Effect of water stress on performance of *Lipaphis erysimi* (Kalt.) and its body size in brassica

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ABSTRACT: The effect of three water regiems on biological parameters of *Lipaphis erysimi* was studied on two cultivars of oilseed brassica, namely Bulbul-98 and UCD 310/3 under complete rendamized design (CRD) having two factors, cultivars and water stress, replicated 15 times. The moisture levels significantly affected these parameters, influencing the performance of *L. erysimi*. Its developmental time increased with the severity of water deficit on both hosts with a trend of the shortest to the longest period from 100 % field capacity to 50 % field capacity. Its fecundity, being highest at field capacity, was decreased with a decrease in water supply. The intrinsic rate of increase (r_m) was inversely proportionate to water regimes and aphid's development. They were small sized in *Brassica carinata* at 75 % field capacity and at 100 % field capacity in *B. napus*. An indirect proportion between the body size of aphid and moisture levels was observed. Bulbul-98 at field capacity was most favourable whereas UCD 310/3 at the same moisture level was the most detrimental for L. erysimi. (**Key words:** Moisture levels, Turnip aphid, Host plants, Pakistan.)

Introduction

Turnip aphid, *Lipaphis erysimi* (Kalt.) is one of the most serious biotic phenomena affecting *Brassica* the world wide. Rustamani *et al*., (1998) has shown heavy losses in Pakistan, but the actual annual crop loss in the country has not yet been estimated. Data from India, where *Brassica* is grown under nearly identical conditions to Pakistan conditions, present a very alarming picture (Khan *et. al*., 2000). In India, a 90 % reduction in yield due to the attack of this pest has been reported (Jadhav and Singh, 1992; Buntin and Raymer, 1994; Sekhon *et al*., 1996). In certain mustard-growing regions, such losses may reach a 100 % (Aamir and Khalid, 1961; Singh and Sachan, 1999). Farmers generally rely on chemicals to overcome the problem of aphid in Pakistan, and, so far, chemical control has been the sole solution to the problem (Aslam and Ahmad, 2001; Gazi *et al*., 2001; Sarwar *et al*., 2003). Besides human and environmental hazards, the use of pesticides has also been reported to be toxic to its natural enemies such as *Diaeretiella rapae* M'Intosh. in different parts of the world (Gamal *et al*., 1992; Kakakhel *et al*., 1998; Longley, 1999).

Any integrated pest management (IPM) for achieving sustainable results in the control of aphids requires the basic information regarding biological parameters on different hosts. The biology of *L. erysimi* (Singh and Sachan, 1995; Amjad *et al*., 1999; Hsiao, 1999), and the utility of resistant varieties for aphids (Hamid, 1988; Ullah and Fareed, 1993) have been extensively investigated to provide the basis for

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formulating result-oriented pest management strategies. Insect biology, the r_m, and the development threshold temperature are affected by various factors such as different host plants, cultivars, plant quality and growth stages (Raworth, 1984; Kundu and Pant 1967). However, the effect of host plants in relation to moisture levels on the biological parameters of *L. erysimi* and its body size has not been studied in Pakistan. Therefore, the objectives of present studies were to investigate the impact of different moisture levels on the growth, development, survival and tibia length of *L. erysimi* reared on susceptible (*B. napus* cv. Bulbul-98 as reported by Rohilla and Singh, 1999) and moderately resistant (*B. carinata* cv. UCD 310/3 as per Amjad, 1991) cultivars of oilseed brassica.

Materials and Methods

The culture of *L. erysimi* was established inside a muslin cage (45 x 45 x 45 cm) in a glasshouse at a photoperiod of 14:10 h (L:D) Natural light was supplemented with high intensity mercury vapour lamps (3000 lux) and the mean maximum temperature ranged from 18 to 26 °C. Care was taken to keep stock culture of *L. erysimi* free from other aphid species, parasitoids and predators. In order to obtain nymphs of uniform age, adult aphids were taken from the culture, transferred to plants of each treatment in a muslin cage and allowed to reproduce for 24 hours. The newly born aphid nymphs were then transferred to the experimental plants. The experiments were organized in a completely rendamize design (CRD) having two factors (i.e., cultivar and water stress) and 15 replicates. Each aphid was treated as an individual replicate.

Two weeks after germination of the plants, different moisture levels in pots were maintained daily by making up the loss of water by weighing on an electric saucer balance until the termination of the experiment. Three water regimes for each susceptible and moderately resistant entries were maintained: a) 100% field capacity, b) 75% of the field capacity and c) 50% of the field capacity. At 100 % field capacity, the pots could hold 50% moisture (w/w) i.e., 96 ml, at 75% of field capacity 37.5% (i.e., 63 ml) and at 50% of field capacity 25% moisture (i.e., 28.5 ml) (Hanks and Ashcroft, 1980).

Individual nymphs were retained on third or fourth leaf of respective treatment in clip cages (a modified form of Noble, 1958; Admas and Van Emden, 1972 and Puterka and Peters, 1988). They were allowed to grow on these plants until reproduction. The position of the cages on leaves was changed after every three to four days to minimize possible effects on fecundity due to plant damage (Dewar, 1977). The developmental time and fecundity were recorded. The r_m was calculated as per Wyatt and White (1977). A total of 20 adult aphids, randomly collected from each treatment, were preserved in 70 % ethyl alcohol. The length of one hind tibia (the only indicator of aphid performance) of each preserved aphid was measured (Hohmann *et al*., 1988). The data were analyzed by analysis of variance (ANOVA) using computer programme, MSTAT-C (Nissen, 1991) and the means were separated using Least Significant Differences (Steel and Torrie, 1980).

Result and Discussions

The results (**Table 1**) revealed that the growth and development of turnip aphid differed significantly (P = 0.05) for various water regiems when reared on susceptible oilseed brassica. The developmental time was shortest (5.35 days) at the field capacity which

Table 1. Impact of various moisture levels on the development of *L. erysimi* reared on susceptible (Bulbul-98) and moderately resistant (UCD 310/3) cultivars of oilseed brassica

Moisture Levels	Developmental Time (Days)		Mean
	Bulbul-98	UCD 310/3	
50% Field capacity	5.86 $\pm$ 0.22 [a]	6.24 $\pm$ 0.25 [a]	6.02 $\pm$ 0.24 [a]
75% Field capacity	5.56 $\pm$ 0.19 [b]	6.02 $\pm$ 0.21 [b]	5.79 $\pm$ 0.20 [b]
Field capacity	5.35 $\pm$ 0.11 [c]	5.66 $\pm$ 0.16 [c]	5.51 $\pm$ 0.14 [c]
LSD (P = 0.05)	0.13	0.15	0.08

Means within the same column followed by the same letter are not significantly different according to lsd (P > 0.05)

was significantly lower from 50% field capacity (5.56 days) and 75% field capacity (5.86 days). The developmental time was progressively prolonged with the decrease in moisture level and it differed significantly in all the treatment means. The maximum moisture stress produced an inclined effect in the developmental time of the turnip aphid. Whereas the developmental time on moderately resistant cultivar was longer than that of susceptible variety. It is apparent that *L. erysimi* took longest time (6.24 days) for developmental at 50 % field capacity which differed significantly (P = 0.05) from a 75% field capacity (6.02 days) and also 100% field capacity (5.66 days) on moderately resistant cultivar which showed that turnip aphid developed earlier at this water level compared to other treatments. The developmental time of turnip aphid did not differ significantly (P = 0.05) on susceptible and moderately resistant cultivars of rapeseed-mustard (**Fig. 1a**). However, it increased with the severity of water-stress and alike inclination was found on both host plants. Similar results were reported by Hale *et al*., (2003) showing that performance of *Rhopalosiphum padi* (L.) decreased on drought-stressed plants due to decrease in feeding rates. In the present study, the trend of shortest to longest developmental time from field capacity to 50 % field capacity on both the host plants was alike to that reported by Kennedy and Abou Ghadir (1979).

It was evident (**Table 2**) that all the treatments were at a variance (P = 0.05) and the moisture levels significantly affected the fecundity of *L. erysimi* reared on different host plants. The fecundity among all moisture levels significantly differed (P = 0.05) from each other on Bulbul-98 which was highest (57 nymphs

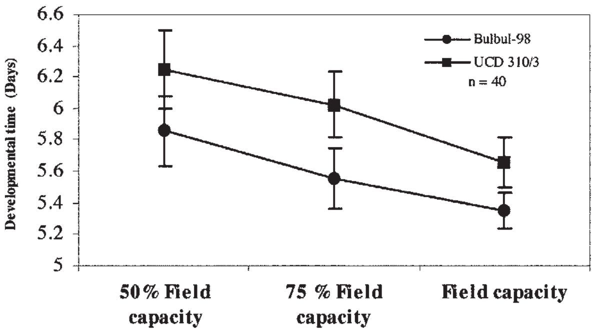

Figure 1a. Impact of different moisture levels on various biological parameters of *L. erysimi* on two different host plants

Table 2. Impact of various moisture levels on the fecundity of *L. erysimi* reared on susceptible (Bulbul-98) and moderately resistant (UCD 310/3) cultivars of oilseed brassica

Moisture Levels	Fecundity (Nymphs/aphid)		Mean
	Bulbul-98	UCD 310/3	
50 % Field capacity	43.76 ± 1.05 [c]	39.53 ± 0.80 [c]	41.64 ± 0.93 [c]
75 % Field capacity	53.81 ± 1.16 [b]	43.95 ± 0.68 [b]	48.88 ± 0.92 [b]
Field capacity	65.68 ± 1.03 [a]	48.32 ± 0.69 [a]	57.00 ± 0.86 [a]
LSD (P = 0.05)	0.80	0.53	0.51

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per aphid) at field capacity followed by 48.88 nymphs per aphid and 41.64 nymphs per aphid at 75 and 50% field capacities, respectively. Similar significant differences were also observed on UCD 310/3. It was highest (48.32 nymphs per aphid) at field capacity compared to 75 (43.95 nymphs per aphid) and 50 % (39.53 nymphs per aphid) field capacity. The fecundity of *L. erysimi* was similar (P = 0.05) on different host plants of rapeseed-mustard at various moisture levels (**Figure 1b**). Highest fecundity was observed when the potted plants were irrigated at the field capacity. The fecundity decreased with the reduction of water. In general, progeny obtained was higher on the susceptible variety than those on moderately resistant cultivars of oilseed brassica. Ansari (1984) also reported a significant reduction in fecundity of cowpea aphid at 10 ml of water per day compared to 100 and 200 ml water per day. Miles *et al*. (1982) observed no significant differences in fecundity on stressed and unstressed plants. They also reported that rate of development of *Brevicoryne brassicae* L. on *B. napus* increased significantly on water-stressed plants compared to wet plants.

The r_m declined with the increase in water stress on both host plants, showing significant differences (**Table 3**). These were highest (0.54) at the 100% field capacity follwed by 75% field capacity (0.50) and had the lowest (0.46) at the 50% field capacity on Bulbul-98. The r_m value was significantly higher (0.51) at 100% field capacity for turnip aphid against 0.47 and 0.44 at 75 and 50 % field capacities, respectively on UCD 310/3. The r_m did not show significant differences (P = 0.05), regardless of which host plant the turnip aphid was reared. However, r_m values were

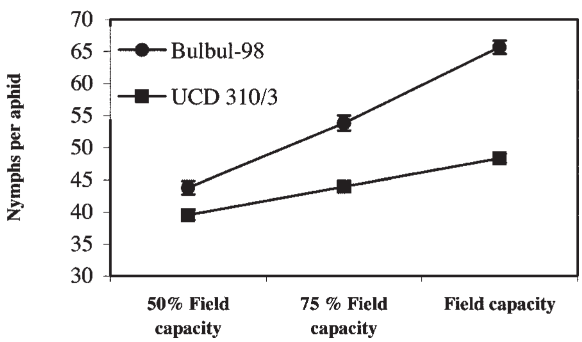

Figure 1b. Impact of different moisture levels on various biological parameters of *L. erysimi* on two different host plants

Table 3. Impact of various moisture levels on the intrinsic rate of increase of *L. erysimi* reared on susceptible (Bulbul-98) and moderately resistant (UCD 310/3) cultivars of oilseed brassica

Moisture Levels	Intrinsic Rate of Increase (r_m)		Mean
	Bulbul-98	UCD 310/3	
50 % Field capacity	0.49 $\pm$ 0.03 [c]	0.44 $\pm$ 0.02 [c]	0.46 $\pm$ 0.03 [c]
75 % Field capacity	0.53 $\pm$ 0.02 [b]	0.47 $\pm$ 0.02 [b]	0.50 $\pm$ 0.02 [b]
Field capacity	0.58 $\pm$ 0.01 [a]	0.51 $\pm$ 0.01 [a]	0.54 $\pm$ 0.01 [a]
LSD (*P* = 0.05)	0.02	0.0007	0.02

Means within the same column followed by the same letter are not significantly different according ot lsd (*P* > 0.05)

high on susceptible and low on moderately resistant cultivars (**Figure 1c**), indicating that development of *L. erysimi* was greater on the susceptible cultivars. Weibulls and Melin (1990) reported better development of turnip aphid on *B. campestris* than on *B. juncea*. It was also apparent from the results that rm values decreased with the increase of water-stress on both the host plants, which depicted that turnip aphid's development declined with the increment of drought conditions in laboratory. It gave an inverse proportion between moisture levels and development of turnip aphid reared on different host plants. Amjad and Peters (1992) also reported lowest and highest r_m values on resistant (K-841) and susceptible (Toria-A) cultivars, respectively, which showed lower fecundity on resistant than susceptible entries of oilseed brassica. Dun and Kempton (1969) reported that nymphs took 13% longer duration to mature on 'Aphis Resistant Rape'; adults had 30% shorter reproductive spans, reduced fecundity and suffered 40% mortality in their progeny. The r_m values in the present study were similar to those of Amjad *et al*. (1999). In the present experiment, the rm values of L. erysimi were increased with the reduction in water-stress. Contrasting results had been reported by Wearing (1967 a, b) concluding that the reproductive rate of *B. brassicae* decreased with an increase in water-stress. These differences may be due to the diversity in aphid species and climate. Landin and Wennergren (1987) intensified that r_m may be determined for a particular aphid species/ population in a particular environment because the r_m value was different for various aphid population/

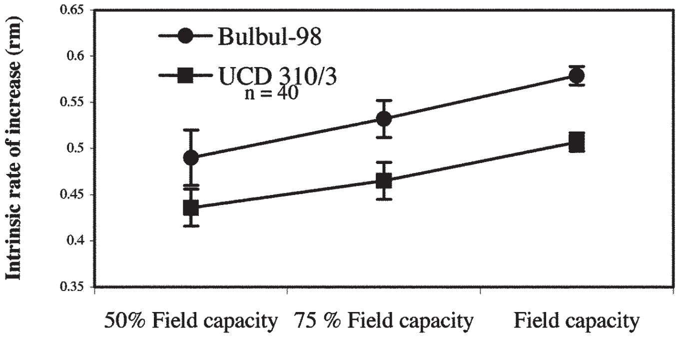

Figure 1c. Impact of different moisture levels on various biological parameters of *L. erysimi* on two different host plants

biotype on separate host plants.

The body size of the turnip aphid (as measured by hind tibia length) varied significantly (P = 0.05) among all three treatments on susceptible variety (**Table 4**). The aphids were large-sized (1203 µm) at the 50% field capacity as compared to the other two water-stress levels. It did not differ significantly at 100% and 75% field capacity while both differed significantly from that of 50% field capacity when the aphids were reared on moderately resistant variety. However, *L. erysimi* was bulky (1312 µm) at field capacity followed by 75% field capacity (1309 µm) on susceptible entry. They were small-sized on 50% field capacity (1271 µm) when raised on moderately resistant cultivar. The identical pattern was observed on various moisture levels across susceptible and moderately resistant varieties regarding body size of the aphids. The body size of turnip aphid revealed significant differences (P = 0.05) at different moisture levels reared on susceptible and moderately resistant cultivars of oilseed brassica in a pot experiment (**Figure 1d**). Smaller aphids were produced at 50% field capacity on UCD 310/3 in contrast to larger ones at the same water regime on Bulbul-98. The size gained by aphid at 75 % and field capacity was non-significant; however, it was slightly smaller at 75% field capacity on UCD 310/3. On susceptible entry, small aphids were produced at field capacity followed by 75% field capacity. Cheng (1970) reported that different species of the host plant produced a wide range of responses. The cultivars of the same species might also differently affect the parasite success. It was indicated that the host plant of the prey might alter parasite performance.

Table 4. Impact of various moisture levels on the body size of *L. erysimi* reared on susceptible (Bulbul-98) and moderately resistant (UCD 310/3) cultivars of oilseed brassica

Moisture Levels	Hind Tibial Length (µm)		Mean
	Bulbul-98	UCD 310/3	
50 % Field capacity	1203.02 ± 6.55 [a]	1271.57 ± 8.97 [b]	1238.20 ± 7.76 [a]
75 % Field capacity	1098.05 ± 6.97 [b]	1309.22 ± 6.23 [a]	1203.64 ± 6.60 [b]
Field capacity	1042.04 ± 6.65 [c]	1312.41 ± 6.70 [a]	1227.22 ± 6.66 [a]
LSD (*P* = 0.05)	0.54	26.36	12.59

Means within the same column followed by the same letter are not significantly different according to lsd (*P* > 0.05)

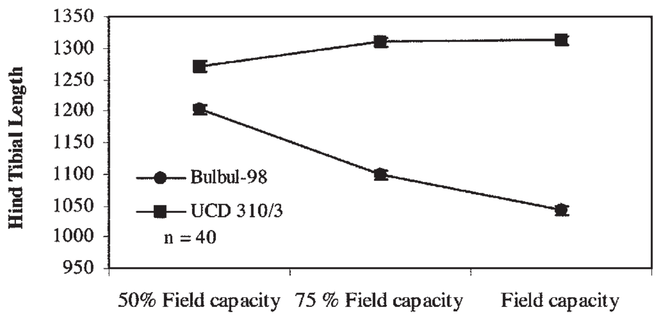

Figure 1d. Impact of different moisture levels on various biological parameters of *L. erysimi* on two different host plants

The present study showed that different moisture levels affected the development, fecundity, r_m and body size of *L. erysimi* reared on different oilseed brassica. The developmental time of turnip aphid was longer with the lowest progeny and r_m at 50% field capacity on both the host plants, except for the hind tibial length, which was largest on the susceptible and smallest on moderately resistant cultivar at the same water level. These results showed that different moisture levels had a considerable influence on turnip aphid performance as reported by Kennedy *et al*., 1958, that a shortage of water resulted in hydrolysis of proteins, and an increased supply of soluble nitrogen and loss of turgor pressure, was unfavourable for aphids because it reduced food uptake by decreasing cell sap pressure.

These two facts possibly had considerable influence on the results obtained in these studies. Wearing and Van Emden (1967) reported that the effect of water shortage on aphids in the plant could be regarded in terms of two main interacting and largely conflicting factors i.e. the concentration of nitrogen and the pressure in the phloem. They further explained that lower turgor pressure might be more important in reducing the frequency of feeding by aphids (increasing restlessness) than in directly reducing the rate of ingestion of sap. In general, it could be concluded that susceptible cultivar grown at the field capacity was the most favourable for development, whereas the partially resistant cultivar at the same moisture level was most detrimental for the growth and development of turnip aphid.

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