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Effect of Sowing Dates within a Season on Incidence and Abundance of Insect Pests of Canola Crops

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Abstract.- This study describes the population difference of some insect pests on canola crops when sown at three dates *i.e.*, mid October, early November and mid November in two years field trials during 2008-2009 and 2009-2010 at Bahawalpur. Crops sown at all three dates were invaded by similar insect pests *viz*., cabbage aphid, *Brevicoryne brassicae* Linnaeus (Hemiptera: Aphididae); turnip aphid, *Lipaphis erysimi* (Kaltenbach) (Hemiptera: Aphididae); peach aphid *Myzus persicae* Sulzer (Hemiptera: Aphididae), whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae); armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) and pod borer, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae). Mean seasonal population per plant of these aphids during two years in these three crops (1st, 2nd and 3rd sowing dates) was recorded for *B. brassicae* as 18.73, 20.81, 26.92 aphids; for *L. erysimi* as 14.09, 16.82 and 18.32 aphids; and for *M. persicae* as 0.24, 0.23 and 0.27 aphids, respectively. Other insects with low numbers per plant were observed as *S. exigua* with 0.10, 0.17 and 0.14 larvae; *H. armigera* as 0.14, 0.16 and 0.18 larvae per plant and *B. tabaci as* 0.32, 0.17 and 0.34 flies per plant in crops grown on 1st, 2nd, and 3rd sowing dates, respectively. Result indicated that there was no difference in time of incidence of insect pests in crops in relation to different sowing dates however a clear difference was noted in per plant population (densities or abundance) of these insect pests. *M. persicae, S. exigua*, *H. armigera* and *B. tabaci* in all three crops were not significantly different, whereas densities of two species of aphids (*B. brassicae* and *L. erysimi*) differed significantly among three sowing dates. These two aphid species made dense colonies during mid to late season. Among the three treatments, mid November sown crop was found the most susceptible to these two aphids when compared to crops sown during mid October and early November.

Key words: Insect pests, canola crop, sowing dates.

INTRODUCTION

Canola, *Brassica napus* L., is one of the most important and valuable oilseed crop grown worldwide (Buntin and Raymer, 1994). Besides high quality oil of rapeseed (Downey, 1983) and canola (Fereidon, 1990), oil recovery of canola was much better (30-38%) than cotton crop (12-13%) in Pakistan (Saljoqi *et al.*, 2006). Because of the better oil profile of canola, it should be cultivated on large area, whereas, oilseed brassicas are minor crops in the country due to their low harvests. Its low harvest is generally due to poor field management (insect pest losses) and low yielding varieties.

Diverse insect pests are associated with canola crop worldwide as reported in Australia (Hainan *et al.,* 2007) and USA (Buntin and Raymer, 1994; Brown *et al.,* 1999). Hainan *et al.* (2007) listed 30 species of invertebrate pests including insects and mites associated to canola crop. In India, Brassica crops were studied for insect pests and their damage (Joshi *et al.*, 1989; Bakhetia, 1990). From Western Australia, Micic (2005) described the damage, biology and management of different insect and mite pests on canola crop. He grouped false wireworm, a number of weevils (like vegetable weevil, Desiantha weevil, small lucerne weevil, Fuller's rose weevil), brown pasture looper, cutworms, European earwig, lucerne flea, Redlegged earth mite, clover mite or Bryobia mite and Balaustium mite into 'seedling pests'. Further, he categorized an aphid complex (turnip aphid, cabbage aphid and green peach aphid), native budworm, diamondback moth and Rutherglen bugs as 'flowering and podding pests' on canola crop. Weiss *et al*. (2013) described the life-history, plant injury and management tactics of a number of insect pests of canola crop in the United States. However, they include aphids (cabbage aphid, *Brevicoryne brassicae* and turnip aphid, *Hyadaphis erysimi*) as minor pests.

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Quite old work from Pakistan (Hashmi and Hassal, 1988; Hashmi, 1994) regarding association of insect pests with Brassica crops (other than canola) is available showing aphids, armyworm, cabbage butterfly, loopers, whitefly, mustard sawfly, pea leafminer, painted bug, green bug, hairy caterpillar, diamond backmoth and cricket which were recorded as pests of these crops. Saljoqi *et al.* (2006) grouped insect pests into major insect pests (turnip aphid, cabbage caterpillar and leafminer as major pests) and minor insect pests (painted bug and cabbage semilooper) from Peshawar. A little work on insect pests of Brassica crops grown in Bahawalpur (southern Punjab) is available. Aslam and Razaq (2007) have listed cabbage and turnip aphids as the most prevalent and abundant insect pests on canola crop. Peach aphid, sawfly, armyworm, pod borer and whitefly were listed as less abundant. They also noted armyworm (*S. litura*) and whitefly (*B. tabaci*) to damage crops occasionally when sown early prior to mid-October.

Timely sown rapeseed and mustard crops were less infested with aphids than late planted crops (Prasad and Lal, 2001), and yields were higher due to low aphid attack (Khattak and Hamed, 1993). Delay in sowing of rapeseed and mustard exposed the crops to higher levels of aphids reducing the yield harvests. Therefore, early and timely sowing was recommended to escape aphid severity (Joshi *et al.,* 1989; Shafiq *et al.,* 1999; Saljoqi *et al.,* 2006). Early sown mustard crops from mid-October to early November yielded higher by avoiding aphid populations on these crops in Bangladesh (Rahman *et al.,* 1989) and in Indian states *i.e.,* Madhya Pradesh and Maharashtra (Bhadauria *et al.,* 1992). Similarly, in Assam, early sown toria crop (*Brassica campestris*) from 25th October to 15th November gave higher yields by escaping the aphid invasion (Yein, 1985). Research work from different parts of Pakistan (Khattak and Hamed, 1993; Shafiq *et al.,* 1999; Saljoqi *et al.,* 2006) on time of sowing in relation to insect pest attack has little value in southern Punjab. From southern Punjab, no work was cited on planting dates, however, Aslam *et al.* (2007) studied raya crop (*Brassica juncea*) and they used two sowing dates in two different crop years (mid October in year 2002 and early November in year 2003). They did not report any other insect pest except two aphid species, ie., cabbage aphids and turnip aphids. Research on other Brassica crops has rarely been examined the effect of sowing date within a season on pest abundance. The present study was therefore conducted to evaluate differences in insect pest incidence and abundance on canola crops sown in southern Punjab on three different dates.

MATERIALS AND METHODS

Location of experiment

This field study was conducted during two consecutive growing seasons (2008-2009 and 2009-2010) on research area located at Regional Agriculture Research Institute (RARI) Bahawalpur in southern part of the Punjab. At the location, canola crop was cultivated on reasonable acreage as a field crop and in orchards or with other crops (like wheat and barseem/ clover).

Variety and crop cultivation

Canola crop, Shiralee variety, was cultivated each year (during 2008 and 2009). Crops were sown at three different planting dates within a season as mid October, early November and mid November with a mean gap of 15 days (Table I). Crops sown during months of October/November (of year 2008 and 2009) were harvested in months of March/April of next year (2009 and 2010).

Table I.- Sowing dates used for insect pest occurrence on canola crop during 2008 and 2009.

Location	Years	Mid October DOS 1	Early November DOS 2	Mid November DOS 3
RARI – Bahawalpur	2008	17.10.2008	02.11.2008	17.11.2008
	2009	13.10.2009	03.11.2009	19.11.2009

DOS = Date of sowings

Experimental plots were followed in randomized complete block design with three replicates. Each plot had an area of 10.24 m^2 with dimensions of 3.2 m each in length and width. Recommended seed rate of 5 kg ha^{-1} was used. Sowing was done with the help of single row hand drill in rows apart at 45 cm, thus 6 rows per plot

were sown. An interplant distance of 15 cm was maintained by thinning the crop when plants were at 4-6 leaf stage. Uniform agronomic practices were maintained for each treatment (sowing dates) and pesticides were not applied and kept unsprayed throughout the season each year. The crops were harvested and threshed manually at respective maturity dates.

Evaluations of insect pests with respect to sowing dates

In each sowing from germination to maturity, for insect pests, plants of each treatment plots (of respective sowing dates) were monitored initially at 15 days interval (up to end of January) and onward evaluations were made at an interval of 10 days (till the crop harvests). Thus, up to maturity (in April of each year) there were 13, 12 and 11 data recordings in crops which were planted at mid October, early November and mid November, respectively.

Scouting was initiated in the early morning from 0700 to 1100 hours. Five plants per plot (15 plants in 3 replicates) were thoroughly observed from emergence to harvest. Each complete plant (with leaves, stem, branches, inflorescence, pods, etc) was scouted. Insect pests with sparse feeding were counted at the spot. However, in case of insects with dense colonies of aphids, sampling method (Aslam *et al.,* 2007) was modified and used wide trays (20×30 cm area and with 4 cm deep pan) and collection vials (measuring 50 ml capacity with 80 mesh lid cap) to collect aphids instead of white paper sheet and field counting, respectively. Collection of dense colonies in vials was used to decrease time and labor in field counts. In this method, insects from whole plant were dislodged in wide trays and transferred to labeled plastic vials which were provided with a piece of absorbent paper to absorb moisture to avoid heating injury to aphids during shipment. In laboratory, counts of aphids were made with respect to separate species of aphids as described by by Berlandier *et al*. (2004). Data were processed to statistical analysis (Steel *et al*., 1997) and insect means were separated by using Tukey HSD pair wise comparisons at $\alpha = 0.05$ as experiment wise error rate.

RESULTS

Insect pests recorded during crop year 2008-2009

Table II showed that in early duration of crop establishment, all three crops were invaded by a light population of whiteflies (*B. tabaci*) followed by low numbers of *M. persicae* aphids and *S. exigua* larvae. In later observations, crops were found heavily infested by two aphids (*B. brassicae* and *L. erysimi*) and pod borer (*H. armigera*) larvae. In first crop (1st sowing), 0.20, 0.20 and 0.27 whiteflies per plant were observed on Nov 17, 30 and Dec 15, respectively. In 2nd and 3rd crops, 0.27 and 0.40 whiteflies were observed on Dec 15, respectively. Peach aphids (*M. persicae*) were recorded 0.27 and 0.20 on Nov 15 and 30 in 1st crop, respectively when compared to 2nd crop (0.40 and 0.13 aphids per plant) and 3rd crop (0.27 aphids per plant on Dec 15). After then 0.07, 0.00 and 0.07 larvae of *S. exigua* were observed in 1st, 2nd and 3rd crops on Dec 15, respectively. With respect to sowing dates, low and negligible populations were observed for *S. exigua*, *H. armigera* and *B. tabaci*.

No insect pests were recorded during December and January of each cropping year. On Jan 30 and onward, *B. brassicae* aphids were first observed while *L. erysimi* were recorded late on Feb 10 onward. In 1st crop, *B. brassicae* were recorded as 1.87, 5.87, 12.67, 29.87, 67.00, 62.27 and 7.73 aphids per plant on dates from Jan 30 to end of March with the highest (67.00 aphids per plant) at Mar 10. *B. brassicae* aphids were recorded in 2nd crop as 9.20, 16.73, 35.20, 61.20, 51.60 and 10.20 aphids per plant on Feb 10, 20, Mar 10, 20 and 30, respectively. In 3rd crop, *B. brassicae* aphids were observed as 4.07, 9.80, 18.80, 45.67, 82.53, 72.20 and 13.47 per plant, respectively. All three crops were significantly different for number of *B. brassicae* aphids with highest on at 3rd crop.

Population of *L. erysimi* were 2.13, 6.33, 16.33, 30.40, 27.73 and 7.27 aphids per plant on Feb 10, 20, Mar 01, 10, 20 and 30, respectively, in 1st crop. On same dates in 2nd crop, *L. erysimi* aphids were found as 2.20, 7.27, 16.80, 33.47, 24.80 and 10.53 aphids per plant. *L. erysimi* aphids appeared in 3rd crop on Feb 10 and remained on crop till the end of March. Number of aphids recorded on Feb 20, Mar 1, 10, 20 and 30 were 8.20, 36.13, 30.80,

Table II.- Population of different insect pests on canola crop sown on different dates at RARI – Bahawalpur during crop year 2008-2009.

Insect pests	Date of observations	DOS-1	DOS-2	DOS-3	F-Cal.	P	Tukey HSD
Bemisia	17/11/2008	0.20 ± 0.12	0.00	no crop	-	-	-
	30/11/2008	0.20 ± 0.00	0.00	0.00	-	-	-
	15/12/2008	0.27 ± 0.07	0.27 ± 0.07	0.40 ± 0.00	4.00 ns	0.1111	-
	30/01/2009	-	-	-	-	-	-
	10/02/2009	-	-	-	-	-	-
	20/02/2009	-	-	-	-	-	-
	01/03/2009	-	-	-	-	-	-
	10/03/2009	-	-	-	-	-	-
	20/03/2009	-	-	-	-	-	-
	30/03/2009	-	-	-	-	-	-
Myzus	17/11/2008	-	-	-	-	-	-
	30/11/2008	0.27 ± 0.07 ab	0.40 ± 0.12 a	0.00 ± 0.00 b	11.20 *	0.0230	0.31
	15/12/2008	0.20 ± 0.12	0.13 ± 0.13	0.27 ± 0.13	0.20 ns	0.8264	-
	30/01/2009	-	-	-	-	-	-
	10/02/2009	-	-	-	-	-	-
	20/02/2009	-	-	-	-	-	-
	01/03/2009	-	-	-	-	-	-
	10/03/2009	-	-	-	-	-	-
	20/03/2009	-	-	-	-	-	-
	30/03/2009	-	-	-	-	-	-
Spodoptera	17/11/2008	-	-	-	-	-	-
	30/11/2008	-	-	-	-	-	-
	15/12/2008	0.07 ± 0.07	0.00 ± 0.00	0.07 ± 0.07	0.40 ns	0.6944	-
	30/01/2009	-	-	-	-	-	-
	10/02/2009	-	-	-	-	-	-
	20/02/2009	-	-	-	-	-	-
	01/03/2009	-	-	-	-	-	-
	10/03/2009	-	-	-	-	-	-
	20/03/2009	-	-	-	-	-	-
	30/03/2009	-	-	-	-	-	-
Brevicoryne	17/11/2008	-	-	-	-	-	-
	30/11/2008	-	-	-	-	-	-
	15/12/2008	-	-	-	-	-	-
	30/01/2009	1.87 ± 0.29 b	0.00 ± 0.00 c	4.07 ± 0.13 a	90.23 *	0.0005	1.08
	10/02/2009	5.87 ± 0.35 b	9.20 ± 0.81 a	9.80 ± 0.31 a	12.42 *	0.0192	3.03
	20/02/2009	12.67 ± 0.87 b	16.73 ± 0.98 ab	18.80 ± 1.10 a	7.11 *	0.0482	5.90
	01/03/2009	29.87 ± 1.07	35.20 ± 1.12	45.67 ± 6.88	3.95 ns	0.1130	-
	10/03/2009	67.00 ± 2.97	61.20 ± 1.10	82.53 ± 11.41	2.85 ns	0.1701	-
	20/03/2009	62.27 ± 5.34	51.60 ± 5.27	72.20 ± 9.21	2.25 ns	0.2216	-
	30/03/2009	7.73 ± 0.94 b	10.20 ± 0.53 ab	13.47 ± 0.82 a	9.67 *	0.0294	-
Lipaphis	17/11/2008	-	-	-	-	-	-
	30/11/2008	-	-	-	-	-	-
	15/12/2008	-	-	-	-	-	-
	30/01/2009	-	-	-	-	-	-
	10/02/2009	2.13±0.35 a	2.20±0.23 a	0.00±0.00 b	22.98 *	0.0064	1.32
	20/02/2009	6.33±1.99	7.27±0.74	8.20±1.12	0.60 ns	0.5924	-
	01/03/2009	16.33 ± 1.91 b	16.80 ± 1.56 b	36.13 ± 3.95 a	36.41 *	0.0027	10.41
	10/03/2009	30.40 ± 6.31	33.47 ± 2.30	30.80 ± 7.38	0.06 ns	0.9452	-
	20/03/2009	27.73 ± 1.19	24.80 ± 1.21	28.40 ± 2.92	0.74 ns	0.5320	-
	30/03/2009	7.27 ± 0.66 b	10.53 ± 1.25 b	15.80 ± 0.81 a	33.37 *	0.0032	3.76

Continued

Insect pests	Date of observations	DOS-1	DOS-2	DOS-3	F-Cal.	P	Tukey HSD
Helicoverpa	17/11/2008	-	-	-	-	-	-
	30/11/2008	-	-	-	-	-	-
	15/12/2008	-	-	-	-	-	-
	30/01/2009	-	-	-	-	-	-
	10/02/2009	0.07±0.07	0.20±0.00	0.13±0.07	2.00 ns	0.2500	-
	20/02/2009	0.13±0.07	0.07±0.07	0.00±0.00	2.00 ns	2.2500	-
	01/03/2009	0.13 ± 0.07	0.07 ± 0.07	0.13 ± 0.07	0.25 ns	0.7901	-
	10/03/2009	-	-	-	-	-	-
	20/03/2009	-	-	-	-	-	-
	30/03/2009	-	-	-	-	-	-

* describes significance (P<0.05) and ns describe non-significance
Means (±SE) against each insect with in a column followed by similar letter are not statistically different; df (DOS, Error) = 2,4; F tabulated value = 6.94.
DOS 1 = mid October on 17/10/2008; DOS 2 = early November on 02/11/2008; DOS 3 = mid November on 17/11/2008.

28.40 and 15.80 per plant, respectively. *L. erysimi* were noted at the highest in numbers on all three crops on Mar 10. *L. erysimi* aphids were statistically significant for dates Feb 10 (higher in 2nd crop), Mar 01 and 30 (with higher aphids in 3rd crop). Mostly aphids were found more in numbers on those crops which were sown late. On Feb 10, 20 and Mar 01, pod borer, *H. armigera* were observed as 0.07, 0.13 and 0.13 larvae per plant in 1st crop; 0.20, 0.07 and 0.07 larvae per plant in 2nd crop; and 0.13, 0.00 and 0.13 larvae per plant in 3rd crop.

Insect pests recorded during crop year 2009-2010

In 2nd crop year (Table III), crops were infested with *B. tabaci* and *S. exigua* at early crop establishment dates while later in the season, crops were found heavily infested by two aphid species (*B. brassicae* and *L. erysimi*) and larvae of pod borer (*H. armigera*). In second year 2009-2010, peach aphid, *M. persicae,* were not observed when compared to previous crop season 2008-2009. Observations for *B. tabaci* on Nov 30 had significant values for all sowing dates (with higher on 1st crop). *B. tabaci* were found as 0.33, 0.47 and 0.47 flies per plant in 1st crop (on Nov 15, 30 and Dec16, respectively) whereas, 0.07 and 0.33 flies per plant were observed in 2nd crop (on Nov 30 and Dec 16, respectively) and 0.27 flies per plant were recorded in 3rd crop (on Dec 16). On Dec 16, *S. exigua* were observed as 0.13, 0.33 and 0.20 larvae per plant in 1st, 2nd and 3rd crop, respectively and larval count in all sowings were found non significant.

Cabbage aphid, *B. brassicae* aphids were recorded from Jan 24 onward up to crop maturity. On dates Jan 24 and dates with 10 days interval, *B. brassicae* aphids were counted on 1st crop, as 2.27, 5.13, 14.13, 12.33, 25.27, 12.53 and 3.27 per plant. On plants of 2nd crop, *B. brassicae* was noted as 2.20, 8.13, 14.13, 16.73, 31.07, 18.87 and 4.93 aphids per plant. Similarly in 3rd crop, *B. brassicae* aphids were 1.33, 7.00, 14.60, 29.00, 42.23, 29.73 and 6.47 per plant on Jan 24, Feb 04, 14, 24, Mar 5, 15 and 25, respectively. Populations of *B. brassicae* aphids were significant for Feb 24, Mar 05 and 15 with the highest numbers of aphids in 3rd crop.

Turnip aphid, *L. erysimi* was first observed on Feb 24 with a gap of one month to appearance of *B. brassicae*. On Feb 24, Mar 5, 15 and 25, *L. erysimi* aphids per plant were recorded as 5.67, 26.73, 13.20 and 7.00 aphids in 1st crop; 7.00, 36.60, 20.13 and 7.40 aphids per plant in 2nd crop; and were 9.00, 34.07, 18.60, and 9.80 aphids per plant in 3rd crop, respectively. Populations of *L. erysimi* were also statistically significant for all the sowing dates on observation dates of Feb 24 and Mar 05 with aphids of high in numbers on 3rd and 2nd crops, respectively. Three crops had non-significant number of *L. erysimi* aphids on dates of Mar 15 and 25. Most of the observations revealed that late sown crops (3rd and 2nd crops) had high number of aphids than early sown crop (1st crop). Though, turnip aphid appeared relatively late when compared to cabbage aphids, yet its population buildup had potential in outnumbering the colony of cabbage aphid. Non-significant values were recorded for

Table III.- Population of different insect pests on canola crop sown on different dates at RARI – Bahawalpur during crop year 2009-2010.

Insect pests	Date of observations	DOS-1	DOS-2	DOS-3	F-Cal.	P	Tukey HSD
Bemisia	15/11/2009	0.33 ± 0.07	0.00 ± 0.00	no crop	-	-	-
	30/11/2009	0.47 ± 0.07 a	0.07 ± 0.07 b	0.00 ± 0.00 b	17.20 *	0.0109	0.31
	16/12/2009	0.47 ± 0.07	0.33 ± 0.07	0.27 ± 0.07	1.75 ns	0.2844	-
	24/01/2010	-	-	-	-	-	-
	04/02/2010	-	-	-	-	-	-
	14/02/2010	-	-	-	-	-	-
	24/02/2010	-	-	-	-	-	-
	05/03/2010	-	-	-	-	-	-
	15/03/2010	-	-	-	-	-	-
	25/03/2010	-	-	-	-	-	-
Myzus	15/11/2009	-	-	-	-	-	-
	30/11/2009	-	-	-	-	-	-
	16/12/2009	-	-	-	-	-	-
	24/01/2010	-	-	-	-	-	-
	04/02/2010	-	-	-	-	-	-
	14/02/2010	-	-	-	-	-	-
	24/02/2010	-	-	-	-	-	-
	05/03/2010	-	-	-	-	-	-
	15/03/2010	-	-	-	-	-	-
	25/03/2010	-	-	-	-	-	-
Spodoptera	15/11/2009	-	-	-	-	-	-
	30/11/2009	-	-	-	-	-	-
	16/12/2009	0.13 ± 0.07	0.33 ± 0.07	0.20 ± 0.00	2.80 ns	0.1736	-
	24/01/2010	-	-	-	-	-	-
	04/02/2010	-	-	-	-	-	-
	14/02/2010	-	-	-	-	-	-
	24/02/2010	-	-	-	-	-	-
	05/03/2010	-	-	-	-	-	-
	15/03/2010	-	-	-	-	-	-
	25/03/2010	-	-	-	-	-	-
Brevicoryne	15/11/2009	-	-	-	-	-	-
	30/11/2009	-	-	-	-	-	-
	16/12/2009	-	-	-	-	-	-
	24/01/2010	2.27 ± 0.18	2.20 ± 0.35	1.33 ± 0.24	4.69 ns	0.0893	-
	04/02/2010	5.13 ± 0.41	8.13 ± 1.35	7.00 ± 0.72	2.22 ns	0.2249	-
	14/02/2010	14.13 ± 0.47	14.13 ± 1.62	14.60 ± 1.14	0.20 ns	0.8295	-
	24/02/2010	12.33 ± 0.48 c	16.73 ± 0.93 b	29.00 ± 0.81 a	115.10 *	0.0003	4.06
	05/03/2010	25.27 ± 0.90 b	31.07 ± 1.01 b	42.23 ± 0.94 a	60.55 *	0.0010	5.84
	15/03/2010	12.53 ± 1.20 b	18.87 ± 2.92 ab	29.73 ± 0.81 a	15.59 *	0.0129	11.11
	25/03/2010	3.27 ± 0.13	4.93 ± 0.52	6.47 ± 1.19	6.83 ns	0.0513	
Lipaphis	15/11/2009	-	-	-	-	-	-
	30/11/2009	-	-	-	-	-	-
	16/12/2009	-	-	-	-	-	-
	24/01/2010	-	-	-	-	-	-
	04/02/2010	-	-	-	-	-	-
	14/02/2010	-	-	-	-	-	-
	24/02/2010	5.67 ± 0.24 b	7.00 ± 0.76 b	9.00 ± 0.92 a	21.23 *	0.0074	1.84
	05/03/2010	26.73 ± 2.60 b	36.60 ± 0.81 a	34.07 ± 0.73 ab	8.90 *	0.0336	8.66
	15/03/2010	13.20 ± 1.29	20.13 ± 1.79	18.60 ± 0.23	6.63 ns	0.0537	-
	25/03/2010	7.00 ± 0.58	7.40 ± 0.80	9.80 ± 0.42	6.93 ns	0.0502	-

Continued

Insect pests	Date of observations	DOS-1	DOS-2	DOS-3	F-Cal.	P	Tukey HSD
Helicoverpa	15/11/2009	-	-	-	-	-	-
	30/11/2009	-	-	-	-	-	-
	16/12/2009	-	-	-	-	-	-
	24/01/2010	-	-	-	-	-	-
	04/02/2010	-	-	-	-	-	-
	14/02/2010	-	-	-	-	-	-
	24/02/2010	0.13 ± 0.07	0.07 ± 0.07	0.20 ± 0.12	0.40 ns	0.6944	-
	05/03/2010	0.07 ± 0.07	0.40 ± 0.12	0.27 ± 0.13	1.65 ns	0.2999	-
	15/03/2010	0.27 ± 0.07	0.13 ± 0.07	0.33 ± 0.07	1.75 ns	0.2844	
	25/03/2010	-	-	-	-	-	-

* describes significance (P<0.05) and ns describe non-significance
Means ((±SE) against each insect with in a column followed by similar letter are not statistically different; df (DOS, Error) = 2,4; F tabulated value = 6.94.
DOS 1 = mid October on 13/10/2009; DOS 2 = Early November on 03/11/2009; DOS 3 = mid November on 19/11/2009

Table IV.- Mean seasonal densities of insect pests on during two crop years (2008-2009 and 2009-2010).

Insects pests	Year 2008-2009			Year 2009-2010			Average of two years		
	DOS 1	DOS 2	DOS 3	DOS 1	DOS 2	DOS 3	DOS 1	DOS 2	DOS 3
B. brassicae	26.75	26.30	35.22	10.70	13.72	18.62	18.73	20.81	26.92
L. erysimi	15.03	15.85	23.87	13.15	17.78	17.87	14.09	16.82	20.87
M. persicae	0.24	0.23	0.27	0	0	0	0.24	0.23	0.27
S. exigua	0.07	0.00	0.07	0.13	0.33	0.20	0.10	0.17	0.14
H. armigera	0.11	0.11	0.09	0.16	0.20	0.27	0.14	0.16	0.18
B. tabaci	0.21	0.14	0.40	0.42	0.20	0.27	0.32	0.17	0.34

DOS = Date of sowings

H. armigera late in the season. Plants were recorded with 0.13, 0.07 and 0.27 larvae per plant of *H. armigera* in 1st crop, when compared to 0.07, 0.40 and 0.10 larvae on 2nd crop, while 0.20, 0.27 and 0.33 larvae in 3rd crop on Feb 24, Mar 5 and 15, respectively.

Mean seasonal population of insect pests during two crop years (2008-09 and 2009-10)

During 2008-2009 year (Table IV), mean seasonal populations (per plant) of *B. tabaci,* whiteflies were recorded at all three sowing dates with the highest (0.40 flies) for 3rd crop (mid Nov). *M. persicae,* peach aphids, were noted as 0.24, 0.23 and 0.27 aphids for 1st, 2nd and 3rd crops, respectively. Mean seasonal populations of cabbage aphid, *B. brassicae* were found at all three sowing dates with the mean values of 26.75, 26.30, 35.22 aphids per plant, respectively. The highest in number of aphids were recorded on plants of 3rd crop (mid Nov). Similarly means of turnip aphids, *L. erysimi* populations indicated that it was the highest in 3rd crop (mid Nov) with value of 23.87 aphids per plant followed by 15.85 and 15.03 aphids per plant in 2nd and 1st crops, respectively. During two years, mean counts of armyworm *S. exigua* were 0.07, 0.00 and 0.07 larvae per plant. Pod borer, *H. armigera,* were counted as 0.11, 0.11, 0.09 larvae per plant on plants of 1st, 2nd and 3rd crop, respectively.

During 2009-2010 (Table IV), mean seasonal population of *B. brassicae* was the highest for number of aphids in 3rd crop (mid Nov) with mean value of 18.62 aphids per plant followed by 13.72 and 10.70 aphids per plant for 2nd (early Nov) and 1st (mid Oct) sown crops, respectively. Highest mean value (17.87 aphids per plant) of *L. erysimi* was recorded on plants of 3rd crop (mid Nov)

followed by 17.78 and 13.15 aphids per plant on plants of 2nd (early Nov) and 1st (mid Oct) sown crops, respectively. The highest mean values of *S. exigua*, *H. armigera* and *B. tabci* were recorded on plants of 2nd (early Nov), 3rd (mid Nov) and 1st (mid Oct) sowing dates with the values of 0.33, 0.27 and 0.42 insects per plant, respectively. *M. persicae* aphid was found absent in 2nd crop season (2009-2010).

Respective seasonal mean populations of both crop years were averaged (Table IV) and data showed that insects numbers were counted as cabbage aphid (18.73, 20.81, 26.92 aphids per plant), turnip aphid (14.09, 16.82 and 18.32 aphids per plant), peach aphid (0.24, 0.23 and 0.27 aphids per plant), armyworm (0.10, 0.17 and 0.14 larvae per plant), pod borers (0.14, 0.16 and 0.18 larvae per plant) and whitefly (0.32, 0.17 and 0.34 flies per plant) on 1st crop (mid October), 2nd crop (early November) and 3rd crop (mid November), respectively.

DISCUSSION

During two years we noted consistently the insects like *B. tabaci,* and *S. exigua* early during the season in low numbers per plant. During mid - late in season we recorded *B. brassicae, L. erysimi* in large numbers and larvae of *H. armigera* were observed at the end of the season. *M. persicae* was recorded in first year observations only and not found during the entire season in second year.

Aslam and Razaq (2007) reported similar insect pests with some exceptions to present findings. They reported an aphid complex comprising *Brevicoryne brassicae, Lipaphis erysimi* and *Myzus persicae.* Moreover, armyworm (*Spodoptera litura*), whiteflies (*Bemisia tabaci*) and pod borer (*Helicoverpa armigera*) were reported as minor insect pests. Sawfly and a different species of *S. litura* were not observed in present study. Our results were partially in line with Hainan *et al*. (2007) who reported same aphids (*Brevicoryne, Lipaphis* and *Myzus* species) and budworm (*Helicoverpa* spp.). They considered these aphids as irregular pests of canola in Australia. Moreover, we did not record diamond back moth (*Plutella* spp.) at all in any of sowing dates each year. Contrary to Hainan *et al*. (2007), in our finding, these insects were found as regular pests during mid to late season canola in all sowing dates. In our study, cabbage aphid, *B. brassicae* remained the most abundant and thus had a dominant role among all insect pests as reported by Biswas and Das, (2000), Aslam *et al.* (2007) and Amer *et al.* (2009). Turnip aphid, *L. erysimi* had comparatively late occurrence in our results similar to reports of other authors (Aslam *et al.,* 2007; Aslam and Razaq, 2007). Amer *et al.* (2010) found both species with almost same levels of infestation in southern Punjab (Dera Ghazi Khan) and occasionally *L. erysimi* at higher side. We also recorded that the numbers of *L. erysimi* aphids had crossed the infestation level of *B. brassicae*.

Earth mite, painted bug and sawfly as recorded by Bakhetia (1990) were not observed during present study. Hashmi (1994) gave records of different insect pests on mustard like cabbage butterfly, loopers, mustard sawfly, pea leafminer, painted bug, green bug, hairy caterpillar, diamond backmoth and cricket but he reported same aphids, armyworm and whitefly as we recorded in both years. We had no record of cabbage pod weevil (*Ceutorhynchus*) and diamondback moth (*Plutella*) late in season as reported by Brown *et al.* (1999) in the Pacific Northwest region (United States). Our results were inconsistent with findings by Saljoqi *et al.* (2006) who considered cabbage caterpillar (*Pieris brassicae*) and leafminer (*Chromatomyia horticola*) as major insect pests on canola crop (sown on 14th December 1998 at Peshawar, KPK) while painted bug (*Bagrada cruciferarum)* and cabbage semilooper (*Plusia orichalcea*) as minor pests. Similar to Micic (2005) we noted two of reported aphids (turnip aphid and cabbage aphid) and pod borer from mid to late in season (on flowering to podding period) on canola crop while we did not record diamond back moth at all on any of the crop growth stages. Ca´rcamo and Blackshaw (2007) had different opinion of insect pests associated to canola crop from south Alberta, Canada. They recorded flea beetle from early crop stand while seedpod weevil and lygus bugs late in crop season. From Aydin (Turkey), Gencsoylu and Akpinar (2010) reported *Scaptomyza flava*, *Chromatomyia horticola* and *Thrips tabaci* as major

pests when compared to population of other insects like *Frankliniella occidentalis*, *Epicometis hirta*, *Pieris brassicae*, *Eurydema ornatum*, *Meligethes* spp., and *Phyllotreta* spp. which were reported as minor pest.

With respect to dates of sowing, our results were in accordance to that of Joshi *et al.* (1989) and Bhadauria *et al.* (1992) that early grown crops in India had the lowest aphid infestations. Similarly, we recorded lowest number of aphids on early sown crops. Likewise, Saljoqi *et al.* (2009) had reported that late sown crops had the highest infestations. In our findings, there was a slight difference in insect pest occurrence (time of infestation) while a significant difference in terms of abundance (level of infestation) on canola crops with respect to sowing dates. We found almost similar aphids (*B. brassicae* and *L. erysimi*) on canola as reported by Aslam *et al.* (2007) who found two species of aphids were more abundant preferably on late in season on *Brassica juncea* (locally known as raya crop) under two sowings in two different crop seasons (mid October 2002 and early November 2003).

The present results are comparable to that of earlier reports from other parts of India and Pakistan. Population of key aphids were also recorded by other authors as from early January (Mar *et al.,* 2000); from mid February onward (Biswas and Das, 2000); and in late January to early February with highest peaks in early to mid March (Aslam *et al.,* 2002). Khan and Begum (2005) reported aphids (with no particular species stated) in low population during months of November, December and January. They observed a population buildup from 4th week of January which had peak population in 3rd week of February during 2004 in a field experiment at Dera Ismail Khan (KPK, Pakistan). In our results all three crops were found free of insect pests from mid December to January each crop year as supported by a number of authors. In Sindh province, Anwar and Shafiq (1999) recorded an appearance of aphids from first week of March of each year during 1995 and 1996 while aphids were observed from third week of February during 1997. Similarly from southern Punjab (Multan), crop sown in mid October had aphid in large population during mid March (Aslam *et al.,* 2002). We noted almost same activity period for aphids each year, as from January to mid March with peak population in end Febrary to early March, as noted by Amer *et al.* (2009). They reported that the highest populations of both aphids (*B. brassicae* and *L. erysimi*) were observed during last week of February to second week of March on crops which were sown on 28th October (Multan) and on 5th November (Bahawalpur) during 2003. Nansen *et al.* (2012) reported same complex of aphids (*B. brassicae, L. erysimi and M. persicae*) on canola crop when grown in September and harvested in April. Aphids were noted during same months (December to April) as crops of both studies were extended in winter season. Our findings were inconsistent to report of Amer *et al.* (2010) who found relatively higher population (60-145 aphids per inflorescence) for two aphids (*B. brassicae* and *L. erysimi*) during mid February, instead we recorded aphids in higher numbers during March each year.

CONCLUSIONS

Our results indicated that in early crop seasons of each year (from October to mid December), canola crops contained insect pests such as peach aphid, armyworm and whitefly in low numbers (less abundant), whereas, these crops under three different sowing dates were heavily attacked by cabbage aphid, turnip aphid and pod borer late in the season. These late season insect pests remained dominant from February to end March each year. Crops sown on different dates had significantly different population of late season aphids (*B. brassicae* and *L. erysimi*). Non-significant change in population of *S. exigua*, *H. armigera*, *M. persicae* and *B. tabaci* was noted with respect to change in sowing dates. There was no difference in occurrence (time of infestation) of different insect pests on all crop sown on different dates; however, there was a significant difference in their abundance (level of infestation). Early sown crops (mid October) in each year had significantly lowest numbers of key aphids when compared to late sown crops (early to mid November) which had significantly high numbers of aphids late in the season.

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