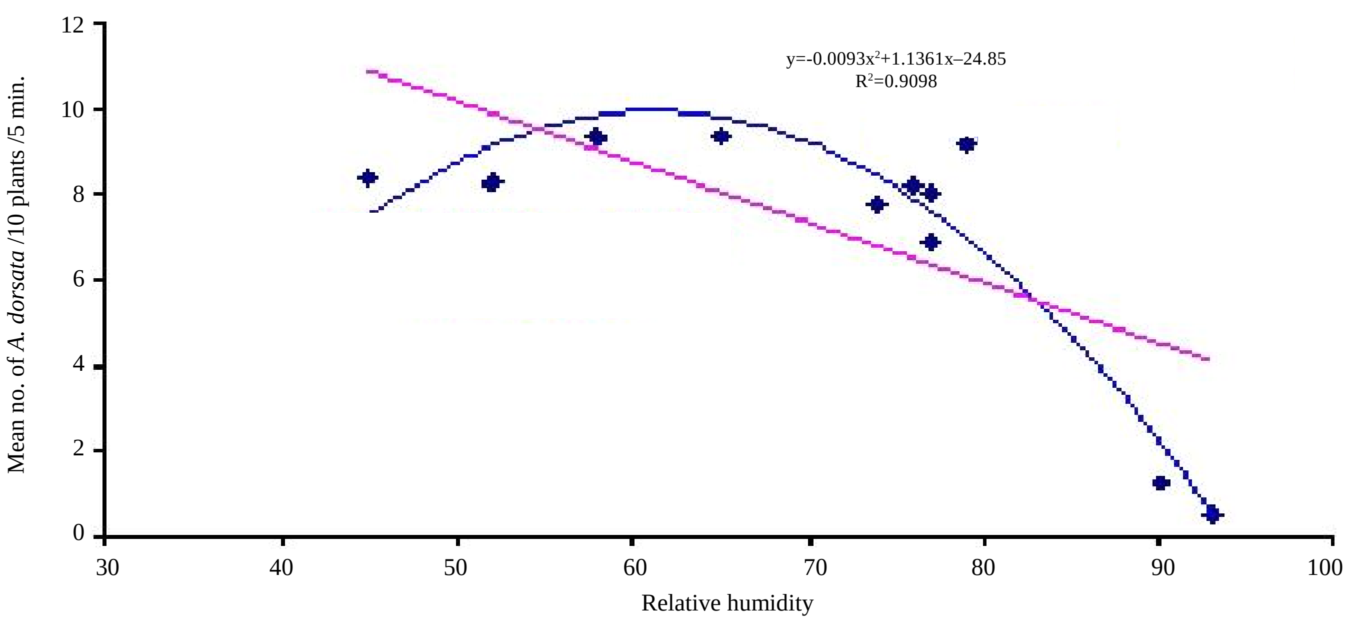

Fig. 2 : Regression co-efficients between A. dorsata and relative humidity

Temperature, relative humidity, sunshine hours, rainfall and wind velocity were presented previous are discussed hereunder.

On hybrid sunflower, all the pollinators *viz., A. dorsata, T. irridipenis, A. cerana, X. fenestrata* and *C. unimaculata* showed significant positive association with increasing temperature and sunshine hours but the most favourable temperature for all the species ranged between 28.4 to 32.2° C whereas, sunshine hours between 6.8 to 8.3 h. The bees' activity showed negative response to rainfall and wind velocity. The preferred wind velocity for bees was recorded as 3.2 to 6.7 km ph. Relative humidity influenced the bee abundance most where bees showed normal activity when relative humidity ranged from 48-60 per cent but they showed strong negative association with increasing relative humidity.

The correlation studies revealed that the cessation of bee activity was mainly governed by fast decline in sunshine hours and maximum temperature and increased relative humidity and wind velocity. The activity was observed to be minimum on rainy days.

The present findings are in agreement with earlier findings with some variations. Abrol (1985) at Hissar, India reported that the reproductive success and perpetuation of cross-pollinated pollinator species depend heavily on abundance of associated pollinator and their pollinating efficiency which is under control of physical

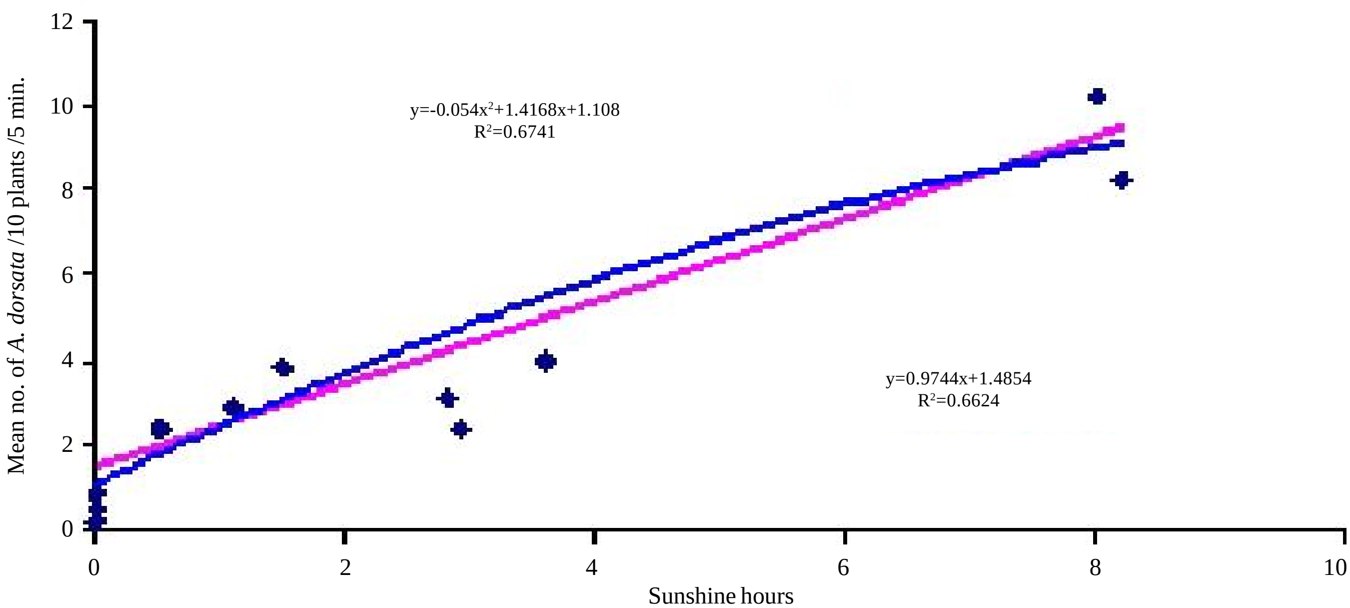

Fig. 3 : Regression co-efficients between A. dorsata and sunshine hours

Table 3 : Regression co-efficients of *A. dorsata* with relative humidity (Hybrid, NDSH-1)

Sr. No.	Type of model	Regression co-efficient	R^2	CD
1.	Linear	$y = -0.1409x + 17.235$	0.4605	46.05
2.	Logarithmic	$y = -8.3303 \ln(x) + 42.548$	0.366	36.6
3.	Polynomial	$y = -0.0093x^2 + 1.1361x - 24.85$	0.9098	90.98
4.	Power	$y = 206098x^{-2.469}$	0.3361	33.61
5.	Exponential	$y = 116.11e^{-0.0421x}$	0.4287	42.87

Table 4: Regression co-efficients of *A. dorsata* with sunshine hours (Hybrid, NDSH-1)

Sr. No.	Type of model	Regression co-efficient	R^2	CD
1.	Linear	$y = 0.9744x + 1.4854$	0.6624	66.24
2.	Polynomial	$y = -0.054x^2 + 1.4168x + 1.108$	0.6741	67.41
3.	Exponential	$y = 1.1376e^{0.3031x}$	0.5314	53.14

environment. Temperature and relative humidity were identified as important environmental correlates controlling honey bee foraging activity by Bish and Pant (1968). In a comparative study of Megachilid bees, Kapil and Jain (1986) showed that temperature, humidity and light intensity affected the commencement and cessation of flights and also the tripping efficiency. Sihag and Khatkar (1999) concluded that bee activity was uniformly, positively and significantly correlated with the ambient temperature and negatively and significantly with relative humidity. Similar observations were made by Choi (1987) in Korea and Kumar *et al.* (2002). Slight variations were also observed in our findings and findings of Puskadija *et al.* (2007) at Croatia who reported that the most frequent visits of honey bees were at 20 to 25 degrees centigrade and humidity 60-65 per cent. The variations may be due to seasonal and climatic differences; in addition adaptability of bees to the changing environment.

Conclusion :

The correlation studies between pollinators' abundance of different bee species and environmental factors revealed that all the pollinator species on hybrid lines of sunflower showed significant positive association with increasing temperature and sunshine hours and significant negative association with relative humidity, rainfall and wind velocity. So, it can be said that the temperature and relative humidity were the key factors determining the bee activities in sunflower capitulum. In general, maximum population was observed between 10.00 to 11.00 h when air temperature ranged between 25.4 to 31.3°C, sunshine hours between 6.8 to 8.3 h and relative humidity between 51 to 63 per cent.

Coopted Authors' :

K. SREEDEVI, Division of Entomology, Indian Council of Agricultural Research, NEW DELHI (INDIA). Email : kolla.sreedevi@gmail.com

REFERENCES

Abrol, D.P. (1985). Analysis of biophysical interactions in foraging behaviour of some bees – A study in bioenergetics, Ph.D. Thesis, Haryana Agricultural University, Hissar, HARYANA (INDIA).

Bish, D.S. and Pant, N.C. (1968). Insect biodiversity in sunflower (*Helianthus annuus* L.) ecosystem in Punjab. *Indian J. Entomol.*, **30**:163-168.

Choi, S.Y. (1987). Studies on diurnal flight activity of honeybees on peach blossom. *Korean J. Apic.*, **2**(1):122-129.

D'Avilla, M. and Marchini, L.C. (2007). Bee pollination of commercial crops in Brazil. *Boletim de Industria Ani.*, **62**(1):79-90.

Gomez, K.A. and Gomez, A.A. (1984). *Statistical procedures for Agricultural Research*. A Willey International publication, John Willey and Sons, NEW YORK, U.S.A.

Government of India (2010). Ministry of Agriculture Area, production and yield of sunflower along with percentage coverage under irrigation in India.

Kapil, R.P. and Jain, K.L. (1986). Subjective evaluation and choice behaviour by nectar and pollen-collecting bees. *Pollina. Biol.,* 103-114pp.

Kumar, Manoj, Singh, R. and Chand, Hari (2002). Foraging activity of *Apis cerana indica* and *Apis mellifera* visiting sunflower (*Helianthus annuus* L.). *Shashpa*, **9**(1): 31-34.

Puskadija, Z., Stefanic, E., Mijik, A., Zdunic, Z., Paradzikovic, N., Florijancic, T. and Opacak, A. (2007). Influence of weather conditions on honey bee visits (*Apis mellifera* carnica) during sunflower (*Helianthus annuus* L.) blooming period. UDK **78**:633-638.

Sihag, R.C. and Khatkar, Sunita (1999). Effect of different environmental factors on the foraging activity of three honeybee species visiting eight cultivars of oilseed crops. *Annal. Agri. Bio Res.*, **4**(2):257-261.

Sinha, S.N. and Vaishampayan, S. (1995). Pollination requirement in sunflower hybrid seed production: effect of caging on bee behaviour and pollination. *Indian Bee J.*, **57**(2):71-73.

Sobard, P.M. (1996). Sunflower a promising oilseed crop. *Kisan World*, **23**(4): 69-73.

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