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Efficacy of some selected botanicals and broad spectrum pesticides against foliage insect pests of cultivars of potato (*Solanum tuberosum* L.) in Zoba Anseba, Eritrea

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Abstract
Potato is one of the major vegetable crops after tomato and onion in Eritrea. This crop is highly attacked by many insect pests mainly Whiteflies, Aphids and Jassids. In Eritrea, limited research is done before on insect pest of potato hence this study aimed to know the most serious foliar insect pests and to determine the relative efficacy and performance of the common potato cultivars and the selected insecticides respectively. The experiment was conducted at Hamelmalo Agricultural College farm station, Eritrea using three potato cultivars (*Picasso, Ajiba* and *Zafira*). The design of the experiment was randomized complete block in triplicate. Besides two broad spectrum pesticides (deltamethrin, dimethoate) and two botanicals; neem seed kernel and tobacco leaf extracts were used. Data on the population count of insect pests before and after each spray were recorded. Whiteflies, aphids, jassids and red spider mites were identified and the result showed the highest aphid population reduction during tobacco leaf extracts spray followed by deltamethrin and neem seed extracts sprays respectively. Nevertheless, there was no significant difference between deltamethrin and neem seed extracts sprays in whitefly reduction and tobacco leaf and neem seed extracts sprays in reducing jassids population. The results further indicated maximum insect pest count in *Ajiba* and *Zafira* cultivars while Picasso showed minimum counts which indicate relative tolerance of the cultivar. The correlation analysis indicated, there was no significant association among insect pests and yield ha^{-1}. However, the growth parameters showed significant correlations with yield ha^{-1} at 0.01% level of significance.

Keywords: Aphids, botanicals, jassids, pesticides, potato cultivars, whitefly

1. Introduction
Potato (*Solanum tuberosum* L.), become an integral part of daily diet among the larger populations. This short duration crop is considered to be an important crop to achieve nutritional security of the nations because of its more quantity of dry matter, edible energy and edible protein as compared to cereals like rice and wheat. It is a special crop which is vegetatively propagated over the largest area in the world (Struik and Wiersema, 1999) [25]. Potato is supplementing meat and milk products by lowering energy intake and also by reducing food cost (Bhajantri, 2011) [6]. Potatoes are cross-pollinated mostly by insects, including bumble bees, which carry pollen from other potato plants, but a substantial amount of self-fertilizing occurs as well (Virginia *et al*., 2001) [28]. According to Silvia, 2012, the top ten potato producers in the world are South America (Which is known to be native of Potato), China, Russia, India, United States, Ukraine, Poland, Germany, Belarus, Netherlands, and France [24]. Different potato varieties differ markedly in yielding ability (Santerre *et al*., 1986) [23]. Globally annual crop production exceeds 330 million tons and it is one of the most important agricultural products in the world (Fabeiro *et al*., 2001) [8]. Worldwide potato production in 2009 was harvested as 329.581 million tons from 18.652 million hectare. Highest production per hectare was found from the central Europe (43.94 ton/ha) followed by North America (42.43 ton/ha); whereas lowest production was from Africa 9.98 ton/ha (Faulkner, 2012) [9].

1.1 Status of potato in Eritrea
Potato is one of the major vegetable crops after tomato and onion in Eritrea. Even though highland areas are suitable for potato cultivation and the total production is very low as

compared to the demands of the consumers. The most of the abiotic and biotic constraints that face the farmers in the potato growing regions of the world are common to all the countries and the regions including Eritrea. Potato production is more traditional and the knowledge of the farmers in identifying pests, suitable cultivars and pesticide selection is poor. The most of the time the crop is attacked by different insect pests and diseases which are very limiting factors for good production and quality. Besides potato varieties differ markedly in their yielding ability. Farmers are more interested in the cultivars that produce consistently high yields under their growing conditions. Total yield, number and weight of tubers per plant and average tuber weight and tuber quality such as specific gravity and starch content showed large variations among potato cultivars (Samih *et al.*, 2011) [22].

The potato seed tubers used in Eritrea today consists of a mixture of many varieties from locally grown (Carnetiom and Shashemene) as well as cultivars (*Picasso, Condor, Ajaba, Zafira, Cosmos* and *Spunta*, etc.) which are imported from time to time. Picasso and Condor are top yielding cultivars however due to their pinkish skin color; they are fetching lesser price and have less demand in the market as compared to *Zafira* and *Ajiba* which are ranking third and fourth in production, and first and second in their market values Anonymous (2009) [4]. In Eritrea; as concerning as its production, potato is one of the favorable vegetables with total production area and yield of 2632 ha and 17.1mt/ha respectively, whereas the total production area and yield of potato in Zoba Anseba is 71 ha and 6mt/ha respectively (MoA, 2012) [16].

1.2 Potato Pests

Potato is attacked by various insect pests and diseases like early blight, late blight, bacteria, nematodes and viruses like potato leaf roll and potato leaf curls. Some of the most potent insect pests that attack on potatoes are Leaf miner fly, Potato tuber moth, Aphid Thrips, Cutworm, White grub, Mole cricket, Whitefly, Spider mite and Jassids etc (Tantowijoyo and Van de Fliert, 2006) [26].

1.3 Role of pesticides

Neem (*Azadirachta indica*) has some medicinal and pesticide properties such as azadirachtin. The lethal effect, as compared to the control, of the powders prepared from different neem parts (Seed 40-55%, leaf 30-45%, stem 30-40% and root 10-30%) against different insects was studied by laboratory experiments (Achio *et al*., 2012) [1]. The extracts from seeds are more effective in controlling pests and the chemical absorbed by the plant can kill sucking insects (Joseph, 2005) [13]. Tobacco also found to be effective against many agricultural important pests and kill soft bodied biting and sucking insects. Tobacco extracts were also found to be the most active against the larval instars, affecting their survival. Earlier workers reported that the use of tobacco extract is effective for control of insect pests (Mari, 2012) [15]. Both of deltamethrin (Non-systemic) and dimethoate (Systemic) broad spectrum insecticides are of very active in controlling many species of insect like whitefly, aphids jassids, hoppers and many other agriculturally important insect pests by having contact and stomach poison action and translocating to whole parts of the plant respectively. Deltamethrin can be successfully applied during the attack of potato tuber moth and provide mutual control over other pests (Venava-Gancheva and Dimitrov, 2013) [27] and was also significantly more effective in suppressing the insect pest population and protecting plants from any injuries (Andi, 2011) [3].

Hence, it is studied with the objectives to analyse the relative performance of the selected broad spectrum pesticides and botanicals in controlling the common foliar insect pests; to understand the most potent foliar insect pests of potato cultivars in the study area and also it is needed to evaluate the relative susceptibility of potato cultivars.

2. Materials and Methods

2.1 Experimental site

The experiment was conducted at Hamelmalo Agricultural College experimental area in sub zoba Hamelmalo of Zaba Anseba which is located around 13km from Keren to the north in Eritrea. It has the altitude 1280 m above sea level with 15˚ 55’ 12.92’’ N latitude and 38˚ 27’ 46.9’’E longitudes. The area receives an average annual rain fall of 459mm and has sandy loam soil with PH of 6-7. The study area has an average temperature of 24 ˚C (MoA, 2005) [17].

2.2 Data collection

During the experiment different Potato seeds (*Picasso, Zafira* and *Ajiba*), chemicals (Deltamethrin, dimethoate, neem seed extract, tobacco leaf extract, carbaryl, mancozeb and fertilizers such as DAP, UREA and FYM were used. Under Eritrean agro-climatic conditions these cultivars are among the potato varieties performing well and adopted by farmers (Fig.1). *Ajiba* is a medium early crop. It is suitable for fresh consumption and produces medium and intermediate type foliage structure. It has medium dormancy period (Agrico, 2014) [2]. *Zafira* cultivar was imported to Eritrea in 2009 from Holland **(**Agrico Seed Company) by National Agricultural Research Institute (NARI). According to NARI field experiment (2011) [19] average yield of this variety is 26t/ha and this is also drought tolerant, suitable in dry areas and for sandy soils (Royal Horticultural Society, 2011) [21]. *Picasso* has long to very long dormancy with tuber size of very large, oval, uniform in shape yellow skin and red eyes, rather shallow eyes, fairly good resistance to internal bruising. It has very high yield and fairly susceptible to blights and good resistance to virus X and Y^n (Netherlands Potato Consultative Foundations, 2011) [20].

Fig 1: Tubers of *Ajiba, Zafira* and *Picasso* cultivars

2.3 Experimental design
The trial was conducted with three potato cultivars and two broad spectrum pesticides (deltamethrin and dimethoate) which act as acaricides and insecticides and two botanicals [(Neem seed (NSE) and Tobacco leaf extracts (TLE)] in two way factorial experimental design with three replications each of it had 15 treatments combination under irrigation and all necessary cultural practices. The broad spectrum pesticides and the botanicals had equal frequency of spray that was three times at an interval of 15 days. Five percent of need seed extract and 6.2% solution of tobacco solution that is enough for half an acre, were applied 8 times (seven-day interval) using the knapsack sprayer (Joseph, 2005) [13]. The experiment had 3m x 2.8m plot size, with 0.7m space between rows, 0.3m between plants, 0.8m space between plots and 1m between replications with the total of 45 experimental plots. Deltamethrin (Rubben), non-systemic insecticide was formulated at 2.5% EC and applied at the rate of 1lit/ha @ 1000 lit/ha of water (i.e. at 0.0025% of concentration). Dimethoate (Dimetox) is systemic insecticide having the ability of translocation once the pest ingest or come in contact to the treated part of the host. It is prepared at 40% EC and applied at the rate of 1.5lit /ha @1000 lit/ha of water (at 0.06% of concentration). In addition to the treatment chemicals a uniform application of mancozeb at the rate of 1kg/hectare was done for the cultivars to protect from the fungal diseases.

2.4 Treatments and its Combinations
V1=*Picasso*	C0=Zero
V2=*Zafira*	C1= dimethoate (0.06% of concentration)
V3=*Agiba*	C2= deltamethrin (0.0025% of concentration)
	C3= neem seed extract (NSE) (5% of solution)
	C4= tobacco leaf extract (TLE) (6.2% of solution)

2.5 Experimental data
2.5.1 Insect pest incidence and population count: To test the efficacy of the four pesticides 3 spray at the interval of 15 days were done to check their efficiency for reducing the pest population. The incidence and population count of the pests before and after spray at the gap of 24 hours were recorded using different techniques based on their behaviour.

A) Immobile insect pests (*Aphids*): The population of aphids were counted by taking leaf samples. Three leaves from each of the 3 sampled plants were taken and total numbers of aphids from the sampled leaves were divided by the sample number to get the average number of aphids per leaf. The incidence of the occasional pests (Spider mites) was also recorded.

B) Mobile insect pests (*Whitefly* and *Jassids*): For the mobile pests taking of leaf sample is quite difficult as they are active fliers, so sweeping nets with uniform movement were used for the population count. Ten sweeps were given for each plot. The population from each sweep were summed and divided by the number of sweeps so as to get the average pest population per sweep per plot. Following Groves *et al*., (2012), population count of the mobile insect pest was assessed by counting the number of adults collected from sweeping net samples [11].

2.6 Statistical analysis
Data recorded on different parameters were analyzed using statistical software GENSTAT and mean comparison were performed using the least significant difference (LSD) at 5% level of significance.

3. Results and Discussion
3.1 Insect pests
The important insect pests are Whiteflies: *Bemisia spp* (Order-Hemiptera, Suborder-Homoptera and Family-Aleyrodidae) are phloem (Sap) feeders. Whitefly-transmitted viruses (WTVs) are among the most destructive plant viruses; early virus infection often results in total crop loss. Aphids belong to Order Hemiptera, Suborder-Homoptera and Family Aphididae. Several aphids species such as green peach aphid (*Myzus persicae* Sulzer), potato aphid (*Macrosiphum euphorbiae* (Thomas), buck thorn aphid (*Aphis nasturtii* Kaltenbach) and foxglove aphid (*Aulacorthum solani* (Kaltenbach) feed on potatoes and act as vector of several damaging viruses in a persistent or non-persistent manner. Jassids belong to Order Hemiptera, Suborder Homoptera and Family Jassidae. Potato Jassids (*Emposca devastans*) are active insects and use their piercing-sucking mouthparts to remove sap from the potato leaf. Red Spider mites belong to the Class-Arachnida, Order-Acarina and Family-Tetranychidae. Spider mites (*Tetranychus telearius* L.) are not actually insects but still belong to the Phylum Arthropoda. *Polyphagotarsonemus latus* and *Rhizoglyphus echnoplus* are the other mites feeding on foliage and tubers in store respectively (Fig. 2). According to Clotuche *et al*. 2011 [7] and Le Goff al. 2010, spider webs help establish a suitable micro-habitat for the pest, protect against abiotic agents, shelter from predators, communicate via pheromones and provides a vehicle for dispersion [14].


A


B


C

D E F

Fig 2: Aphids (A); Whiteflies sucking sap on potato leaves (B and C); Jassids feeding on potato leaves (D and E) and microscopic photo of Red spider mites (F) from potato leaves

3.2 Insect population count

3.2.1 Aphid population

Effect of cultivar, chemical and combination of cultivar and chemical on aphid populations count: Pest population count was recorded and analyzed to know the effect of cultivar, chemical and interaction (Cultivar x chemical). From the results of analysis of variance there was highly significant difference in aphid population count except in pest population after application three which showed significant difference at 5% level of significance due to cultivars effects. The *Picasso* cultivar had the lowest pest population count in all the three application which showed high difference from the other cultivars. Whereas the *Ajiba* and *Zafira* cultivars remained equal except the highly significant before application two; this might probably be due to the cultivars difference (Table 1).

The uppermost aphid population reduction was recorded from cultivars *Zafira* and *Ajiba* in application one (20%) and application three (33.3%); where as in application two maximum aphid population decreased in *Zafira* cultivar (20%). *Picasso* cultivar showed no pest population reduction in both application one and two (0%) but there was 100% pest population increment in application three. This was due to the late emergence (Late sprouting) of the cultivar and also the two cultivars *Ajiba* and *Zafira* were suffered with high incidence of the diseases of early bight fungus which cause leaf dryness and necrosis. The sucking pests were therefore unable to get enough food or sap from the necrotic leaves. Not only the incidence of the blight fungus but the occurrence of the collar rot disease also had a great impact on pest population reduction in case of the *Ajiba* and *Zafira* cultivars.

The efficacy of the different insecticides also provided significant difference in population count of the aphids except in pest population before application two which was found highly significant difference in pest population count at 5% level of significance. The treatment plot C0 before application and C0 and C1 after application one showed the highest population record which was significantly different from the rest chemicals; whereas (C0, C1) and (C0, C2) showed variation from the other used chemicals before and after application two respectively. In application-three, there was a variation in C0 before and C0 and C4 after from the rest of the chemicals (Table 1).

In application one the chemicals deltamethrin (C2), NSE (C3) and TLE (C4) behaves equally in population reduction (25%) where as in the application two and three the top reduction was obtained from deltamethrin (C2=33.3%) and TLE (C4=50%) respectively. According to Andi, 2011, deltamethrin was consistently more effective in suppressing the insect pest population and protecting plants from any injuries [3]. The efficacy of Neem product (phytopesticide) was found effective against sucking pests (Aslam, 1999) [5]. These results are in agreement with their work.

Table 1 shows that the interaction effect was not found to bring any significant difference in the aphid population count. Although the interaction showed no significant difference at 5% level of significance the combination V3C4 (*Ajiba* x TLE) scored the highest aphid population reduction (66.7%).

Table 1: Effect of cultivar, chemical and cultivar x chemical on aphid populations count

Treatments	Application-1			Application-2			Application-3		
	Before	After	PPR* in%	Before	After	PPR* in%	Before	After	PPR* in%
V1	3	3	0(0)	2	2	0(0)	1	2	-1(-100)
V2	5	4	1(20)	5	4	1(20)	3	2	1(33.3)
V3	5	4	1(20)	4	4	0(0)	3	2	1(33.3)
LSD 5%	0.643	0.64		0.649	0.642		0.51	0.478	
CV%	20	22.6		23.7	27.9		29	33.2	
C0	5	5	0(0)	5	4	1(20)	3	3	0(0)
C1	4	4	0(0)	4	3	1(25)	2	2	0(0)
C2	4	3	1(25)	3	2	1(33.3)	2	2	0(0)
C3	4	3	1(25)	3	3	0(0)	2	2	0(0)
C4	4	3	1(25)	3	3	0(0)	2	1	1(50)
LSD 5%	0.831	0.82		0.838	0.829		0.66	0.617	
CV%	20	22.6		23.7	27.9		29	33.2	
V1C0	4	3	1(25)	3	2	1(33.3)	2	2	0(0)
V1C1	4	3	1(25)	3	2	1(33.3)	1	1	0(0)
V1C2	3	2	1(33.3)	2	2	0(0)	2	2	0(0)
V1C3	2	2	0(0)	2	2	0(0)	1	1	0(0)
V1C4	3	2	1(33.3)	2	2	0(0)	1	1	0(0)
V2C0	6	6	0(0)	7	4	3(42.9)	4	3	1(25)

V2C1	5	4	1(20)	4	4	0(0)	3	2	1(33.3)
V2C2	4	4	0(0)	4	3	1(25)	3	2	1(33.3)
V2C3	5	4	1(20)	4	4	0(0)	2	2	0(0)
V2C4	5	4	1(20)	4	3	1(25)	2	2	0(0)
V3C0	5	5	0(0)	5	5	0(0)	4	3	1(25)
V3C1	5	5	0(0)	4	4	0(0)	3	3	0(0)
V3C2	4	4	0(0)	3	2	1(33.3)	2	2	0(0)
V3C3	4	4	0(0)	4	4	0(0)	3	2	1(33.3)
V3C4	5	4	1(20)	4	3	1(25)	3	1	2(66.7)
LSD 5%	NS	NS		NS	NS		NS	NS	
CV%	20	22.6		23.7	27.9		29	33.2	

*PPR = Pest Population Reduction; NS=Non-significant

3.2.2 Whitefly population

Effect of cultivar, chemical and (Cultivar x chemical) on Whitefly population count: Based on the analysis of the data there was significant difference in whitefly population count except there was highly significant different before application one and after application two and non-significant different after application one and three at 5% level of significance. Before application one, before and after application two and before application three, the *Picasso* cultivar recorded with the lowest whitefly population which showed significant different from the two cultivars *Ajiba* and *Zafira* as they were at par in all the three applications (Table 2).

The whitefly population reduction was obtained from *Ajiba* (22.2%), *Picasso* (25%) and *Ajiba* and *Zafira* (25%) in application one, two and three respectively. The cultivar *Picasso* registered the lowest population reduction in case of application one and three. The highest reduction of whitefly population in the two cultivars (*Ajiba* and *Zafira*) was probably because of the high incidence of the diseases of early bight and collar rot which cause leaf dryness and necrosis. As a result the sucking pests were unable to get enough food or sap from the necrotic leaves. The peak reduction value of the *Picasso* cultivar in application two was due to its vegetative stage response.

The efficacy of the different chemicals and botanicals were tested and it was found that there was highly significant difference among the chemicals in the pest population count apart from before application one as it was showed no significant difference at 5% level of significance. The control plot (C0) scored the top whitefly population in all the application except before application one and the plot gave the highest difference from the treatments. The lowest population was recorded from deltamethrin (C2) after application one and before and after application two showed difference from the rest chemicals. Whereas before application three deltamethrin (C2), NSE (C3) and TLE (C4) behaved equally; unlike after application three where NSE scored the lowest pest population which showed significant difference from the other used chemicals. The results are in support of Achio *et al*., 2012 [1], Andi, 2011 [3] and Aslam, 1999 [5].

The most appreciated reduction of population was given from the chemical deltamethrin (50%) and (33.3%) in application one and two respectively; whereas (50%) reduction was also recorded from NSE in application three. These results are in agreement with the findings of Ghahhari *et al*., 2001, that effects of deltamethrin, on oviposition was studied in 3 intervals of 2, 24, and 72 h after treatment by exposing whiteflies to insecticide-treated leaves [10]. The effect of deltamethrin on ovipositional performance reduction was higher than other insecticides in all intervals.

The maximum percentage increase of whitefly population was recorded from the control (C0) treatment (44%) in case of application one but it was showed to the reverse in the third application. This variation might probably be due to the repellent odor and drift effects of the chemicals. There was no significant difference in whitefly population count at 5% level of significance except before application one which gave significant difference in population count of the particular insect pest due to the interaction effects. From the combinations V2C0, V3C0 and V2C3 were found with maximum whitefly population which showed variation from the other combinations. This was because of the fact that no chemical application and the high leaf number in case of *Zafira* which provided good food and shade to the pest. The lowest pest population was obtained from the combination effects of V1C4 which provided significant difference from the other combination treatments. The reason might be due to late emergence in case of the *Picasso* cultivar (Table 2).

Table 2: Effect of cultivar, chemical and cultivar x chemical on whitefly population count

Treatments	Application-1			Application-2			Application-3		
	Before	**After**	**PPR* in%**	**Before**	**After**	**PPR* in%**	**Before**	**After**	**PPR* in%**
V1	6	6	0(0)	4	3	1(25)	3	3	0(0)
V2	9	8	1(11.1)	5	4	1(20)	4	3	1(25)
V3	9	7	2(22.2)	5	4	1(20)	4	3	1(25)
LSD 5%	1.17	NS		0.742	0.653		0.76	NS	
CV%	20.2	29.7		22.6	22.4		27.2	29.1	
C0	9	13	-4(-44)	6	6	0(0)	9	5	4(44.44)
C1	8	6	2(25)	5	4	1(20)	3	2	1(33.3)
C2	8	4	4(50)	3	2	1(33.3)	2	2	0(0)
C3	7	6	1(14.3)	4	4	0(0)	2	1	1(50)
C4	7	7	0(0)	4	3	1(25)	2	2	0(0)
LSD 5%	NS	2.02		0.958	0.843		0.98	0.706	
CV%	20.2	29.7		22.6	22.4		27.2	29.1	
V1C0	5	11	-6(-120)	5	5	0(0)	7	6	1(14.3)

V1C1	7	8	1(14.3)	5	3	2(40)	3	2	1(33.3)
V1C2	7	3	4(57.1)	2	2	0(0)	2	1	1(50)
V1C3	5	4	1(20)	3	3	0(0)	2	1	1(50)
V1C4	4	4	0(0)	3	2	1(33.3)	2	1	1(50)
V2C0	11	13	-2(-18)	7	7	0(0)	9	5	4(44.4)
V2C1	8	5	3(37.5)	5	4	1(20)	3	2	1(33.3)
V2C2	8	4	4(50)	3	2	1(33.3)	2	2	0(0)
V2C3	11	8	3(27.3)	5	5	0(0)	3	1	2(66.7)
V2C4	8	8	0(0)	5	4	1(20)	3	2	1(33.3)
V3C0	11	14	-3(-27)	7	7	0(0)	9	5	4(44.4)
V3C1	8	5	3(37.5)	4	4	0(0)	4	3	1(25)
V3C2	9	4	5(55.6)	4	3	1(25)	2	2	0(0)
V3C3	5	5	0(0)	3	3	0(0)	2	1	1(50)
V3C4	10	8	2(20)	4	3	1(25)	3	1	2(66.7)
LSD 5%	2.617	NS		NS	NS		NS	NS	
CV%	20.2	29.7		22.6	22.4		27.2	29.1	

*PPR= Pest Population Reduction; NS=Non-significant

3.2.3 Jassids population

Effect of cultivar, chemical and (Cultivar X chemical) on Jassid population count: The ANOVA result briefs that there was a significant difference in the cultivars for population count of jassids in application one and two and also it showed highly significant difference in population count of jassids after application one. But there was no significant difference in population count in case of application three at 5% level of significance (Table 3).

Picasso cultivar showed variation from *Ajiba* and *Zafira* cultivars before application one; whereas after application one variation was observed among all the cultivars. However the *Picasso* and *Zafira* were found equal before and after application two in which they showed variation from the *Ajiba* cultivar in jassid population counts. The lowest population counts from the cultivar *Ajiba* was due to the high incidence of the collar rot and early blight diseases which cause disintegration of the whole plant. As a result the jassid population might have migrated to the cultivars which had relatively healthy vegetative part and new flash of leaves.

Generally the ceiling population reduction was recorded from *Ajiba* cultivar (V3) 33.3% and 25% in application one and two respectively (Table 3). Although no commercial potato cultivar is completely resistant to insect damage, there are variations in the susceptibility of cultivars to the pest (Hoy *et al*., 2008) [12]. Effectiveness of the different insecticides against the particular insect pest were recorded and analyzed in such a way that the analysis briefed there was highly significant difference among the chemicals in population count of the jassids in all applications with the exception of population count before application one which was found not significant at 5% level of significance. The highest efficacy (Lowest pest population) was shown from both NSE and TLE in all the application with no variation between them and also same population counts was recorded from deltamethrin before application two and three which showed significant difference from the other used chemicals. This results in agreement of Mari, 2012 that the use of tobacco extract is effective for pest controlling. The chemicals C0 and C1 behave equally after application one and two and were found significantly different in the other applications.

Above all, the most efficacies was resulted from chemical neem seed extract (C3) Tobacco leaf extract (C4) each of them scored 33.3% of population diminution in application one and three whereas 25% of reduction in application two. The lowering in population was due to the effectiveness of the botanicals as they have repellent and anti-feeding actions.

In addition to that the analysis of variance indicated no significant difference in population count of jassids due to interaction effects at 5% level of significance, however the peak population percentage decrease was achieved in the treatment combinations of V3C4 (50%) followed by V1C4 (42.9%) and V2C3 (42.9%) in application one (Table 3).

Table 3: Effect of cultivar, chemical and cultivar x chemical on jassid population count

Treatments	Application-1			Application-2			Application-3		
	Before	**After**	**PPR* in%**	**Before**	**After**	**PPR* in%**	**Before**	**After**	**PPR* in%**
V1	7	6	1(14.3)	5	4	1(20)	4	3	1(25)
V2	6	5	1(16.7)	5	4	1(20)	4	3	1(25)
V3	6	4	2(33.3)	4	3	1(25)	3	3	0(0)
LSD 5%	0.705	0.6		0.697	0.552		**NS**	**NS**	
CV%	15.1	15.9		20.1	18.5		16.6	17.6	
C0	6	6	0(0)	6	5	1(16.7)	5	5	0(0)
C1	7	6	1(14.3)	5	5	0(0)	4	4	0(0)
C2	6	5	1(16.7)	4	4	0(0)	3	3	0(0)
C3	6	4	2(33.3)	4	3	1(25)	3	2	1(33.3)
C4	6	4	2(33.3)	4	3	1(25)	3	2	1(33.3)
LSD 5%	**NS**	0.77		0.899	0.712		0.57	0.534	
CV%	15.1	15.9		20.1	18.5		16.6	17.6	
V1C0	6	7	1(16.7)	7	6	1(14.3)	6	5	1(16.7)
V1C1	7	7	0(0)	6	5	1(16.7)	4	4	0(0)
V1C2	7	5	2(28.6)	4	4	0(0)	3	3	0(0)
V1C3	6	5	1(16.7)	4	3	1(25)	3	2	1(33.3)
V1C4	7	4	3(42.9)	4	3	1(25)	3	3	0(0)

V2C0	6	6	0(0)	6	6	0(0)	5	4	1(20)
V2C1	8	6	2(25)	5	4	1(20)	4	3	1(25)
V2C2	6	6	0(0)	5	4	1(20)	3	3	0(0)
V2C3	7	4	3(42.9)	4	4	0(0)	3	3	0(0)
V2C4	5	4	1(20)	4	3	1(25)	2	2	0(0)
V3C0	6	6	0(0)	6	4	2(33.3)	5	4	1(20)
V3C1	5	5	0(0)	5	4	1(20)	4	3	1(25)
V3C2	6	5	1(16.7)	4	3	1(25)	3	3	0(0)
V3C3	5	4	1(20)	3	3	0(0)	2	2	0(0)
V3C4	6	3	3(50)	3	3	0(0)	2	2	0(0)
LSD 5%	NS	NS		NS	NS		NS	NS	
CV%	15.1	15.9		20.1	18.5		16.6	17.6	

*PPR= Pest Population Reduction; NS=Non-significant

3.2.4 Red spider mites

The occurrence of the red spider mites was observed at the late season of the potato crop growing period that is at the time when the cultivars were reaching their maturity stage. Similar results were also noticed on spider mite identified as *Tetranychus utricae* Koch (Acari: Tetranychidae) which was recorded for the first time infesting potato (*Solanum tuberosum* L.) in Ethiopia. This pest also infests tomato, cucumber and other *Solanaceous* weeds growing within potato fields and was observed that the pest causes quantitative crop damage by sucking the plant fluids (Muluken *et al*., 2016) [18]. Their infestation due to spider mites was localized to some of the plots; especially the plots nearer to the source of infection were highly infested and damaged. Their sparsely coverage was due to their slow movement and less availability of green and fresh leaves to feed, as the leaves were turned black and wilted due to the incidence of blight fungus and collar rot diseases. The high incidence of the spider mite was observed on *Picasso* (16.03%) and *Ajiba* cultivars (16.01%) with no variation between them. Figure-3 shows that both the cultivars showed significant difference to *Zafira* cultivar which had the lowest percentage incidence of Red spider mites (12.35%). It seems to be of the same opinion with Clotuche *et al*., 2011 [7] and Le Goff *et al*. 2010, that spider webs help establish a suitable micro-habitat for the pest, protect against abiotic agents, shelter from predators, communicate via pheromones and provides a vehicle for dispersion [14].

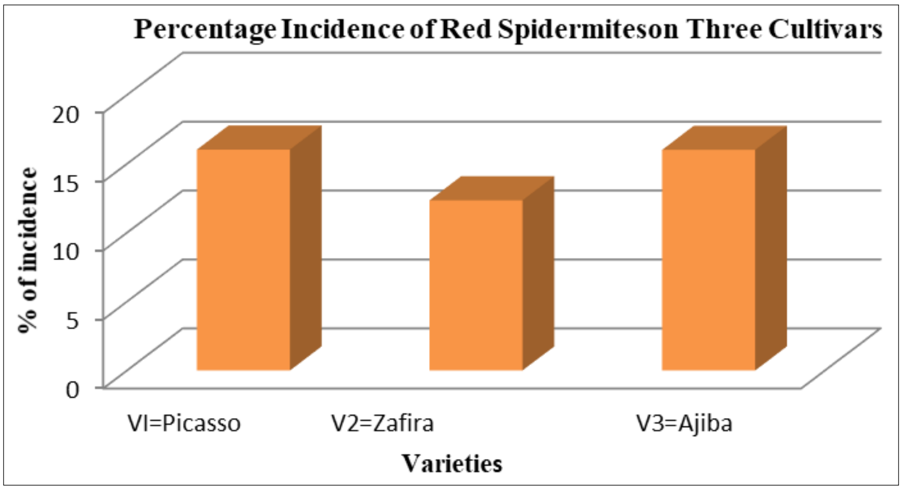

Fig 3: Percentage incidence of Red Spider (SR) mites on three cultivars

4. Conclusion

The experimental results indicated that *Picasso* cultivar had the lowest aphid and whitefly infestations unlike the *Ajiba* and *Zafira* cultivars which suffered highly due to whitefly and aphids infestations whereas minimum jassid incidence was observed in the *Ajiba* cultivar. It is concluded that the upper most reduction in aphid population was seen from the tobacco leaf extracts followed deltametrine and neem seed extracts. However, there were equal effects of “deltametrine and neem seed extract” and “tobacco leaf and neem seed extracts” in reducing the infestation or population counts of whitefly and jassids respectively.

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6. Conflict of interest

Authors declare that there is no potential conflict of interest.

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