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Review article

A BRIEF REVIEW ON SAFFLOWER APHID, *UROLEUCON COMPOSITAE* (THEOBALD) AND ITS MANAGEMENT

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INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is one of the important oilseed crops in the world. The crop has been traditionally grown for its flowers as a source of dye for colouring food and fabrics. Safflower oil has highest content of linoleic acid (75%). India with an area of 2.71 lakh ha, production of 1.71 lakh tonnes of seed and average productivity of 632 kg/ha is the leading producer of safflower in the world (DOR, 2011). A total of 101 pests are known to attack safflower at different stages of crop growth and development (Singh *et al.*, 1996). Amongst the various pests, the aphid *Uroleucon compositae* Theobald, badly affects the crop growth and yield. Nymphs as well as adults suck the cell sap from the lower surface of the leaves and tender shoots and impair the vitality of the plants. Besides sucking the sap from the plants, the aphids also excrete honeydew which attracts a black sooty mould that adversely affects the photosynthesis. Seed and oil content losses due to this pest to an extent of 20 to 80 per cent have been reported from different parts of the country (Singh *et al.*, 2000). Control of safflower aphid has been achieved by using different insecticides. Recently, the emphasis is being given on ecological basis of control based on suitable integrated pest management strategies. Seasonal incidence helps in planning need based application of insecticides as it clearly reveals the insect peak activity as well as insect free periods during crop growth. To achieve satisfactory suppression of this destructive pest, manipulating the sowing time, testing and evaluation of newer insecticides are necessary. The available literature related to the present study has been reviewed under the following heads.

1. Effect of different dates of sowing on the incidence of safflower aphid.
2. Effect of weather factors on the incidence of safflower aphid and distribution pattern of safflower aphid.
3. Bioefficacy of newer insecticides against safflower aphid.

Effect of different dates of sowing on incidence of safflower aphid

Management of aphid by early sowing is very essential for sustainable and profitable production of safflower. Manipulation of dates of sowing is an effective tool in escaping the pest.

Singh (1991) reported that crop growth stages between 7th and 11th weeks were the most vulnerable stage to the aphid attack. Sowing the safflower crop in the first fortnight of October is most ideal time to escape aphid attack. Low incidence of aphid, *U. compositae* was found in September sown safflower crop while moderate and severe in crops sown between mid September to mid October and afterwards, respectively. The heavy incidence of this aphid resulted in complete drying of the crop (Bade and Khadam, 1993). Field experiments carried out to determine the effect of sowing time on the incidence of safflower aphid revealed that early sowing (during October) of safflower resulted in higher yields since the aphid appears in large numbers only in the late stages of the crop growth. In late sown crop (30th November) the aphid population was more and also its build up was fast during early stages of the crop growth compared to early and normal sowings (Rao, 1996). Singh *et al.* (1999) opined that date of sowing is crucial for aphid management.

Sowing during mid or second fortnight of September, under drought prone conditions and September to mid October in irrigated conditions, was found effective to keep aphid population below economic threshold in India because of asynchrony between adequate aphid population and susceptible stage of the crop. Bade and Khadam (2001) revealed that the first incidence of aphid commenced during the last week of November and continued until January. It was the lowest on the crop sown on 15^{th} September, and the crop sown on subsequent dates showed gradual increase in population density of the pest. The lowest incidence of aphid population (33.82 aphids/10 cm twig) was recorded on the crop sown on 12^{th} September. The population started increasing with delay in sowing and reached maximum levels (149.82 aphids/10 cm twig) on crop sown on 7^{th} November (Kulkarni and Byadgi, 2004).

Akashe *et al.* (2009) conducted field experiment consisting of four different sowing dates (S_1,S_2,S_3 and S_4) and two safflower varieties Bhima (tolerant) and SSF-702 (susceptible). Planting of safflower in first fortnight of September (S_1) possessed minimum aphid incidence and produced significantly higher seed yield of 662.0 kg ha^{-1} and 405.09 kg ha^{-1} from Bhima and SSF-702, respectively under unprotected conditions. It was followed by second fortnight of September (S_2) (465.28 and 207.18 kg ha^{-1}). Therefore the sowing of safflower crop in the month of September is recommended under dryland conditions. Studies conducted on incidence of safflower aphid on timely and late sown safflower crop revealed that in timely sown safflower crop, the incidence of aphids was initiated during 51^{st} MW (7 aphid/ 5 cm) and continuously increased upto 3^{rd} MW (19.9 aphis/5cm apical twig) and then after reduced down *i.e.* 16 aphids per 5 cm twig. In late sown crop, incidence of aphids was initiated at 1^{st} MW *i.e.* 55 aphids per 5 cm twig. Overall increased trend of aphid infestation was observed in late sown crop and it was observed during pre flowering and flowering stage of the crop (Mane *et al.*, 2012).

Effect of weather factors on the incidence of safflower aphid and distribution pattern of safflower aphid

Effect of weather factors on the incidence of safflower aphid

In order to understand the influence of abiotic factors (meteorological parameters) on the population build-up of safflower aphid *U. compositae* the individual and cumulative effect of different weather parameters, maximum and minimum temperature (^{0}C), maximum and minimum relative humidity (%), rainfall (mm) and sunshine (hrs) during different stages of crop growth are worked out through correlation and regression studies.

Studies on seasonal monitoring on safflower aphids, *U. carthami* revealed that though the population occurs throughout the crop growth period, it attained a peak during the second week of January with decline in temperature, and population declined thereafter with gradual rise in temperature. It was also observed that in high RH levels, the population of aphids per plant was usually high, whereas under high population pressure the rainfall could not influence population decline (Kulat *et al*., 2000). Bade and Khadam (2001) revealed that the first incidence of aphid commenced during the last week of November and continued until January. Cold temperature and moderate relative humidity favoured the pest development. There was a significant and negative correlation between the aphid population per leaf of plant and minimum temperature.

Kamath and Hugar (2001) found that the mean maximum temperature of 28-30^{0}C and the minimum temperature of 13-16 ^{0}C and high relative humidity were the most conducive for aphid multiplication. The mean maximum temperature coupled with relative humidity had significant negative correlation (r=-0.63) on aphid population. The mean minimum temperature alone had highly significant and positive correlation (r=0.92 and 0.96, respectively) with aphids. Aphids were first noted in the last week of December, when the average temperature and relative humidity were 17.85 ^{0}C and 53%, respectively. The aphid activity increased gradually and heavy incidence (190.60 aphids/plant) was recorded in the first week of February, and then it decreased subsequently. The average aphid population was 92.04 aphids per plant throughout the season. The aphid population was positively correlated with temperature and negatively correlated with relative humidity (Mane *et al.*, 2002). Studies on the population dynamics of safflower aphid (*U. carthami*) and its natural enemies at various standard weeks and phenological age of safflower cv. Manjeera revealed that the number of aphids per 5 cm apical twig, percentage mummification of aphids due to parasitoids and predatory coccinellid beetles, *Cheilomenes sexmaculata* (Fabricius) per plant varied. The trend was higher *i.e.* from 198 to 226, 5 to 9 and 4 to 5, respectively, when the crop was 70 to 84 days old during 2000-2001; and 72 to 108, 3.5 to 5.5 and 5 to 6, respectively when the crop was 93 to 107 days old during 2001-2002. However, this trend was quite less or zero during early and late stages of the crop. There was a positive and highly significant correlation between aphids' population and its natural enemies (Singh, 2002). Painkra *et al*. (2003) conducted field experiment to study the population dynamics of safflower aphid *U. carthami* and reported that the peak population was observed on 72-day-old crop. Maximum and minimum temperature showed positive and negative correlations with aphid population densities, respectively. The aphid population density was negatively correlated with morning relative humidity, while evening relative humidity showed negative correlation. Mallapur *et al.* (2005) conducted studies to know the influence of meteorological parameters on the incidence of safflower aphid. The observations were recorded on aphid load and were correlated with corresponding values of various meteorological parameters.

The average of six-year results has indicated that there was significantly positive correlation with relative humidity, minimum temperature, drizzling rainfall and cloudy weather. Whereas the aphid population was negatively correlated with maximum temperature, heavy rainfall and as the crop age advances. The average regression [r] value was 0.55 for six years. Singh (2007) reported that minimum and maximum temperatures of 15-17 and 31-35^{0}C, respectively coupled with minimum and maximum RH of 21-30 and 69-81%, respectively and rainfall of 31 mm during 5th MW were more congenial for aphid population built up on safflower. Studies conducted to determine the influence of crop phenology on population dynamics of safflower aphid, *U. compositae* revealed that the population of aphids reached ETL in 50th SW when crop was in pre-flowering stage and 50 days old. Crop phenology of two months *i.e.* 50th SW of 2001 to 6th SW of 2002 was crucial for survival and multiplication of safflower aphid. The temperature ranging from 16-28^{0}C coupled with 66% RH proved conducive for aphid multiplication coinciding with crop reproductive stage. Population of predatory coccinellids @ 3-4 beetles/aphid colony was enough to deplete drastically the aphid population below economic threshold and it was not required to follow any insecticidal measures for the control of safflower aphid (Singh and Singh, 2007). The incidence pattern of aphid showed that the highest percentage infestation on branches of 85.81+/-3.96% was observed in the fifth standard week (86 days after germination) and later on decreased gradually. The percentage infestation on branches increased as the crop growth increased and there was a decline in the aphid population as the plant reached maturity (Shirisha and Singh, 2008). The aphid appeared in the safflower field in 51st standard week, *i.e*., December 3rd week when the crop was seven weeks old. Later the population gradually increased up to 2nd standard week and reached the peak (118.4 aphids/5 cm apical twig in 3rd standard week). The mean maximum temperature of 28-30^{0}C and minimum temperature of 13-16 ^{0}C and relative humidity of 83 per cent were found most conducive for aphid multiplication. The peak aphid population was observed at 83.4 per cent relative humidity. Lower relative humidity of 74.2 per cent and increase in temperature during first week of February set in a decline in aphid population. Mean maximum temperature coupled with relative humidity had significant negative correlation (r=-0.63) on aphid population (Patil *et al.*, 2008). The field experiments to determine the effect of weather parameters on population dynamics of safflower aphid *U. compositae* revealed that low temperature and high humidity were conducive for the multiplication of this pest. Aphid population attained a peak of 147.5 aphids/5 cm twig/plant in the 52nd SMW when the mean minimum and maximum temperatures, morning and evening relative humidity were 31.6 ^{0}C, 11.4 ^{0}C, 71 and 28%, respectively (Akashe *et al.*, 2010). Seasonal incidence of aphids on safflower was studied on Bhima and CO-1 (susceptible) varieties under normal and late sown conditions. Incidence of aphid began on 46 SMW (Standard Meteorological Week) in normal sown crop and 47 SMW on late sown crop irrespective of varieties. The aphid population was higher in CO-1 compared to Bhima. Aphid population increased drastically from 50 SMW and reached peak during 4 SMW in normal sown crop but peak population occurred earlier under late sown conditions *i.e.,* 1 SMW. Aphid population was negatively correlated with maximum and minimum temperatures irrespective of dates of sowing (DOR, 2011). Studies on population density, economic threshold and management of safflower aphid, *U. carthami* revealed that the aphid made its first appearance on safflower after seven weeks of sowing (51st SW), increased gradually and attained peak during 11th week after sowing (3rd SW) and thereafter the aphid population declined and finally disappeared during 10th SW. the mean minimum temperature had significant but negative correlation with aphid load while the predators *i.e.* the coccinellids and chrysopids had strong positive correlation with aphids. The economic threshold for *U. compositae* was worked out to be 39 aphids on 5 cm apical twig per plant (Patil and Kamath, 2012).

Distribution pattern of safflower aphid

Population has been defined by different workers. Nicholson (1957) has defined population as a group of inter-acting and inter-breeding individuals which normally has no contact with other groups of the same species. Milne (1957, 1962) has described population as a number of individuals of a particular species existing in a particular space. The manner in which the members of a pest population are distributed through space is the distribution pattern or the dispersion of the population. Spatial distribution is one of the most important characteristics of ecological significance of a species. It yields characteristic parameters that segregate species. The spatial pattern of an insect is of specific interest in both applied and fundamental studies. No field sample is viable without understanding the underlying spatial distribution. Some insect species reproduce so rapidly that population density can change greatly during the course of field experiment as in case of aphids. Most of the workers have described the natural insect population with negative binomial model (Anscombe, 1948; Harcourt, 1960; Morris, 1960). Sylvester and Cox (1961) and Shiyomi and Nakamura (1964) found that the distribution of aphids during the initial phase of infestation is random and it becomes contagious as their number increases. The dispersion parameters revealed that *U. compositae* in safflower followed contagious pattern of distribution. The different signs of dispersion and x^2 test statistic confirmed behaviour of the aphid and the negative binomial model was found to be good made in the observed data (Singh and Singh, 2002).

Bioefficacy of newer insecticides against safflower aphid

In view of high reproductive capacity of aphids and rapid reproduction, short life cycle, there is an urgent need to manage the aphid population to avoid losses. There is a need to continuously test newer insecticides and screening of safflower cultivars. Insecticidal control against safflower aphid has been reported by several workers. Basavaraju *et al.* (2000) recommended the application of acephate at 1 g l^{-1} of water against *Uroleucon compositae* at 40 days after sowing and against *Helicoverpa armigera* at the flower initiation stage for effective management of these pests. Foliar application of dimethoate (0.05%) or malathion dust (5%) @ 20 kg ha^{-1} applied alternatively at 60 days after sowing gave best protection against aphid and registered highest benefit cost ratio (Balikai, 2001).

Mallapur *et al*. (2001) revalidated the recommended insecticides methyl parathion, dimethoate, oxydemeton-methyl, monocrotophos, endosulfan and malathion dust against safflower aphid, *U. compositae*. All the treatments were found superior over the control, which recorded yield of 8.8 q ha^{-1}. The results revealed that all the recommended insecticides have still retained their effectiveness against the safflower aphid. Among them, monocrotophos and dimethoate were proved to be the best, followed by oxydemeton-methyl, methyl parathion and endosulfan.

Kamath *et al.* (2001) noted that safflower crop was treated with 0.05% dimethoate at an interval of 10 days starting from 40 days after sowing recorded better plant height, number of branches/plant, number of capsules/plant, main head diameter, number of mainhead seeds/plant, 1000-seed weight, oil content, and seed yield over untreated control.

Neharkar *et al.* (2003) found that dimethoate and phosphamidon were significantly superior over untreated control in reducing aphid population and increasing safflower yield. All the yield attributing characters (plant height, number of leaves per plant, number of branches, number of capitula per plant, diameter of capitulum and grains per capitulum) were found superior in the treated plots than in the untreated control.

Pote *et al.* (2005) reported that significantly lowest aphid population and maximum seed yield were recorded in treatments with two sprayings of fluvalinate (at 45 and 60 days after sowing (DAS)) followed by two dustings of carbaryl D (at 45 and 60 DAS) and one dusting of parathion-methyl D (at 45 DAS). However, one dusting of parathion-methyl D gave the highest incremental cost-benefit ratio (ICBR) (1:15.14) resulting into the highest net profit.

Among different insecticides, dimethoate (0.05%) was more effective than the other treatments against safflower aphid. Dimethoate recorded highest yield and incremental cost benefit ratio than other treatments (Shirisha, 2005).

Field experiments were conducted to evaluate the efficacy of newer insecticides from different groups against safflower aphid (*U. compositae*) revealed that two sprayings of Thiamethoxam 0.005% or Acetamiprid 0.004% proved best by recording maximum per cent decline in aphid population and providing the highest seed yield of 1087 kg ha^{-1} and 952 kg ha^{-1}, respectively. Among eight chemical treatments, the B: C ratio was highest in Thiamethoxam (1.89) followed by Acetamiprid (1.62), Dimethoate (1.52) and Imidacloprid (1.46) (Akashe *et al.*, 2008).

Sharma *et al.* (2009) reported that ethofenprox (0.01%) and cartap hydrochloride (0.02%) provided effective suppression of safflower aphids followed by dimethoate(0.05%) and malathion (0.05%).

Gore *et al.* (2010) observed that at 1, 3, 7 and 14 days after spraying, the lowest incidence of aphids per 5 cm shoot length was recorded for thiamethoxam (0.005%). The highest seed yield (15.55 q ha^{-1}) was also registered for thiamethoxam. All the insecticides *i.e.* imidacloprid (0.0045%), acetamiprid (0.004%), fipronil (0.01%), acephate (0.03%), diafenthiuron (0.06%) and dimethoate (0.03%) significantly increased the yield over the untreated control.

Two rounds of sprays of thaimethoxam @ 125g per ha, acetamaprid @ 100 g per ha, imidacloprid @ 200 ml per ha, clothianidin @ 50 g ha^{-1}, [chlorpyriphos 50%+cypermethrin 5%] @ 1000 ml ha^{-1} and [endosulfan 35%+ cypermethrin 5%] @ 1000 ml ha^{-1} kept aphid population below 6 per plant and recorded higher yield compared to other insecticides evaluated (DOR, 2011). Studies conducted to determine the bioefficacy of newer insecticidal molecules against safflower aphid revealed that two sprays of thiamethoxam 25% WG and clothianidin 50% WDG at 45-55 and 60-65 days after sowing were found to be effective by recording maximum decline in aphid population and recording the highest yield of 1025.1 and 945.3 kg ha^{-1}, respectively (Basavaraj *et al.*, 2012).

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