Short Communication

Morph and Age Structure of Pea Aphid, *Acyrthosiphon pisum* (Hemiptera: Aphididae) in Lentil

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Abstract

The study was conducted for three consecutive years (2011/12 to 2013/14) at Debre Zeit and Chefe Donsa to generate information on the morph and age structure of pea aphid population in lentil. The data were generated from pea aphid management trial on two lentil genotypes Alemaya and ILL7664. There were 12 plots per genotype and from each plot aphid sample was collected by beating the plant three times onto a counting board of 20cm x 39cm. Aphids dropped on the counting board were put in a labeled plastic bag, brought to laboratory and separated in to alate, adult apterae and nymphs. Morph and age composition were not affected by lentil genotypes. Thus, the pattern of morph and age structure was similar on both genotypes in any one year and location. At Debre Zeit, depending on season and sampling date pea aphid population was composed of 0.0 to 10.0% alate, 6.6 to 34.4% adult apterae and 62.3 to 92.7% nymphs. The corresponding values for ILL7664 were 0.3 to 14.8%, 3.7 to 29.3%, and 68.9 to 92.9%. Similarly, at Chefe Donsa out of the total pea aphid population on Alemaya 0.0 to 10.2% were alate, 8.3 to 38.1% were adult apterae and 57.1 to 88.9% were nymphs. On ILL7664 the population constituted of 0.0 to 11.2% alate, 9.1 to 37.0% adult apterae and 59.3 to 89.9% nymphs. The presence of larger proportion of nymph indicates either the population is at an increasing rate or the survival rate i.e. the number of nymphs reaching adult stage is low. Therefore, the generated information will enable to understand the population dynamics of pea aphid and helps to develop effective integrated pest management program.

Key words: pea aphid, *Acyrthosiphon pisum*, lentil, morph, age structure

Introduction

The area coverage of lentil, *Lens culinaris* Medik is close to 130 thousands of hectares (CSA 2014), and it is cultivated either in rotation with or as double crop after cereal crops. The national average yield is estimated at about 1.3t/ha (CSA 2014), which is much less than the yield potential of 3.7t/ha under experimental conditions (Geletu and Yadeta 1998). The major yield limiting factors includes susceptibility to wilt/ root rot diseases and insect pests, poor agronomic practice, low yield potential of local cultivars and weak technology extension. The pea aphid, *Acyrthosiphon pisum*, is the major insect pest of lentil, field pea and other cool

season pulse crops of Ethiopia. It is known by different local names, which includes *kishkish* in central Ethiopia, *abekt* in Adet area of East Gojam, *gramte* in Wogera and *chemig* in Maksegnit areas of north Gondar. Aside from its direct damage, the pea aphid is known to transmit viral diseases such as pea seed borne mosaic virus (PSbMV), broad bean mottle virus (BBMV), bean yellow mosaic virus (BYMV), and luteoviruses in lentil, although lentil does not express any viral disease symptoms (Tadesse *et al.* 1999; Berhanu *et al.* 2005).

The biology of pea aphid on lentil was studied under laboratory condition by Melaku *et al.* (2000) and Tebkew *et al.* (2002). Later Tebkew and Mohamod (2006) suggested field biology study using these laboratory studies as background information. However, as in the case of many other insect pests in the country, the field biology and the ecology of this aphid has not yet been studied.

Population structure reflects several variables that describe the number, morphs, age, sex, and genetic composition and spatial distribution of individuals, while age structure reflects the proportions of individuals at different life stages and indicates if the population is growing, declining or in stable state (Schowalter 2011). Pea aphid also exhibits polymorphism, which is the existence of several distinct forms of the same life stage (Lowe and Taylor 1964; Mackay and Wellington 1975). Morphs in the pea aphid can be presence or absence of wing (alate or apterae, respectively) or color (red, yellow or green). These adult morphs have different role in the lifecycle as well as pest status of pea aphid. For instance, red morphs are more fecund, produce more alate, and reproduce more rapidly than the green ones (Lowe and Taylor 1964). Moreover, alate morphs are responsible for long rang dispersal and as stated above, pea aphid transmits viral diseases, and therefore any influence on alate morph induction would influence further disease epidemiology (Katis *et al.* 2007). This shows that understanding the population structure of pea aphid is critical in developing an integrated pest management program. Therefore, the objective of this study was to generate information on the morph and age structure of pea aphid population in lentil.

Materials and Method

The experiment was conducted for three consecutive years (2011/12 to 2013/14) by superimposing on pea aphid management trial at Debre Zeit (alt. 1900m.a.s.l) and Chefe Donsa (alt. 2400m.a.s.l). Two lentil genotypes vis. Alemaya and ILL7664, which are known to have some level of tolerance to this aphid, were sown at the rate of 65kg/ha on plots of 2m wide and 4m long. Treatments included phosphorus (DAP) fertilization at the rate of 100kg/ha, seed dressing with apron star at the rate of 2.5g per kilogram seed after wetting the fungicide in 5 to 8mm of water for a kilogram of seed, foliar spraying of dimethoate at the rate of 1.8l/ha when the aphid population reached ≥20 per 10cm x13 cm counting board and untreated check. Each treatment was replicated four times in a randomized complete block design. The lentil crop was monitored at weekly interval to detect the initial appearance of the aphid. The calendar date was recorded along with the standardized growth stages of lentil as described by Erskine et al. 1990. There were 12 plots per genotype and from each plot aphid sample was collected by beating the plant three times onto a counting board of 20cm x 39cm. Aphids dropped on the counting board were put in a labeled plastic bag, brought to laboratory and separated in to alate (individuals with fully grown wing or with wing pad), adult apterae (individuals with fully grown cauda i.e. long and sharp cauda) and nymphs (individuals without wing or wing pad and undeveloped cauda i.e. blunt cauda). Preliminary analysis of age structure and morph types revealed that phosphorus fertilization and seed dressing didn't affect these population structures. Therefore, data from these treatments and the untreated check were pooled and the total ($12x20x39cm^2$ = $9360cm^2$) was calculated for each population structure on each genotype, while datum from foliar insecticide sprayed lentils was excluded from the analysis. For each sampling date chi-square test was used to test if the frequency of morphs and age groups was affected by variety.

Results and Discussion

2011/2012 season

At Debre Zeit, the pea aphid first appeared in the second week of September and the crop was at the beginning of flowering and only 2 to 3 nymphs per 130cm^2 were recorded. However, beginning from the third week of September to the last week of October the pea aphid population was composed of alatae, adult apterae and nymphs (Table 1). A chi-square test revealed that morph and age composition was not affected ($p > 0.05$) by lentil genotypes. On the basis of color there were yellow colored pea aphid morphs but accounted for less than 1% of the total population, whereas red colored morph was not found throughout the growing season. According to Hutchison and Hogg (1983) cornicle length is the appropriate morphological character for identifying pea aphid nymphal stages and the suggested cornicle lengths in mm were instar I ≤ 0.2, $0.24 \leq$ instar II ≤ 0.33, $0.36 \leq$ instar III ≤ 0.52 and instar IV ≥ 0.56. In this study only total nymph density was estimated because of the difficulty of handling the nymphs and lack of appropriate measuring device.

Table 1. Morph and age composition (number per 9360cm^2) of pea aphid population at Debre Zeit in 2011/12 season

Sampling date	Crop stage	Lentil Genotypes					
		Alemaya			ILL7664		
		Alate	Apterae	Nymph	Alate	Apterae	Nymph
21/9/2011	Full bloom	4	19	238	3	23	208
29/9/2011	Early pod	8	71	996	3	75	1017
6/10/2011	Flat pod	18	83	781	21	99	857
12/10/2011	Full seed	17	127	571	21	140	718
19/10/2011	Full pod cavities	23	154	1228	18	101	593
27/10/2011	Physiological maturity	5	69	253	8	55	195

The percentages of morphs and age groups were affected by sampling date on both genotypes. Thus, on Alemaya out of the total aphid population 0.74 to 2.38% were alate, 6.60 to 21.10% were adult apterae and 77.37 to 92.65% were nymphs. Similarly, on ILL7664 alate, adult apterae and nymphs accounted for 0.27 to 3.10%, 6.85 to 21.32% and 75.58 to 92.88%, respectively.

The pea aphid population structure at Chefe Donsa was similar to that of Debre Zeit (Table 2) and was independent of genotypes. However, the density i.e. number per unit area of alate, adult apterae and nymphs was greater at Chefe Donsa than at Debre Zeit. On Alemaya, the aphid population was composed of 1.81 to 10.15% alate, 12.51 to 20.63% adult apterae and 69.33 to 84.11% nymphs. Similarly on ILL7664, 1.31 to 11.24% of the pea aphid population was alate, 12.63 to 19.57% adult apterae and 71.43 to 86.06% nymphs.

Table 2. Morph and age composition (number per 9360cm^2) of pea aphid population at Chefe Donsa in 2011/12 season

Sampling date	Crop stage	Lentil Genotypes					
		Alemaya			ILL7664		
		Alate	Apterae	Nymph	Alate	Apterae	Nymph
8/10/2011	Full bloom	37	228	1339	22	212	1445
13/10/2011	Early pod	23	137	592	16	112	484
20/10/2011	Flat pod	16	148	722	13	164	661
26/10/2011	Flat pod	34	126	847	28	109	643
2/11/2011	Full seed	137	266	1465	102	213	934
10/11/2011	Physiological maturity	47	95	321	48	74	305
15/11/2011	Full maturity	24	118	430	16	81	391

2012/2013 season

The pea aphid at Debre Zeit appeared first in the third week of August, which is about three weeks earlier than the preceding season. The crop was at 7 to 8 leaf stage. The aphid density remained very low until the third week of September. Even at this low density, the population structure was composed of alate, adult apterae and nymphs. Beginning from the early pod to the physiological maturity stage of the crop the density of all forms increased (Table 3). As in the previous season morph or age structure was not affected by lentil genotypes. It was found that 0.93 to 10.00% and 0.67 to 14.81% of the population on Alemaya and ILL7664, respectively, were alate, while the percentage of adult apterae varied between 12.01 and 27.20% on Alemaya and 3.70 and 17.48% on ILL7664. The remaining 68.8 to 86.51% of the population on Alemaya and 79.54 to 87.58% on ILL7664 were nymphs.

Table 3. Morph and age composition (number per 9360cm^2) of pea aphid population at Debre Zeit in 2012/13 season

Sampling date	Crop stage	Lentil Genotypes					
		Alemaya			ILL7664		
		Alate	Apterae	Nymph	Alate	Apterae	Nymph
24/9/2012	Early pod	7	13	50	4	1	22
1/10/2012	Flat pod	10	34	81	3	15	70
10/10/2012	Full seed	4	67	359	3	72	337
17/10/2012	Physiological maturity	9	73	526	11	61	285
23/10/2012	Full maturity	5	37	221	2	35	261

The composition of pea aphid population at Chefe Donsa in 2012/13 season is given in Table 4. The density of alates and the adult apterae were much less than their respective density in the 2011/12 season. Besides, population structure of the aphid was not affected by genotypes. However, on Alemaya, depending on sampling date, out of the total pea aphid population 1.04 to 2.78% were alate, 8.33 to 21.74% were adult apterae and 76.09 to 88.89% were nymphs. The corresponding values on ILL7664 were 0.41 to 7.69%, 9.13 to 28.70% and 68.59 to 89.93%.

Table 4. Morph and age composition (number per 9360cm^2) of pea aphid population at Chefe Donsa in 2012/13 season

Sampling date	Crop stage	Lentil Genotypes					
		Alemaya			ILL7664		
		Alate	Apterae	Nymph	Alate	Apterae	Nymph
4/10/2012	Full bloom	1	3	32	2	5	38
11/10/2012	Early pod	2	18	103	3	31	74
19/10/2012	Flat pod	3	55	229	1	40	200
25/10/2012	Full seed	8	86	651	7	69	679
19/11/2012	Full maturity	1	10	35	4	7	41

2013/2014 season

In 2013/14 season at Debre Zeit the pea aphid began infestation in the first week of September when the crop was at 10 leaf stage. The pea aphid population remained low until the third week of September. As in the 2012/13 season the pea aphid density was low and the population structure was not affected by lentil genotypes (Table 5). Moreover, similar to the preceding two seasons the larger percentage of the population i.e. 62.30 to 84.75% on Alemaya and 68.97 to 89.10% on ILL7664 constituted of nymphal stage, whereas 12.16 to 34.43% and 9.90 to 29.31% of the population on Alemaya and ILL7664, respectively, were adult apterae. The rest 0 to 7.46% on Alemaya and 0.99 to 11.11% on ILL7664 were alate.

Table 5. Morph and age composition (number per 9360cm^2) of pea aphid population at Debre Zeit in 2013/14 season

sampling date	Crop stage	Lentil Genotypes					
		Alemaya			ILL7664		
		Alate	Apterae	Nymph	Alate	Apterae	Nymph
19/9/2013	Early pod	5	11	56	7	7	49
25/9/2013	Early pod	3	9	62	3	8	48
3/10/2013	Flat pod	5	12	50	1	8	66
9/10/2013	Full seed	1	35	200	2	20	180
16/10/2013	Full pod cavities	1	25	48	2	18	63
23/10/2013	Physiological maturity	2	21	38	1	17	40
28/10/2013	Full maturity	0	10	48	4	12	43

The 2013/14 season pea aphid population density at Chefe Donsa was similar to the 2012/13 season (Table 6). The pea aphid population composition on Alemaya was 0.00 to 4.76% alate, 15.00 to 38.10% adult apterae and 57.14 to 84.44% nymphs. Similarly of the total pea aphid population on ILL7664 0.00 to 3.85% were alate, 23.16 to 37.04% were adult apterae and 59.26 to 76.84% were nymphs.

Table 6. Morph and age composition (number per 9360cm^2) of pea aphid population at Chefe Donsa in 2013/14 season

Sampling date	Crop stage	Lentil Genotypes					
		Alemaya			ILL7664		
		Alate	Apterae	Nymph	Alate	Apterae	Nymph
10/10/2013	Full bloom	0	13	40	1	9	18
22/10/2013	Flat pod	0	21	38	2	17	39
31/10/2013	Full seed	1	19	66	1	25	64
7/11/2013	Full pod cavities	7	59	172	0	41	136
13/11/2013	Physiological maturity	2	16	24	2	20	32
19/11/2013	Full maturity	1	27	152	3	20	74
23/11/2013	Full maturity	1	13	27	1	8	17

The 2011/12 season data were subjected to correlation analysis and it was found that the correlation between adult apterae and nymph were positive in both location and genotypes, although it may or may not be statistically significant. Similarly the association between alate and nymphs was positive. However, there was no definite pattern of association between number of alate and apterae. Since both alate and apterae morphs are capable of giving birth to nymphs, the positive association of nymphs with both alate and adult apterae explains why there were more nymphs than alate and apterae morphs. However, from the perspective of population dynamics the presence of larger proportion of nymphal stage indicates either the population is at an increasing rate or the survival rate of the insect i.e. the number of individuals reaching adult stage is low.

It is believed that winged morphs are produced in response to crowding, decline in nutritional quality of the plant, natural enemy attack and/or unfavorable environmental conditions (Williams and Dixon 2007). The pea aphid produced alate morhps on lentil at both locations regardless of the level of population density. Besides, with the exception of few predator coccinellid beetles, under Ethiopian condition parasitoids of pea aphid associated with lentil appear only when the pea aphid population reached very high density. This was observed at Chefe Donsa only in the 2011/12 season when a unidentified parasitoids parasitized the pea pahid. Thus, it is clear that winged morph production in pea aphid on lentil was not due to crowding and natural enemy pressure. Perhaps decline in plant nutrition quality and unfavorable environmental conditions are the likely reasons for the induction of wing formation.

In all years, on both genotypes and locations the frequency of alate was less than the frequency of adult apterae and nymphs. According to Mackay and Wellington (1975) in pea aphid the mortality among the alate is higher than among the apterae near the time of the final molt. The high mortality rate at the final instar stage coupled with high energy cost for wing production might have been responsible for the low number of alate individuals in pea aphid population in lentil. In cereals and grasses, however, Dent (1986) associated alate production with resistance of crops and grass to *Metopolophium festuca cerealium*.

The age of the test insect is directly proportional to the amount of plant biomass it will consume (Smith *et al.* 1994). In Adet area Melaku (2002) reported high field pea grain yield in the

presence of high level of pea aphid. Although he did not give any explanation, age composition might be one of the possible reasons for the obtained result. Moreover, alate morphs of aphids in general are responsible for initiation of colonization of crop fields, while both walking and flying are the major means by which alate and other morphs are redistributed within a field. Therefore, understanding the population structure will enable to understand the population dynamics of pea aphid and develop effective integrated pest management program.

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