Ethiop. J. Agric. Sci. 27(3) 21-32 (2017)

Effects of Phosphorus Fertilization and Seed Dressing Fungicide on Occurrence of Pea Aphid (*Acyrthosiphon pisum)* and Yield of Lentil

Tebkew Damte
EIAR, Debre Zeit Research Center P. O. Box 32, Debre Zeit, Ethiopia

አህፅርኦት

ምስር ላይ የፎስፎረስ ማዳበሪያ መጠቀም ወይም ዘርን በፀረ-ፈንገስ ማሸት በአተር ክሽክሽ (Acyrthosiphon pisum) አህዛብ ላይ ተፅዕኖ እንዳለውና እንደሌለው ለማወቅ አለማየና ILL-7664 የተባሉ የምስር ዓይነተ-ዘሮች 60 ኪግ በሄክታር በሆነ መጠን 2 ሜ በ 4 ሜ በሆነ መደብ ላይ በመዝራት ጥናቱ ደብረ ዘይትና ጨፌ ዶንሳ ላይ ለስድስት ተከታታይ ዓመታት ተካሄደ:: ጥናቱ የተካሄደው በሄክታር 100 ኪግ ዳፕ እንደ ፎስፎረስ ምንጭ፣ ኤፐሮን ሰታር 42ws ፀረ-ፈንገስ (2.5 ግራም ለአንድ ኪሎ ግራም ዘር) እንዲሁም ለማወዳደሪያ እንዲሆኑ ፀረ-ተባይ (ዳይሜቶይት 1.8 ሊትር በሄክታር በ200 ሊትር ውሃ በሄክታር) እና ምንም ባልተደረገ ምስር ላይ ነበር:: የአተር ክሽክሽ ናሙና የተወሰደው ምስሩን ቀስ አድርጎ መቁጠሪያ ሰሌዳ ላይ በእጅ በመምታት ክሽክሹ ሲረግፍ በመቁጠር ነው:: የአተር ክሽክሽ አህዛብ በ130 ካሬ ሜ ከሃያ ሲበልጥ ፀረ-ተባዩ ተረጨ:: ዓይነተ-ዘሮችና ተጠኝዎች ከተጣመሩ በኋላ በራንደማይዜድ ኮምፕሊት ብሎክ ዲዛይን (RCBD) በአራት ድግግሞሽ ተፈተሹ:: የአተር ክሽክሽ ሁለቱም ጣቢያዎችና በሁሉም የሙከራ ዓመታት ምስር ላይ ተከስቷል:: በተጠኝዎች መካከል ጉልህ ልዩነት ባይኖርም ፎስፎረስ ማዳበሪያ የተጨመረበት ወይም ዘሩ በፀረ-ፈንገስ ታሽቶ በተዘራ ምስር ላይ የበለጠ የአተር ክሽክሽ አህዛብ ነበር:: ፀረ-ተባይ መጠቀም ግን የአተር ክሽክሽ አህዛብን በጉልህ ቀንሶታል:: ነገር ግን በሁለቱም ጣቢያዎችና በሁሉም የሙከራ ወቅቶች ፎስፎረስ ማዳበሪያ መጨመር፣ በፀረ-ፈንገስ ዘርን ማሸት ሆነ ፀረ-ተባይ መርጨት ጉልህ የሆነ የምርት ጭማሪ አላስገኘም::

Abstract

Study on the effect of phosphorus fertilization and seed dressing fungicide on occurrence of pea aphid, Acyrthosiphon pisum and yield of lentil was conducted at Debre Zeit and Chefe Donsa for six consecutive years. Lentil genotypes Alemaya and ILL-7664 were sown at the rate of 60kg/ha on 2m wide and 4m long plots. Treatments consisted Apron star 42WS (@ 2.5g per kilogram seed), phosphorus fertilizer (DAP @ 100kg/ha), dimethoate (@ 1.8l/ha in spray volume of 200l/ha) as standard check and untreated control. Pea aphids were sampled by gently beating lentil plants on 20cm by 39cm counting board. The insecticide was applied when the average pea aphid density was ≥20 per 130cm^2. The treatments were combined in factorial combination and tested in randomized complete block design with four replications. Pea aphid infested lentil on all treatments at both locations and in all years. Although statistically nonsignificant, fertilized and seed dressed lentils had greater pea aphid density than the untreated control. On the other hand, spraying insecticide (dimethoate) significantly reduced pea aphid density. However, in all years and both locations, the yield of phosphorus fertilized, seed dressed and insecticide treated lentils were not statistically different from the untreated control.

Introduction

The productivity of lentil, *Lens culinaris* under Ethiopian condition is generally low compared to many lentil producer countries. This low yield is ascribed to inappropriate agronomic practices, diseases, weeds and insect pest problems. Among the insect pests, the pea aphid, *Acyrthosiphon pisum* (Hemiptera: Aphididae) is one of the economically important pests of lentil in different parts of the world (Erskine et al. 1994). In Ethiopia, although the grain yield losses are variable between time of sowing, seasons, production system and locations, the pea aphid causes an average loss of 4 to 72% annually (Tebkew and Mekasha 2013; Mintesnot 2017). This aphid is also known as vector of many viral diseases of lentil (Berhanu *et al*. 2005).

Soil nutrient content is known to affect the survival and reproductive performance of insect pests by altering the nutritional content of the host plant or by affecting the ability of the host plant to compensate for damages done by the insect pest (Pitan *et al.* 2000; Dosdall *et al*. 2004; Johnson *et al.* 2009). Besides, tritrophic interactions i.e. host plant-herbivore-natural enemy interactions are also influence by fertilizers applied to grain yield of crops (Garratt *et al.* 2010; Aqueel *et al.* 2014). In Ethiopia, some farmers fertilizes lentil with P_2O_5 in the form of Diammonium phosphate (DAP) at the rate of 100kg/ha.

Seed dressing pesticides are absorbed by the root and translocate to all parts of the plant. Therefore, they provide continuous protection against the target pest for certain period of time. Apron star 42WS is one of such pesticide and is composed of fungicides (Metalaxyl-M and Difenoconazole) and insecticide (Thiamethoxam). It is recommended to manage Fusarium wilt (*Fusarium oxysporum*), spread of seed born fungal diseases and early season seedling insect pests. In Ethiopia, although not labeled for use on lentil, it is used for dressing lentil and chickpea seeds before distribution. However, the impact of neither phosphorus fertilization nor seed dressing with Apron Star 42WS on the occurrence and population performance of pea aphid and associated natural enemies has not been studied under Ethiopian condition. The information is used to devise management strategies in response to pest problems that resulted from modification of agronomic practices. Therefore, the objective of this study was to assess whether or not phosphorus fertilization and seed dressing fungicide has any impact on pea aphid population and yield of lentil.

Materials and Methods

The experiment was conducted for six years (2011/12 to 2016/17) at Debre Zeit and Chefe Donsa using two lentil genotypes (Alemaya and ILL7664), fungicide (Apron star 42 WS), insecticide (dimethoate) and Diammonium phosphate (DAP) fertilizer. Each genotype was sown at the rate of 60kg/ha on 2m wide and 4m long plots. Fungicide treated seeds were dressed with Apron star 42 WS prior to sowing at the rate of 2.5g per kg seed after wetting the fungicide in 8mm water for a kilogram of seed. On P fertilized plots, Diammonium phosphate (DAP) was applied at the rate of 100 kg/ha at the time of sowing. For comparison, untreated control and standard insecticide (dimethoate) were included. Dimethoate was applied by hand operated knapsack sprayer at the rate of 1.8 l/ha in spray volume of 200 l/ha water when the average pea aphid density was ≥ 20 per 130 cm^2. Lentil genotypes and treatments were combined in factorial combination and tested in randomized complete block design with four replications. The spacing between replications and plots within replications was 1 m.

Aphid sampling

In each season, plots were monitored beginning from seedling establishment to determine the start of invasion by pea aphids. Aphids were sampled by gently beating lentil plants on 20 cm by 39 cm counting board. The board was subdivided in to six 10cm x13cm rectangles. At each sampling spots, pea aphid and other insects dislodged on the counting board were counted from randomly chosen two rectangles. There were four sample spots per plot; therefore, there were eight samples per plot. From these samples average values were calculated. The data were analyzed by Proc GLM of SAS and means were separated by Tukeys' Studentized Range Test. Before analysis, count data were transformed to logx+1, where x is the original data value. Analysis of variance was performed on both transformed and untransformed data but only means of untransformed data are reported.

Results and Discussion

Time of initial pea aphid infestation at Debre Zeit

Except in the 2013/14 season, in all years the pea aphid appeared first in the last week of August and it remained at low density in the first three weeks of September. The stage of the crop at which pea aphid infestation began first was first bloom stage (R1) in 2011/12 and 2016/17, 10 leaf stage (V10) in 2012/13 and 2013/14, 9 leaf stage (V9) in 2014/15, six leaf stage (V6) in 2015/16 season. At V9 and V10 stages lentil begins to produce flower buds. The aphid density increased in October when the crop flowers and form pods.

In field pea, the pea aphid reaches peak intensity (number per plant) in mid-August in central (Kemal 1999) and late August in northwestern Ethiopia (Melaku 2002). Moreover, although alate pea aphids are abundant on lentil throughout the infestation period (Tebkew 2014), this aphid species is known to produce alate under crowded condition (Weisser and Braendle 2001; Purandare *et al*. 2014). Therefore, it is stipulated that the alate produced on field pea in the first three weeks of August might have migrated and invaded lentils in the fourth week of August. The alate pea aphid on lentil might in turn migrate and infest grasspeas sown later in September or October.

Pea aphid population

2011/12 Season

In 2011/12 season, at Debre Zeit, on 21 September 2011 sampling (end of the third week of September), there was no significant difference among treatments in pea aphid density, but treatments differed highly significantly ($p < 0.01$) in pea aphid density thereafter (Table 1). Insecticide sprayed lentils had less aphid density than either fertilized or seed dressed lentils. Moreover, although statistically nonsignificant, fertilized and seed dressed lentils had greater pea aphid density than the untreated check. Both the amount and the frequency of rainfall decreased starting from the second week of September and it rained only 42.0 mm in four days in the remaining part of the month, while the entire October was dry. Although statistically nonsignificant, on each treatment pea aphid density was correlated positively and negatively with minimum and maximum temperature, respectively.

Table 1.Pea aphid population density (average number per 130cm^2) in lentil sown on July 26, 2011 at Debre Zeit

Treatment	Sampling date (crop stage*)					
	21/9/2011 (R-2)	29/9/2011 (R-3)	6/10/2011 (R-4)	12/10/2011 (R-5)	19/10/2011 (R-6)	27/10/2011 (R-7)
Alemaya + fertilizer	16.6	20.7	31.8	28.0	24.9	8.6
Alemaya + Apron star	17.2	25.7	30.9	33.2	35.7	8.0
Alemaya + dimethoate	16.9	0.4	0.8	1.9	13.7	20.1
Alemaya untreated	16.5	19.9	16.2	20.9	42.5	28.9
ILL7664 + DAP	14.6	25.1	25.4	26.8	21.4	10.5
ILL7664 + Apron star	10.1	19.5	24.9	36.3	38.6	16.7
ILL7664 + dimethoate	16.4	0.2	1.0	1.9	17.0	19.2
ILL7664 untreated	10.8	25.2	19.9	21.7	28.9	11.9
LSD (1%)	NS	19.8	19.4	24.8	21.1	13.8
CV(%)	11.9	17.5	15.6	19.1	15.5	25.2

** R2= full bloom, R3= Early pod, R4= flat pod, R5= full seed, R6= full pod cavity and R7= Physiological maturity*

The pea aphid density at Chefe Donsa was assessed beginning from the full bloom stage (R2) and there was no statistically significant difference among treatments in pea aphid density on 8 October 2011 sampling (end of first week of

October (Table 2)). In the subsequent four sampling dates (between the second and last week of October), treatments differed highly significantly ($p < 0.01$) in pea aphid density and insecticide application significantly reduced pea aphid density than the other treatments. As was the case at Debre Zeit, the fertilized and the seed dressed lentil tend to have greater aphid density than the untreated lentil. The pea aphid density was so high and in some plots there were as many as 96 aphids per 130 cm^2. Consequently, the seed dressed, fertilized and untreated lentils withered and died before seed setting.

Table 2.Pea aphid population density (average number per 130cm^2) in lentil sown 2 August 2011 at Chefe Donsa

Treatment	Sampling date (crop stage*)						
	8/10/11 (R-2)	13/10/11 (R-3)	20/10/11 (R-4)	26/10/11 (R-5)	2/11/11 (R-6)	10/11/11 (R-7)	15/11/11 (R-8)
Alemaya + fertilizer	71.4	66.9	71.6	77.6	95.7	31.3	42.1
Alemaya + Apron star	71.1	73.4	75.5	66.5	92.1	32.7	42.0
Alemaya + dimethoate	63.2	1.1	1.5	6.9	20.4	45.3	32.6
Alemaya untreated	63.1	66.9	61.9	74.9	80.8	35.9	46.1
ILL7664 + DAP	71.6	59.4	60.1	73.2	50.8	29.7	47.7
ILL7664 + Apron star	56.5	68.7	58.4	79.3	79.0	35.3	48.1
ILL7664 + dimethoate	51.2	0.4	1.1	6.1	17.2	35.6	34.8
ILL7664 untreated	60.4	58.2	51.3	65.1	71.2	29.3	56.3
LSD (1%)	NS	33.9	30.9	58.4	64.7	NS	NS
CV(%)	6.6	10.7	7.7	14.7	13.2	6.1	14.2

** R2= full bloom, R3= Early pod, R4= flat pod, R5= full seed, R6= full pod cavity, R7= Physiologicalmaturity and R8= full maturity*

2012/13 Season

At Debre Zeit, the pea aphid population remained at low density up to the third week of September and it reached the static economic threshold level of ≥ 20 per 130cm2 at the end of the first week of October (Table 3). Treatments did not vary in pea aphid density until insecticide was applied on 10 October 2012, by this time the crop was at full seed stage (R5). There were more pea aphids on fertilized, seed dressed or untreated lentils than those sprayed with insecticide. The rainfall amount and distribution was similar with previous season and rapid pea aphid population growth occurred in October.

Table 3. Pea aphid population density (average number per 130cm^2) in lentil sown on August 3, 2012 at Debre Zeit

Treatment	Sampling date (Crop stage*)				
	24/9/2012 (R-3)	1/10/2012 (R-4)	10/10/2012 (R-5)	17/10/2012 (R-6)	23/10/2012 (R-7)
Alemaya + fertilizer	9.1	22.9	48.6	55.6	33.5
Alemaya + Apron star	9.1	20.3	44.3	42.5	17.9
Alemaya + dimethoate	7.6	15.4	36.9	0.2	0.9
Alemaya untreated	6.7	16.8	37.5	41.5	29.4
ILL7664 + DAP	8.1	15.3	33.5	32.9	15.6
ILL7664 + Apron star	7.1	12.9	41.1	48.2	32.2
ILL7664 + dimethoate	5.4	13.5	30.7	0.5	1.0
ILL7664 untreated	6.0	13.9	32.8	35.3	31.4
LSD(5%)	NS	NS	NS	36.3	30.1
CV(%)	15.5	12.9	6.3	12.3	26.2

** R3= Early pod, R4= flat pod, R5= full seed, R6= full pod cavity, and R7= Physiological maturity*

2013/14 season

At Debre Zeit, the pea aphid population remained at low density up to the first week of October. In the second week of October, it surpassed the static economic threshold level and reached peak density of 19 to 24 aphids per 130cm^2 only in fertilized lentils (data not shown). By this time the crop was at full seed stage and insecticide was applied on dimethoate treated plots. Soon after insecticide application, the pea aphid population on the other treatments crashed perhaps due to the extended rain that fallen in the first two weeks of October. It rained 64 mm in 8 days in September and 16.0 mm in 4 days in the first two weeks of October.

The pea aphid population densities at Chefe Donsa in 2013/14 was generally very low (an average of ≤ 10 aphids per 130cm^2 at peak density), as a result, there was no difference among the different treatments (data not shown).

2014/15 season

At Debre Zeit, in the 2014/15 the pea aphid remained at low density throughout the season on all treatments and at the flat pod stage of the crop, maximum density of 13 aphids per 130 cm^2 was recorded in the first week of October (data not shown). In this season, the rainy season was unusually long and it rained 108.5 mm in 12 days in September and 40.3 mm in five days in the first two weeks of October, while the average minimum temperature in September and October was greater than 10°C. These climatic conditions might have severely affected increase of pea aphid population. Similarly, at Chefe Donsa, the density of pea aphid population in 2014/15 was very low throughout the growing period. It reached peak of 14 pea aphids per 130 cm^2 in the second week of October when the crop was at full bloom stage. However, unlike at Debre Zeit, the population

does not collapse after reaching peak density rather it remained at stable density until the crop matures (data not shown).

2015/16 season

At Debre Zeit, as was the case in the 2014/15 season, the pea aphid population remained at low density throughout the season and maximum density of 14 aphids per 130 cm^2 was recorded between the last week of September and first week of October. Consequently, there was no significant difference among treatments in pea aphid population density. The rainfall in September of 2015/16 was low in amount (43.8 mm) and frequency (7 days); while the average minimum temperature in September and October was greater than 10°c.

At Chefe Donsa, the pea aphid population density in 2015/16 was greater than the density in the preceding season. Insecticide spraying significantly reduced pea aphid density up to the beginning of the third week of October; however, there was no difference among treatments in pea aphid density thereafter (Table 5). Dimethoate was sprayed on 16 October 2015 when the crop was at flat pod stage. In most of the time the pea aphid population on fertilized, seed dressed and untreated lentil fluctuated around the static economic threshold level of ≥ 20 pea aphids per 130 cm^2.

Table 4.Pea aphid population density (average number per 130cm^2) in lentil sown 3 August 2012 at Chefe Donsa

Treatment	Sampling date (Crop stage*)				
	4/10/2012 (R-2)	11/10/2012 (R-3)	19/10/2012 (R-4)	25/10/2012 (R-5)	19/11/2012 (R-8)
Alemaya + DAP	3.2	6.7	10.7	22.9	3.1
Alemaya + Apron star	3.3	8.1	31.7	45.3	2.2
Alemaya + dimethoate	2.7	7.1	21.3	1.4	1.2
Alemaya untreated	5.5	11.3	47.6	50.4	2.4
ILL7664 + DAP	2.8	6.7	29.3	28.9	4.0
ILL7664 + Apron star	5.8	8.7	34.9	52.8	4.2
ILL7664 + dimethoate	3.5	6.8	24.3	0.8	0.3
ILL7664 untreated	2.8	5.3	27.2	51.2	2.4
LSD(5%)	NS	5.3	32.7	40.2	3.6
CV(%)	20.3	11.7	20.3	16.8	37.1

** R2= full bloom, R3= Early pod, R4= flat pod, R5= full seed, and R8= full maturity*

Table 5. Pea aphid population density (average number per 130 cm^2) in lentil sown 11 August 2015 at Chefe Donsa

Treatment	Sampling date (Crop stage*)				
	7/10/2015 (R3)	16/10/2015 (R4)	23/10/2015 (R5)	30/10/2015 (R6)	6/11/2015 (R7)
Alemaya + fertilizer	24.5	15.1	18.7	25.7	18.0
Alemaya + Apron star	12.9	24.2	17.5	24.7	13.8
Alemaya + dimethoate	12.1	3.2	9.5	15.3	21.5
Alemaya untreated	16.5	22.8	20.8	26.6	26.5
ILL7664 + DAP	19.6	34.4	27.6	25.1	16.4
ILL7664 + Apron star	11.1	18.5	24.6	20.6	16.8
ILL7664 + dimethoate	13.0	2.3	11.0	16.0	22.8
ILL7664 untreated	14.1	13.1	16.4	21.1	23.4
LSD(5%)	9.1	22.7	NS	NS	NS
CV(%)	11.0	28.4	17.7	14.6	17.9

**R3= Early pod, R4= flat pod, R5= full seed, R6= full pod cavity, and R7= Physiological maturity*

2016/17 season

The pea aphid population at Debre Zeit increased continuously from last week of August up to the end of the third week of September and then it declined. In the fourth week of September Dimethoate was applied and it reduced significantly the pea aphid population. However, the pea aphid population also declined in the fertilized, seed dressed and untreated lentil due to the unfavorable climatic conditions. As a result, in the first week of October, there was less than one pea aphid per 130 cm^2 in all treatments. In September it rained 66.2 mm in 10 days and the average minimum temperature was ≥ 12◦C

At Chefe Donsa, in 2016/17, the pea aphid population density did not exceed nine pea aphids per 130cm^2 throughout the growing season, which might be attributed the late planting time (10 August 2016). Consequently, dimethoate was not sprayed.

The early seedling phase of lentil was pea aphid free, which might be attributed to the environmental condition under which the crop grows. Moreover, the vegetative growth phase of lentil occurs during August, which is characterized by relatively heavy rainfall, high soil moisture content, and low evapotranspiration. Whereas the transition from vegetative growth phase to reproductive phase occurs in September, in which the soil moisture depletion begins. Consequently, the pea aphid population increases during the reproductive phases of the crop. Other than the environmental conditions, this population increase is attributed to the increase in nitrogen content of the plant. According to van Kessel (1994) and Kurdali *et al*. (1997) nitrogen content of lentil shoots increases substantially during flowering and podding stages.

The pea aphid population crashes shortly after cessation of rainfall despite the low natural enemy density that acts on it. Pea aphid is sensitive to drought condition under which the host plant grows (McVean and Dixon 2001; Forbes *et al.* 2005). Therefore, the crash of pea aphid population shortly after the cessation of rainfall could be attributed to the decline of soil moisture content.

Pea aphid population density tends to be greater on phosphorus fertilized lentils than on untreated ones. Similar findings have been reported in other crops and insect pests. For instance, in petunia (*Petunia axillaris hybrid)* population of potato aphid (*Macrosiphum euphorbiae)* increased with increasing phosphorus (Jansson and Ekbom 2002).

Natural enemies

The generalist predator larvae and adults of *Adonia sp.* and other coccinellids were prevalent in each year but their average density was less than one per 130 cm^2. Besides, except in 2011 at Chefe Donsa, where there was high level of pea aphid infestation (Table 2), parasitoids were not recorded at both locations. In 2011 at Chefe Donsa, unidentified parasitoid parasitized pea aphid only as the aphid population reached extremely high density, which is not desirable characteristic of an effective natural enemy. On the other hand, in field pea Kemal (1999) has reported high level (up to 42%) of parasitoid attack on pea aphid. The host plant on which the pea aphid feeds (Hufbauer 2002) affects the degree of susceptibility of pea aphids to parasitoids. Therefore, in the future, it is recommended to study if pea aphid is differentially affected by parasitoids when it infests different hosts or determine if lentil is providing enemy free space for the pea aphid.

Other insect pests

In all seasons and both locations, the pod borer, *Helicoverpa armigera*, cowpea aphid (*Aphis crassivora*) and thrips occurred at an average of less than one individual per 130cm^2.

Grain yield

In all years, there was no statistically significant difference ($p > 0.05$) among treatments in grain yield (Table 6) and in percentage of pods without grains (data not shown). Although dimethoate reduced pea aphid population density, reduction in pea aphid population did not lead to increase in grain yield. Neither phosphorus fertilization nor seed dressing with Apron star 42 WS did significantly increased grain yield of lentil. At Debre Zeit, the average percentage of pods that did not bore grain ranged from 9.18 to 23.4, while at Chefe-Donsa it ranged from 7.7 to 30.5%.

Table 6. The effect of insecticide, fungicide and phosphorus fertilization on grain yield of lentil at Debre Zeit and Chefe Donsa in different seasons

Treatment	Season									
	2012/13		2013/14		2014/15		2015/16		2016/17	
	Debre Zeit	Chefe Donsa	Debre Zeit	Chefe Donsa	Debre Zeit	Chefe Donsa	Debre Zeit	Chefe Donsa	Debre Zeit	Chefe Donsa
Alemaya + DAP	1891.6	1458.8	1438.8	2368.7	1627.2	2127.3	853.9	2036.8	1538.6	1691.2
Alemaya + Apron star	1985.9	1404.4	1244.1	1969.0	1941.5	2373.3	996.4	2020.1	1607.6	1877.4
Alemaya + dimethoate	1738.1	1873.8	1150.3	2166.6	1627.1	2433.6	1147.1	2115.1	1601.2	1938.3
Alemaya untreated	1864.1	1407.5	1072.2	1987.9	1704.4	2101.1	1044.6	1885.2	1655.7	1807.2
ILL7664 + DAP	1898.1	1773.4	1391.9	2356.4	2139.4	2229.9	813.3	1903.8	1532.5	1720.5
ILL7664 +Apron star	1797.2	1461.6	1284.4	2451.3	2216.5	2254.5	1027.4	1843.3	1558.6	1746.9
ILL7664 + dimethoate	1819.7	1985.0	1232.8	2163.3	1920.0	2601.3	1192.6	2044.1	1484.3	2028.4
ILL7664 untreated	1775.6	1343.4	1188.4	2402.3	2227.6	2134.5	1038.3	2192.2	1582.9	1689.7
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	11.5	25.7	14.2	14.2	18.1	18.3	14.20	13.7	38.0	19.2

In all years, the grain yield of lentil was very low compared to those reported by Geletu and Yadeta (1998). The low yield might be due to the sowing time used to plant the experiment. According to Geletu 1991, the appropriate planting time for lentil around Debre Zeit is last week of June to the second week of July. The yield of fertilized lentil was not statistically different from the yield of untreated ones, which might be ascribed to the available phosphorus in the soil. Turk et al. (2003) assert that lentil responses to phosphorus application only if the available phosphorus in the soil is very low.

Conclusion

The pattern of pea aphid population growth under different treatment regime at Debre Zeit and Chefe Donsa was similar. The application of phosphorus fertilizer or seed dressing with Apron star 42WS does increase pea aphid population relative to the untreated control and dimethoate sprayed lentils. Moreover, these treatments did not have effect on grain yield of lentil.

Pea aphid infestation begins at vegetative stage usually in the last week of August but it remains at low density for three weeks perhaps because of rainfall effect. Rainfall during the first two weeks of October suppressed aphid population, while dry period and minimum temperature below 10◦C favored pea aphid population growth.

The pea aphid reached the static economic threshold level during the reproductive phase of the crop. Consequently, there was no yield advantage from insecticide spraying. Besides, given the current price of lentil grain, reestablishing and validating new economic threshold level is required.

Acknowledgements

The author acknowledges Ato Assefa Kebede and Geteneh Mitiku for their help during data collection. The study was financed by the Ethiopian Institute of Agricultural Research (EIAR).

References

Aqueel MA, CM Collins, AM Raza, S Ahmad, M Tariq, and SR Leather. 2014. Effect of plant nutrition on aphid size, prey consumption, and life history characteristics of green lacewing. Insect Science, 21:74–82.

Berhanu Bekele SG, Kumari, Kemal Ali, Abdulrazak Yusuf, KM Makkouk, Mandefro Aslake, Melkamu Ayalew, Gelelbelu Girma and Dereje Hailu. 2005. Survey of viruses affecting legume crops in the Amhara and Oromia regions of Ethiopia. Phytopathol. Mediterr. 44: 235–246

Dosdall LM, GW Clayton, KN Harker, JT O'Donovan, and FC Stevenson. 2004. The effects of soil fertility and other agronomic factors on infestations of root maggots in canola. Agron. J. 96:1306–1313.

Erskine W, M Tufail, A Russell, MC Tyagi, MM Rahman, and MC Saxenal. 1994. Current and future strategies in breeding lentil for resistance to biotic and abiotic stresses. Euphytica.73 : 127-135.

Forbes AE, CT Harvey, and KJ Tilmon. 2005.Variation in the responses of spotted alfalfa aphids, *Therioaphis maculate* Buckton (Homoptera: Aphididae) and pea aphids, *Acyrthosiphon pisum* Harris (Homoptera: Aphididae) to drought conditions in alfalfa (*Medicago sativa*L., Fabaceae). Journal of the Kansas Entomol.Society.78: 387–389

Geletu Bejiga. 1991. Effect of sowing date on the yield of lentil *(Lens culinaris* Medik.). J. Agronomy & Crop Science 167: 135-140

Geletu Bejiga and Yadeta Anbessa. 1998. Alemaya self-adjusting lentil variety to different environments in Ethiopia. NVRSRP Newsletter No. 1. pp.1-4

Garratt MPD, SR Leather, and DJ Wright. 2010. Tritrophic effects of organic and conventional fertilisers on a cereal-aphid-parasitoid system. Entom. Exper. et Appl. 134: 211–219

Hufbauer RA. 2002. Aphid population dynamics: does resistance to parasitism influence population size? Ecological Entomology 27: 25-32

Jansson J and B Ekbom. 2002. The effect of different plant nutrient regimes on the aphid *Macrosiphum euphorbiae* growing on petunia. *Entom. Exper. et Appl.* 104: 109–116.

Johnson Scott N, C Hawes, and AJ Karley. 2009. Reappraising the role of plant nutrients as mediators of interactions between root- and foliar-feeding insects. *Functional Ecology*, 23: 699–706

Kemal Ali. 1999. Population dynamics of *Acyrthosiphon pisum* (Homoptera: Aphididae) and its natural enemies on *Pisum sativum* (L). Pest Mgt. J. Eth. 3: 23-29

Kurdali F, K Kalifa and M Al-Shamma.1997. Cultivar differences in nitrogen assimilation, partitioning and mobilization in rain-fed grown lentil. Field Crops Research 54 : 235-243

McVean RIK and AFG Dixon. 2001.The effect of plant drought-stress on populations of the pea aphid *Acyrthosiphon pisum*. Ecological Entomology. 26: 440-443.

Melaku Wale. 2002. Population dynamics of the pea aphid, *Acyrthosiphon pisum*(Harris) (Homoptera: Aphididae) on field pea *(Pisum sativum*L.) in northwestern Ethiopia. *Insect Sci. Applic.*22: 131-137

Mintesnot Worku. 2017. Efficacy of sowing dates integrated with insecticides against pea aphid (*Acyrthosiphon pisum*) on lentil. Indian Journal of Entomology. 79: 1-5

Pitan OOR, JA Odebiyi, and GO Adeoye. 2000. Effects of phosphate fertilizer levels on cowpea pod-sucking bug populations and damage. International Journal of Pest Management, 46**:** 205-209

Purandare SR, B Tenhumberg, and JA Brisson. 2014. Comparison of the wing polyphonic response of pea aphids (*Acyrthosiphon pisum*) to crowding and predator cues. Ecol. Entomol., 39: 263–266

van Kessel C. 1994. Seasonal accumulation and partitioning of nitrogen by lentil. Plant and Soil 164: 69-76.

Tebkew Damte and Mekasha Chichaybelu. 2013. Evaluation of the insecticides-King 5EC and Lamdex 5EC for managing pea aphid, *Acyrthosiphon pisum* (Hemiptera: Aphididae) on lentil. Ethiop. J. Crop Sci. 3:105-115

Tebkew Damte. 2014. Morph and age structure of pea aphid, *Acyrthosiphon pisum* (Hemiptera: Aphididae) in lentil. Pest Management Journal of Ethiopia 17:29-35

Turk MA, AM Tawaha, and MKJ El-Shatnawi. 2003. Response of lentil (*Lens culinaris* Medik) to plant density, sowing date, phosphorus fertilization and ethephon application in the absence of moisture stress. J. Agronomy & Crop Science 189 : 1-6

Weisser WW and C Braendle. 2001. Body colour and genetic variation in winged morph production in the pea aphid. *Entomologia Experimentalis et Applicata* 99: 217–223