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POLLINATION MECHANISM AND BEHAVIOUR OF POLLINATORS IN SAFFLOWER (*CARTHAMUS TINCTORIUS* L.)

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Safflower (*Carthamus tinctorius* L.), an oil seed crop, is usually considered as self pollinating crop. However, cross pollination increases the number of seed setting. During flowering span in Bhagalpur area (Bihar, India), several insect species visit the safflower rather indiscriminately and thus pollination is highly generalized. The flowering span extended from the middle of February to second week of April. During this period the population of insect pollinators varied remarkably. Diptera spp. were most active towards the end of the flowering span and some of them are highly active during early flowering (February). *Apis mellifera* was active during whole period of flowering while *Apis indica* and *Apis dorsata* were more active when maximum number of the plants were at bloom (only in the middle of the flowering span). Only some Lepidoptera spp. (butterflies) are active during middle period of flowering span. Towards the fag end of the flowering span bees population was drastically reduced and replaced by flies like *Dacus cucurbitae*. Relative importance of different groups of insects with reference to their periods of activity within the flowering span, and foraging behaviour of some important pollinators have been discussed.

Key words: *Carthamus tinctorius*, pollination, pollination mechanism.

Safflower (*Carthamus tinctorius* L.) is an important commercial oil seed crop, grown in rabi season. Safflower oil is primarily used for edible purposes due to high percentage of (70%) linoleic acid (Hasan Baydar, 2002).

Seed production in safflower is directly related with success of pollination because the plant shows self pollination in absence of pollinators (Knowles, 1969). Claasen (1950) reported zero to 100 percent cross pollination. In most of the plants, cross pollination ranged from 5-40%. Pollinators contribute to various degree of pollination of the flower (Kadam and Patanker, 1942; Levin and Butler, 1966; Butler *et al.*, 1966; Levin *et al.*, 1967). Safflower is usually considered to be a self pollinated crop. Insects, particularly bees, are the major agents of pollination (Boch, 1961; Eckert, 1962; Rubis *et al.*, 1966). Temperature and humidity affect seed setting of bagged flowers (Patil and Chavan, 1958).

The family Asteraceae, to which safflower belongs is said to be homogeneous in features of the pollination syndrome and generalist with respect to pollinators. Members of many insect groups visit the capitula, apparently indiscriminately (Lane, 1996). Role of different species of insect and their relative contribution in pollination of the crop is still not defined. The present study attempts to describe pollination mechanism and behaviour of pollinators in safflower (*Carthamus tinctorius* L.) and record the changes in pollinator populations during the flowering span of the crop.

MATERIALS AND METHODS

The study was conducted with plants growing in experimental plots of about 96 sq.m. area in the Department of Botany, T.M. Bhagalpur University, Bihar, India. Observations were made on three successive crops in the years (2002-2004). Morphological characteristics were noted by field observations as well as with the help of a dissecting microscope.

Insects visiting safflower crop were collected by sweeping with an insect net. Honey bees and butterflies were killed by pressing on their thorax with the thumb and forefinger and preserved in butter paper bags. For other insects caught, the net was

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inserted inside a wide -mouth bottle containing chloroform. The unconscious insect was picked out with a forceps and kept in butter paper packet. The insect packets were preserved inside a cardboard box with naphthalene balls inside it. These insects were identified in the Department of Zoology, T. M. Bhagalpur University.

Visits of important pollinating insects were studied throughout the flowering span of the crop, i. e. from the middle of February to the second week of April, devoting one day per week for the study. Observations were recorded between 06:00h to 17:30h. The insects with pollen attached on their body were considered as pollen gatherers whereas those without pollen load were considered as nectar collectors.

Of all insects visiting the crop, 12 species which were most frequent and abundant visitors, were particularly selected for the study of foraging behaviour. Total duration for which the insects worked in field was recorded separately for each species. To ascertain the number of flowers visited by the insect in one bout, an individual insect was followed in the field for the maximum possible time till the insect totally left the field. Total time spent by the individual foraging insect in one bout and the duration of time spent by it in each flower were recorded.

RESULTS

Pollination mechanism

The inflorescence of safflower, typical of the Compositae, consists of numerous disc florets collected together on a circular receptacle which is surrounded by several layers of involucral bracts; the outer ring being heavily spined, protective, and foliage green. Floret head varies from 2.5 cm to 4.00 cm. A single plant bears 9 - 45 capitula. Each capitulum has 41-69 hermaphrodite disc florets which are arranged in 3 to 5 whorls.

The period from emergence to flowering was about 90 to 120 days and the first flower came into bloom within 17-20 days from the first appearance of the bud. Flowering span (from first bloom to last bloom) is three to four weeks only. The florets at the margin of the capitula open first and flowering proceeds centripetally, the whole process takes about 3-4 days. Anthesis of disc florets takes place between 06:30 h to 08:00 h.

Before flowering, stigma is enclosed by five fused anthers, which are attached by very short filaments to the tip of the corolla tube. Usually all florets that open during a given day begin to elongate by sunrise. Anther dehiscence, which normally occurs soon after sunrise, takes place at the top of the anther column as the stigma emerges from within the anther tube. The combined elongation of the style through the corolla tube pushes the brush-like stigma through the anther until all the stigmatic surface of the pistil has grown well beyond the tip of the anthers. By the time this process of elongation is completed, the stigma is usually well covered with the floret's own pollen.

Behaviour of Pollinators

During the flowering span, several insect species visit the safflower crop from early morning (about 06:30h) till evening (about 17:30 h); most of them being regular pollinators (Table 1). The pollinators were ascertained on the basis of pollen adherence on their body parts, and also from relevant literature confirming their role as pollinator of the members of Asteraceae. The identified insects fall into 3 different orders of class Insecta.

Table 1. Insect visitors of safflower crop

ORDER	SPECIES
Hymenoptera:	*Apis indica, Apis mellifera, Apis dorsata, Solenopsis geminate*
Lepidoptera :	*Pieris brassica, Danaus plexipus, Euplea core*
Diptera:	*Syphus latifaciatus, Dacus cucurbitae Musca domestica, Calophora spp.*
Coleoptera :	*Epilachna sp., Epilachna sparsa, Chilomenes sexmaculata*
Odonata :	*Ischnura sp., Libula sp.*

Observations on the foraging behaviour of some of the important and most frequent pollinators are presented in Table 2. Among the visiting bees, *Apis indica* visit the flowers from 07:00 to 17:30 h. The bees are most abundant in the middle of the flowering span when maximum number of plants were at bloom. Their population gradually decreases at the fag end of the flowering span and only a few bees are seen in the field after the 4th week of March. Flies constitute another important group of pollinators, perhaps the most significant in the absence of the bees. They are regular at the end of flowering season.

Table 2 Foraging behavior of some important pollinators of safflower

Name of insect	Duration of insect visit(h)	Average time spent by the insect in one bout (min.)	Average time spent on one flower (min.)	Number of flowers visited in one bout
Apis indica	07:00-17:30	10-25	3.12	6-15
Apis dorsata	09:30-12:00	12-15	0.30-1.30	7-11
Apis mellifera	10:30-16:00	15	0.25-2	5-8
Apis sp.	08:00-14:00	10	1.30-2	9
Solenopsis geminate	10:00- 14:30	4 –7	1.28-2	3-5
Musca domestica	07:30-16:00	11	0.3-0.15	6-10
Calophora spp.	06:00-12:00	5	0.20-0.30	8
Pieris brassicae	07:00-11:00	3-4	0.25-0.36	5-7
Danaus plexipus	06:30-10:30	2	0.15-0.28	4
Sirphus latifaciatus	11:30-16:00	8	0.20-0.45	7
Dacus cucurbitae	10:00-14:00	10	2:00-3:00	5-6

The flies become active early in the morning and remain in the field for the whole day. They are most abundant and active towards the fag end of the flowering season, when heads start drying. Only the flies and a few butterflies visit the heads during this period (Fig.1). Only some butterflies are regular at the middle of flowering season. Out of which *Danaus plexipus* and *Eupoloea core* are noted as casual pollinators. Butterflies start to visit the crop normally early in the morning. However, at about noon, their activities slow down and their population is greatly reduced. Only a few occasional butterflies are encountered between 09:00 h to 11:00 h and visit the flower not for more than 0.36 minutes on a single head before flying to next flower.

Fig 1. Foraging span of different insects visiting safflower field during the flowering span of safflower.

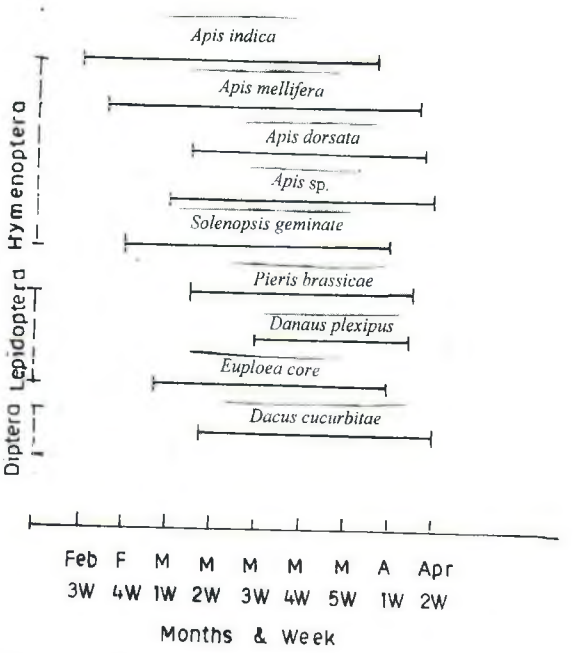

Fig 1. Foraging span of different insects visiting safflower field during the flowering span of safflower.

DISCUSSION

Safflower is basically self-pollinated, but bees or other insects are generally necessary for optimum fertilization and maximum yield. Absence of pollinators results in self-pollination. In this behaviour, safflower differs from other Asteraceae members which are mostly self-incompatible. Amongst pollinating insects, Hymenoptera (bees), Lepidoptera (butterflies) and Diptera (flies) play a major role in pollinating the safflower crop, a feature also observed by Weiss (1961) and Landgridge and Goodman (1980). Foraging behaviour of bees observed in present study is basically similar to sunflower (Srivastava and Srivastava, 1985), dahlia (Patil and Zingre, 1985), and niger (Panda *et al.*, 1993a; 1995; Dhakal and Pandey, 2003). The present study shows that in the absence of bees in the end of flowering span, Dipterans seem to be the only significant pollinators.

A large number of Coleoptera visit the safflower plants, some of them being predators. Odonata species which visit the safflower plants are

carnivorous and eat other insects which visit the safflower crop.

Interestingly, the types as well as the number of insect visitors change with time during the flowering span of safflower crop. In the beginning, bees are most abundant while towards the end of flowering span flies become dominant but some of the butterflies are also seen in the middle of the flowering span. Safflower crop flowers between February and April. The flowering lasts for 40-50 days and this period is remarkably constant but, a single plant can flower only for three to four weeks. Bees population decrease with decreasing number of flowers per plant due to advancing age (Dhaliwal and Atwal, 1985). Ants act as a nectar eater and continue up to midday.

Generally the flower visitors tend to start foraging low on inflorescence and work upward (Waddington, 1983). This pattern is followed in safflower when the insects visit from one inflorescence to the other on a single plant. Within a single head the insects move centrifugally, visiting the newly opened flower and then moving to the older flowers. The pattern of pollinator movements between and on patches of flowers and on inflorescences has been interpreted in terms of optimal foraging theory by which the foragers maximize their net rate of energy accumulation (Pyke, 1984).

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