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Comparison of important aphids population on seed potato farms

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Abstract
Potato as a valuable agricultural product has some injurious pests. In a research, we compared the important aphids abundance in two parts of Iran. Collection of aphids was carried out by yellow water trap and aphid/leaf count methods every week in 2015-2016. We selected seed potato fields with five distances (0, 100, 200, 400, 500m) from viral plant resources in Hamadan and Isfahan, Iran. The results showed in Hamadan *Aphis gossypii* Glover had the most/lowest numbers (3.40 and 0.17 at distances (0) and (200) m) however, in Isfahan were 10.00 and 0.00 aphid at distances (200) with (500) m, correspondingly. The furthest population for *Myzus persicae* (Sulzer) was found at (0) distance in Isfahan. There was no significant difference between the parts aspect of photosynthesis and Leaching tests on potato. Geographical indices may influence on aphids and pay attention to field distances is important to control aphids in the first step on crop management.

Keywords: *Solanum tuberosum*, Distance, Aphididae, Frequency, Iran

Introduction
Potato (*Solanum tuberosum* L.) has been considered as one of the best vegetables crops, which is consuming in daily human regime. In this regard, around more than 130 countries throughout the world have developed its planting and other food industrials [1, 2]. Aphids (Hemiptera: Aphididae) have a world-wide distribution, especially in temperate zones and produce much losses economically [3, 4]. It is interesting to note that around 750 aphid species are reported in India, 550 species in America, 750 species in Russia (USSR) and 430 species in Iran [5]. Aphids have been believed rush on many plants, such as potato, feeding on the epidermal tissues or by inserting their stylets through the phloem may transmit viruses to other plants during sucking tap and rapidly cause wilting damage [6]. Nearby 43 species of aphids transmit viruses between plants [7]. In Iran, around 14 species of aphids such as; *Myzus persicae, Aphis gossypii, Therioaphis trifolii, Ahis craccivora, Acyrthosiphon pisum and Macrosiphum euphorbiae* have been identified as harmful pests on potato fields [5, 8]. Regarding, a large number of aphids was caught in yellow-pan trap in Haringhata (India) that *Aphis gossypii* showed furthest population [9]. In addition, winged-aphid morph may appear in long-distances and transfer viruses [10]. A few aphids can undertake migrations over the range of different distances. Moreover, it was studied Influence of distance from adjacent forest fragments on aphids (Hemiptera: Aphididae) parasitoidism in wheat fields in Parana State, Brazil [11]. Also, in Kosovo was observed frequency of *Myzus persicae* reached to unlike build-up and distribution in three distinctive areas [12]. At present, 400 meters distance is considered between seed potato field with orchards, alfalfa fields and commercial potato fields as standard distance, because it is believed that at this open space neither aphid has been observed nor viral disease existed in different areas [13]. In this sense, it is an irrefutable issue that should be developed research to increase the understanding about influence of potato aphids and their importance related to different distances of this farms. So we aimed to pursue frequency of the major aphids which were considered as the consequential pest on seed potato fields with different distances. Also, assessment of some effective factors (ecological and geographical) of potato may be remarkable on fluctuation of aphid population.

Materials and Methods
Two important location, consist of Isfahan and Hamadan (Iran) were selected in our experiments.

Fields of Hamadan **(**is located in west of Iran) were at 35° 19′ N latitude, 48° 29′ E longitude with 2142m altitude. Isfahan is situated in central of Iran and potato fields were at 32° 16′ N latitude, 51° 51′ E longitude with 1564m altitude. Two methods were used to monitor alate and apterous aphids using yellow water traps (containers 30*50*8 cm in size) and aphid/leaf count [4, 14]. Potato fields (3 fields for each distance, 20*10 m in size), consist of Agria variety were under experiments with five distances (*d*): 0, 100, 200, 400 and 500 m from probable viral resources (orchards, alfalfa fields and/or commercial potato fields). From June to September (2015–2016) every week 50 leaves from different bushes (up, middle and down) were randomly collected. In the field, the leaf samples were put into the plastic bag with amount of air (inside ice-chest). Falcon tubes consist of alcohol (70%) used for collecting aphids. At the laboratory, aphid samples were separated into the new tubes, classified and identified (by validate references Prof. Ali Rezvani, Entomologist in IRRIP). The information of their climates were collected and some aspects of potato accounted in the field and/or lab, including photosynthesis (*Pn*) by CI-340, osmotic potential (ψ_π) by vescor Inc., electrical conductivity (*EC*) and *pH* [15, 16], chlorophyll (*Chl*) by Spad 502 (Minolta Japan), leaf area (*La*) by Li 3100C Area Meter USA, leaf dry weight (*Ldw*), leaf humid weight (*Lhw*). Geographical and climate information collected from meteorological organization of Iran. Data were compared using proc GLM and means (ls-means) procedures [17]. If the model was significant, then means comparisons were made using the Fisher protected LSD test ($p<0.05$). Since the data were whole numbers standard deviation may be proportional to the mean and/or their effects might be multiplicative; hence, they were logarithmically transformed [18, 19]. The relationship between aphid population (*Aph*) and the other aspects of potato were described using linear regression: y=a+bx and/or by the other regression trends, where *y* is the aphid population parameter (as depending variable), *x* is the morphological or physiological aspect of plant or even climate data (independent variable), *a* is the intercept and *b* is the slope of the fitted line.

Results and Discussion

In our study, no considerable population of wingless-aphids was collected from leaves. On the whole, there was few winged-less aphids (immature stages) on leaves samples that were unrecognizable. Actually, we expected there should be a lot of aphids in wing-less shape however, it did not happen at all. It seems that date of plant affected on appearance and outbreak of this pest, because in this research seed potatoes sowed at the end of June, although food and commercial potatoes were planted in May regularly, so they showed different conditions. Respecting, some aspect of agronomic practices may join with the warmth of weather circumstances which affect on aphid distribution [20]. Similarly, it was mentioned temperature and planting date influence on seasonal abundance on lettuce aphids strongly, or even unusual occurrence during season that may be owing to dry and warm irrationally [5, 21, 22]. Moreover, Soltani *et al.* [14] confirmed that low population with the seasonal fluctuation was observed between last of May to July. Therefore, it is believed that a little environmental component with cultural practices cause effects on wingless-aphid activities, alongside ecological or physiological conditions, cooperatively natural enemies are recognized publicly as effective important constituents on abundance expanse [5, 23, 24, 25, 26]. In present work, yellow water traps demonstrated remarkable intensity of frequency fluctuation for winged-aphids, except two months (June and July). The mean aphid numbers was showed for two parts of Iran in table 1, separately. These results explained the greatest abundance at *d* (0) in front of the other *d*s. However, the least population was at *d* (400 and 500) m in Hamadan and *d* (500) m in Isfahan on both year. Table 1 present that *d*s have difference from each other, statistically. Also, in table 2 locations and distances with their interaction had significant difference. It means that several components may influence on population aphid, not only between two locations, but also for some changes among *d*s in each part. Figure 1 is related to *Aphis gossypii* abundance and showed that *d* (200) m in Isfahan had the most numbers of aphids in contrast with Hamadan in which *d* (0) was fixed by this level. Distance (0) in figure 2 displays population of *Myzus persicae* at the top level in Isfahan, while *d* (500) m was in less number at the same place. As it comes into view, in figure 3 *Therioaphis trifolii* in *d* (200) m revealed further population in Isfahan, despite *d* (500) m had the lowest rate. Comparison population of aphid entirely, showed that *d* (0) had collected utmost occurrence in front of *d* (500) m in Isfahan (Fig. 4). It is clear cut that from *d* (0) to *d* (500) m in Isfahan, aphid numbers become less as it shows adaptation by linear equation (R^2= 0.86) in figure 5. Falling shape was found in figure 6 as well. There was the same decrease from *d* (0) to *d* (500) m mark with an address, linear equation (R^2= 0.93) in Hamadan. As it was stated by the referenced graphs, aphid immensity showed that less population was in the last distance from polluted resources (*d*= 500 m), so linear equation present this adaptation also, the coefficient of correlation was adjusted more in Hamadan. In agreement with Tahtacioglu & Ozbek [20] in Erzurum of Turkey also, Pourrahim *et al.* [27] in Bahar of Hamadan, Iran which was resulted unlike aphid abundance and species on those areas. Reasonably, host characteristics with pest conditions not only change level of insect mass, but they also affect on pests aspects in adaptability and activity on different host [28, 29, 30]. According to this, in every distance or place, potato farms consist of several kind or population aphids. Undoubtedly, aphids have interaction with each other or other insects, and so at distinctive *d*s frequencies for aphids were different. This research showed that distances 400 and 500 m contained the least number of aphid population. On both area, Hamadan and Isfahan, frequency was assumed by 1.13 and 7.77 aphids chronologically, although at distances 100 and 200 m data was around 9.00 and 15.58 numbers. As a result, distance 400 m in Iran has more confidence with less aphid population and so low level of virus disease that probably, confirm the suitable or standard *d* to sow seed potato. In this regard, other studies have demonstrated different results. As a case in point, in India to be considered 5 meters distance between seed potato farm and viral polluted areas [31, 32], while in the United States of America 91.5 m is as the normal distance [33]. Then, the standard distance for seed potato farms should be considered in different range at distinctive areas. Environmental factors namely temperature, humidity or precipitation has an important influence upon potato and other vegetable crops [11, 22]. These aspects have revealed a close correlation with aphid frequency. According to this, we found that at the beginning of growth for potato in Hamadan (Fig. 7), *Aph* number was assumed around zero (June and July at high temperature), until August 18 that rate of the population gradually went up, while temperature decreased. Respect to the graph (Fig. 7), suitable temperature (20–25) at August and September probably enforces growth and activity of *Aph*. In

this graph (Fig. 7), once the peak of *Aph* frequency was around 80 numbers at 22 ºC, however, in the other temperatures population showed down grade. Probably, some ecological condition may affect on this fluctuation. *Log* of aphid frequency (Fig. 8) indicated that from 15 to 23 °C a rise can be seen, but afterwards went a drop. The equation in this figure displayed a quadratic polynomial relation between temperature and aphid population (R^2= 0.59). This mutual connection was somewhat meaningful by negative trend. Concurrently, this condition occurred in the other place i.e. Isfahan (Fig. 9). Aphids at this part appeared on August 18 by 5 numbers and population gradually climbed to 40 numbers on August 24. From August 30 to September 12, an upward frequency happened. Correspondingly, figure 10 presents *log* of aphid frequency with the same result (R^2= 0.40). This attribute was sharp at 24.2 °C then, declined steeply. Hence, it seems that growth and increase of aphid was adapted with a range of temperature. Similar results were observed that aphid frequencies are increasing during the growing of potato, when temperature is around 22–25 ºC [4, 5], and sometimes it becomes down for the sake of rising temperature (30 °C), dramatically [34, 35]. Likewise, the other scholars believed that at temperature 20–25 °C, aphid development was accelerated therefore, reproduction capacity and migration would be predictable [36, 37]. Subsequently, the percentage of relative humidity (*RH*) in the field of Hamadan varied from 20 to 40 (Fig. 11). The equation of quadratic polynomial (R^2= 0.59) points out a negative relation for *RH*% in versus of aphid abundance logarithm. As well, this is further comparable with Isfahan that *RH*% modifies *log* of aphid numbers conversely, so it is clarified by the mentioned equation in figure 12 (R^2= 0.96). In this respect, was found the reverse correlation between two mentioned aspects by Niaz & Ayub [38] Karim *et al*. [39] and Shamim-Hasan & Mamunur-Rashid [40] similarly. Understanding of some potato characteristics was the other objective of this study. According to table 3, our results have been classified that leakage factors consist of ψ_π, *EC* and *pH* had no significant differences, except *pH* (between two places). Really, we expected no contrasting between each feature in these areas, because of the fact that potato variety (Agria), irrigation, spraying and the other cultivation had equal condition. Since, it was observed some leakage factors can influence insect damage or their life duration at different circumstances [11, 12, 41], we pursued to find new knowledge related to aphid numbers and leaching tests or physiological trends, but regression equation showed no correlation statistically except one (Table 4). Of course, in this research, we had just one variety of potato and it was not other kind, so this result may be for this reason and the same practices. The mean number of *Pn*, *Chl*, *Ldw*, *Lhw* and *La* was larger for Hamadan (Table 3), even though no having meaning against Isfahan was observed (Tables 3 and 4). Only *Ldw* displayed correlation with *Aph*, and regression equation for this parameter in table 4 was present. In this regard, some physiological or morphological changes in plants bring about biotic stress [42]. In this issue, Darvishi [43] and Hassani [2] assessed some aspect of potato in order to find better circumstances and correlation between physiological factors with relation of certification and protection of seed potato [42] on farms. They indicated some aspects of plant (*Pn*, *Chl*, *Ldw*, *Lhw*, *La*), probably affect on the other living organisms (interaction), which are significant appearing damage on plants. Altitude was the other valuable item which was effective on aphid abundance. Potato farms in Hamadan had more height (2142m) in versus of Isfahan (1564 m) to address this issue winged-aphid population was less in Hamadan averagely (7.4<13.38) as Seyedoleslaami *et al*. [44] with Tahtacioglu & Ozbek [20] hinted the same results. In agreement with other works that geographical elements as much as ecological condition come into force predatory, interaction between plant-insect and aphid colonization [45, 46, 47].

Table 1: The average number of accumulative aphids in two provinces of Iran: Hamadan and Isfahan, in 2015–2016.

Year	Area	Distance (m)	Mean ± SE
2015	Hamadan	0	17.13 ± 2.50a
2015	Hamadan	100	9.80 ± 2.51b
2015	Hamadan	200	8.50 ± 2.80b
2015	Hamadan	400	1.53 ± 2.50c
2015	Hamadan	500	0.60 ± 2.51c
2016	Hamadan	0	16.53 ± 2.50a
2016	Hamadan	100	9.20 ± 2.51b
2016	Hamadan	200	8.50 ± 2.80b
2016	Hamadan	400	1.06 ± 2.50c
2016	Hamadan	500	1.06 ± 2.51c
2015	Isfahan	0	25.38 ± 2.29A
2015	Isfahan	100	16.80 ± 2.50B
2015	Isfahan	200	17.47 ± 2.50B
2015	Isfahan	400	5.80 ± 2.51C
2015	Isfahan	500	3.00 ± 3.24C
2016	Isfahan	0	23.55 ± 2.29A
2016	Isfahan	100	11.33 ± 2.50B
2016	Isfahan	200	16.73 ± 2.51B
2016	Isfahan	400	3.73 ± 2.50C
2016	Isfahan	500	3.00 ± 3.24C

Means following by different letters with in the column are significantly different at the 0.05 level.

Table 2: The GLM procedure, combined analysis of variance for aphid population.

Source	F_{value}	Pr>F	DF
Location	109.29**	<.0001	1
Distance	21.56**	<.0001	4
Year	1.87 ns	0.1729	1
Location*Distance	15.09**	<.0001	4
Year*Distance	0.19 ns	0.9431	4
Location*Year	0.05 ns	0.8160	1
Location*Year*Distance	0.09 ns	0.9848	4

CV =30.36 Ns=non-significant **= probably level at 1%

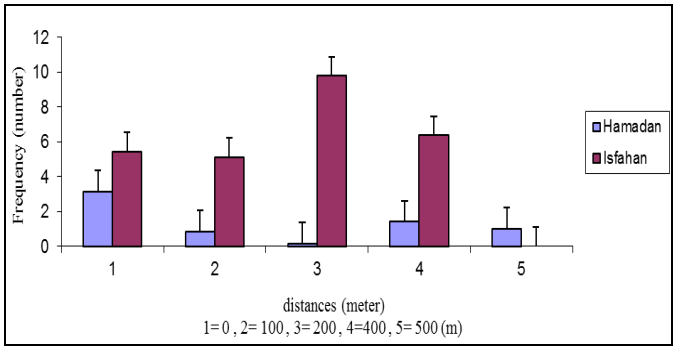

Fig 1: Comparison of mean population: *Aphis gossypii* in Isfahan and Hamadan at five distances in 2015–2016.

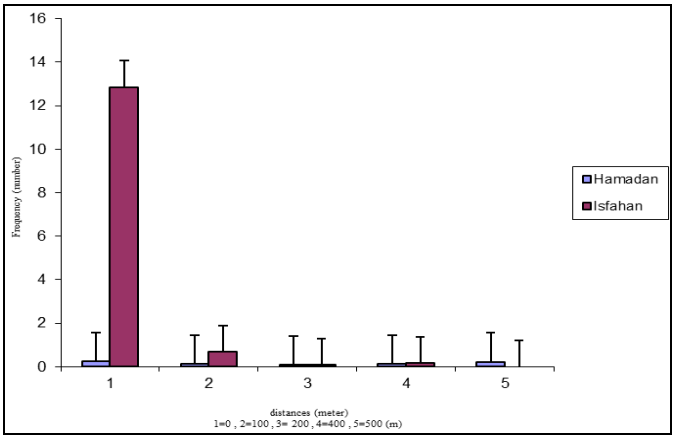

Fig 2: Comparison of mean population: *Myzus persicae* in Isfahan and Hamadan at five distances in 2015–2016.

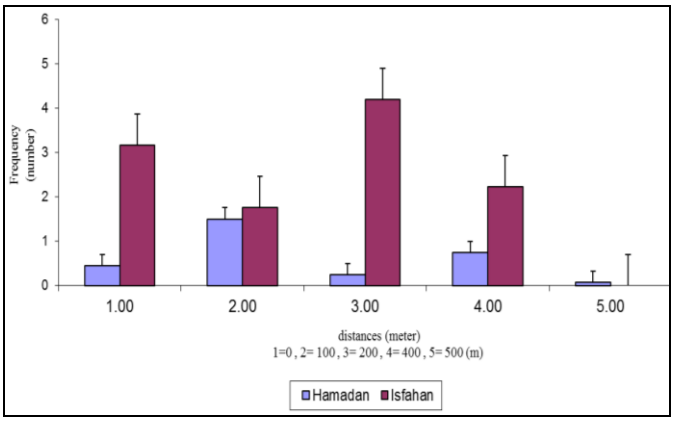

Fig 3: Comparison of mean population: *Therioaphis trifolii* in Isfahan and Hamadan at five distances in 2015–2016.

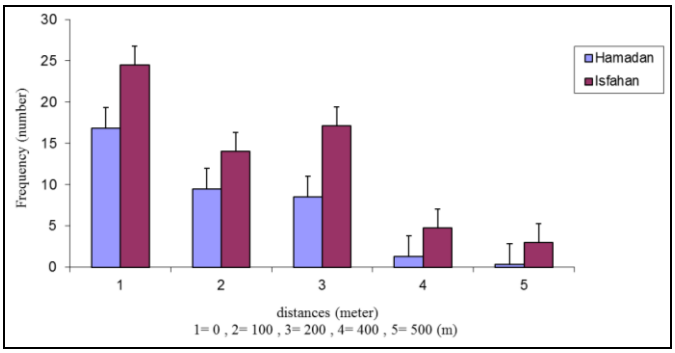

Fig 4: Comparison of mean population all aphids in Isfahan and Hamadan at five distances in 2015–2016.

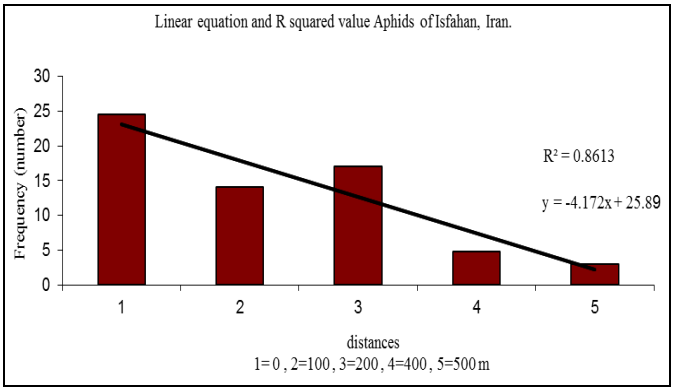

Fig 5: Linear equation and R^2 value of the aphid populations in Isfahan at different distances in 2015–2016.

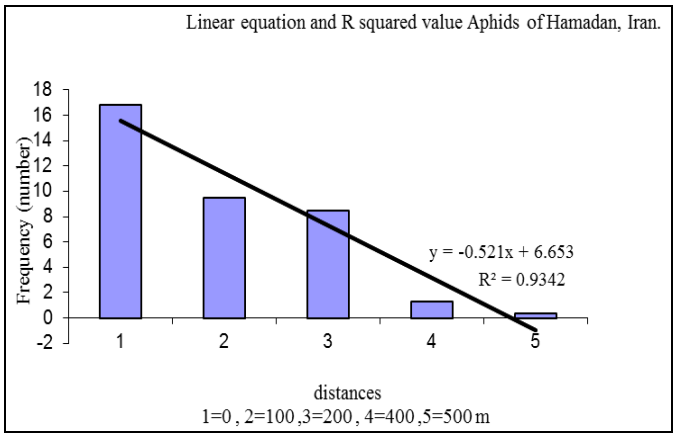

Fig 6: Linear equation and R^2 of the aphid population in Hamadan at different distances in 2015–2016.

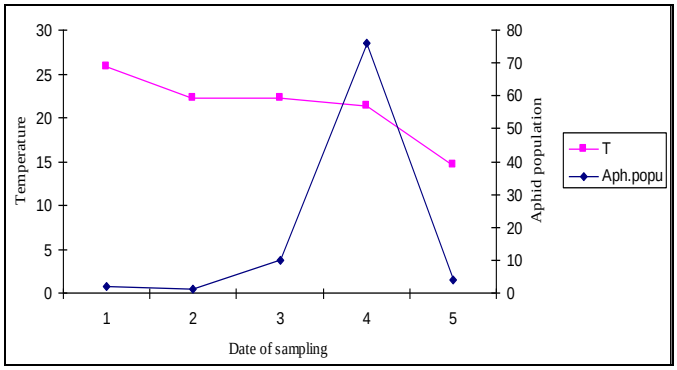

Fig 7: Incidence of aphid numbers at the end of season according to temperature from August 17 to October 4 in Hamadan, Iran (2015–2016). (1= 17 Aug., 2= 27 Aug., 3= 8 Sep., 4= 21 Sep., 5= 4 Oct.)

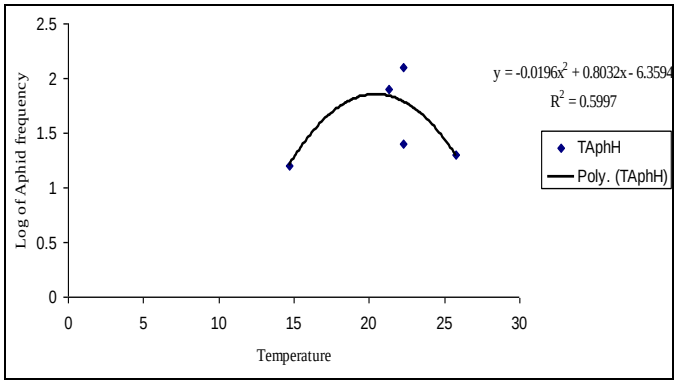

Fig 8: Relationship between *log* of aphid numbers and temperature in Hamadan, Iran (2015–2016).

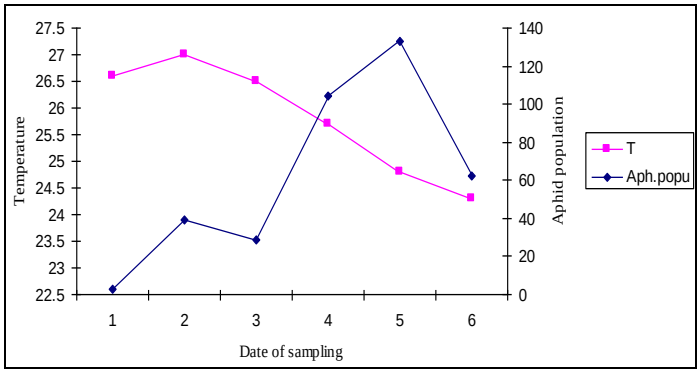

Fig 9: Incidence of aphid numbers at the end of season in range of temperature from August 18 to September 18 in Isfahan, Iran (2015–2016). (1= 18 Aug., 2= 24 Aug., 3= 30 Aug., 4= 5 Sep., 5= 12 Sep., 6= 18 Sep.)

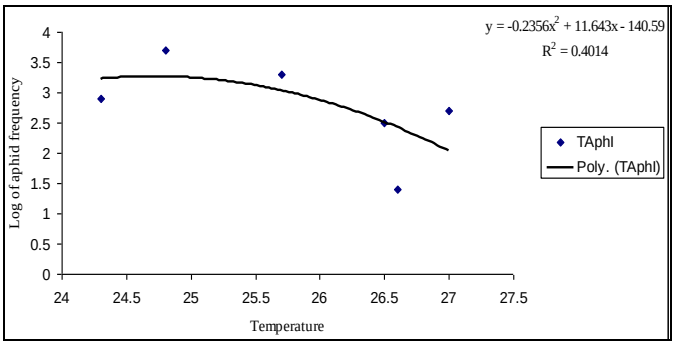

Fig 10: Relationship between *log* of aphid numbers and temperature in Isfahan, Iran (2015–2016).

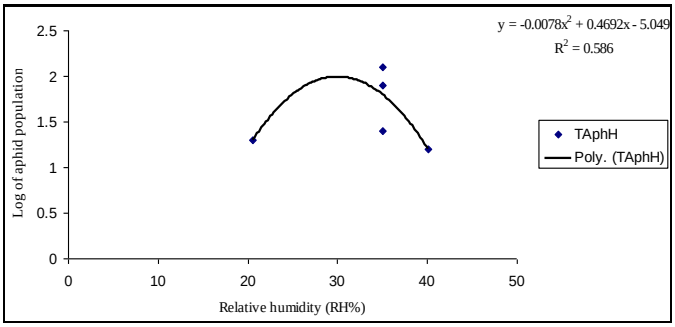

Fig 11: Relationship between *log* of aphid numbers and relative humidity in Hamadan,Iran (2015–2016).

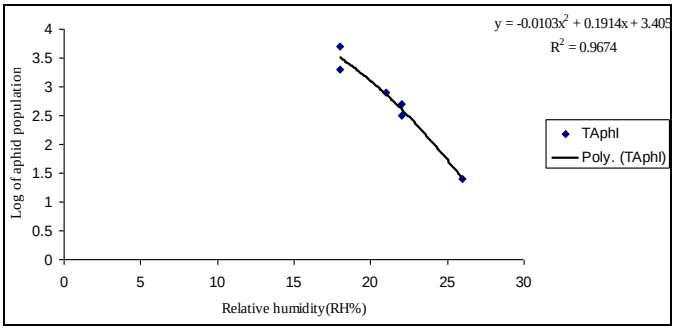

Fig 12: Relationship between *log* of aphid numbers and relative humidity in Isfahan, Iran (2015–2016).

Table 3: The GLM procedure of t-Test (LSD) on some aspects of potato (Agria variety) and aphid population (*Aph*) at zero distance, between two provinces of Iran (Hamadan and Isfahan). (N= 10, df = 18)

Variable	Mean ± SE	Location	C.V
ψπ	-0.3081 ± 0.007 a -0.3030 ± 0.007 a	Hamadan Isfahan	7.02
EC	0.642 ± 0.026 e 0.614 ± 0.026 e	Hamadan Isfahan	12.91
pH	6.65 ± 0.047 A 6.45 ± 0.047 B	Hamadan Isfahan	2.29
Pn	16.70 ± 1.821 p 12.08 ± 1.821 p	Hamadan Isfahan	24.01
Chl	42.04 ± 1.315 c 40.17 ± 1.315 c	Hamadan Isfahan	10.11
Lhw	4.652 ± 0.314 w 4.125 ± 0.314 w	Hamadan Isfahan	22.65
Ldw	4.253 ± 0.299 d 3.507 ± 0.299 d	Hamadan Isfahan	24.39
La	11.054 ± 0.941 F 10.977 ± 0.941 F	Hamadan Isfahan	27.01
Aph	16.83 ± 2.15 m 24.48 ± 2.15 n	Hamadan Isfahan	25.77

Means following by the same letters with in the column are not significantly different at the 0.05 level.

Table 4: Analysis of variance for the regression procedure dependent variables and their regression equations of few features of Agria (potato variety) related to aphid population (df_{er}= 18, df_{Reg}= 1).

S.O.V	MS	C.V.	Reg. equation
ψπ	0.00046 $^{n.s}$	6.78	-
EC	0.00037 $^{n.s}$	13.11	-
pH	0.02274 $^{n.s}$	2.74	-
Pn	106.64360 $^{n.s}$	24.01	-
Chl	3.71912 $^{n.s}$	10.34	-
Lhw	2.74266 $^{n.s}$	21.77	-
Ldw	3.88729*	23.53	Aph= 2.481 + 0.7569Lhw
La	11.32336 $^{n.s}$	26.03	-

*= significant at 5% level, ns= not significant.

Conclusion

There were three kind of significant aphid pest consist of; *Myzus persicae*, *Aphis gossypii* and *Therioaphis trifolii* in Isfahan and Hamadan. The highest frequency of *Myzus persicae* found at 0 distance in Isfahan also, the most population for *Aphis gossypii* and *Therioaphis trifolii* was in 200 distance at the same area. Hamadan with more height had less aphid population however, in Isfahan average of total mean population aphid was further. In Hamadan and Isfahan distances: 100 and 200m are probably less polluted in front of 0 distance, although both area showed distances: 400 and 500m had the equal condition (aphid population) with the least aphid abundance. It is supposed that 400 m as standard distance may be proved in Iran as it performs now. Weather condition, geographical situation and host plant physiological circumstances affect on aphid abundance, so these finding may help us on integrated crop management in seed potato fields.

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