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ORIGINAL ARTICLE

Evaluation of Some Selected Botanicals and Pesticides on Diseases of Common Cultivars of Potato in Sub Zoba Hamelmalo, Eritrea

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ABSTRACT
Potato is one of the most stable vegetable crops in Eritrea; however, the crop is highly attacked by various diseases. In Eritrea, limited research is done before on disease incidence and relative efficacy of chemicals and botanicals on the common potato cultivars. Hence this research aimed to evaluate the most serious diseases; to determine the relative efficacy of two broad spectrum chemicals (Deltamethrin and dimethoate) and two botanicals (Neem Seed Extracts and Tobacco Leaf Extracts) on three potato cultivars (Picasso, Ajiba and Zafira). The Ajiba cultivar was found to be the most susceptible to early blight among the cultivars (46.6% at 40 days and 98.9% at 60 days after planting). Based on the analysis carried out the three cultivars Picasso, Zafira and Ajiba were not significantly different at 5% level of significance at 40 and 60 days after planting for collar rot. Maximum yield was obtained from the Ajiba (29.33 ton/ha) followed by Zafira (27.99 ton/ha). There was no significant difference among the treatment combination of (cultivar x chemical) for the total yield production but the maximum and minimum yield was obtained from the combination effects of Ajiba x Neem extract (35.87 ton/ha) and Picasso x Tobacco leaf extract (16.19 ton/ha) respectively. The highest marketable yield was obtained from the combination effects of Ajiba x Neem extract (33.33 ton/ha). The high unmarketable produce from Ajiba cultivar was due to the high percentage incidences of collar rots and blight fungus. As concerning as Cost-Benefit Ratio, the highest profit was recorded from the combination treatments of Ajiba and neem seed extracts.
Key words: *Collar rot, Deltamethrin, Dimethoate, Early blight, Leaf curl, Potato cultivars, Neem seed extract, Tobacco leaf extract.*

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INTRODUCTION

Potato (*Solanum tuberosum* L. family Solanaceae) is nutritionally superior vegetable due to its edible energy and edible protein and because of this reason majority of populations use potato in their diet regularly. Potato is supplementing meat and milk products by lowering energy intake and also by reducing food cost [1]. It is a special crop which is vegetatively propagated over the largest area in the world [2]. In the year 2010 the total volume of world potato production was more than 324.1 million tons that was harvested from the total area of 18.6 million hectare [3]. Different potato varieties differ markedly in yielding ability [4].

Status of Potato Production and Yield in Eritrea

In Eritrea, potato is one of the major vegetable crops after tomato and onion. The total production is very low as compared to the demands of consumers; even it is grown in highlands which are more suitable for potato cultivation. Potato production is common in the high land and mid land of Eritrea especially in the zobas Debub and Maekel. This crop can also be adapted to low lands in Eritrea. Potato varietal experiments are important since potatoes are very sensitive to their growing environment and not all cultivars are adapted to all potato growing areas. Under these Eritrean conditions, farmers are more

interested in the cultivars that produce consistently high yields. According to [5], total yield, number and weight of tubers per plant and average tuber weight and tuber quality and starch content showed large variations among potato cultivars. Today in Eritrea, locally available varieties (Carnetiom and Shashemene) and different cultivars (*Picasso, Condor, Ajaba, Zafira, Cosmos, Spunta*) are grown in high and intermediate land areas. *Picasso* and *Condor* are top yielding varieties 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 [6]. In Eritrea; it is produced in area and yield of 2632 ha and 17.1mt/ha respectively whereas the total production and yield of potato in zoba Anseba is 71ha and 6mt/ha respectively [7].

Diseases ver. Cultivars of Potato

Most of the time, the crop is infested by different insect pests and infections which are very limiting factors for good production and quality. Most of the noninfectious and infectious constraints that face the farmers in the potato growing regions are common in this country. Potato is facing by various diseases caused by fungi, bacteria, nematodes and viruses. At each phenological stage these plants are vulnerable to certain pests and diseases, and the yield loss caused by late blight varies among potato CULTIVARS AS WELL AS VARIETIES. Generally, late VARIETIES are more tolerant because of their vigorous foliage growth. However, no variety is totally resistant to blight so some form of fungicide must be used. Moreover, a cultivar may be resistant to only one or two races of blight. Many of the more recent resistant cultivars are considered field-resistant meaning that they are partially resistant to all races of the pathogen which can be managed with very few chemicals or fungicides [8]**.** Hence, this work is done to evaluate diseases and analyse the relative performance of the selected chemicals and botanicals on disease control; and to evaluate the cost-benefit ratio of potato cultivars.

MATERIAL AND METHODS

EXPERIMENTAL LOCATION

The research work was conducted in Hamelmalo Agricultural College (HAC), subzoba Hamelmalo of Zaba Anseba. The area of HAC located at the altitude 1280 m above sea level with 15^{o} 55' 12.92'' N latitude and 38^{o} 27' 46.9''E longitudes. This area receives an average annual rain fall of 459mm and has an average temperature of 24 ^{0}C [9].

SAMPLES COLLECTION

Among the potato cultivars, under Eritrean agro-climatic conditions, *Ajiba, Zafira* and *Picasso* performing well and adopted by farmers**.** *Ajiba* is a medium early crop and is suitable for fresh consumption and produces medium and intermediate type foliage structure. It has medium dormancy period [10]. *Zafira* cultivar was imported from Holland **(**Agrico Seed Company) to Eritrea in 2009, by National Agricultural Research Institute (NARI). According to [11] NARI the average yield of this variety is 26t/ha. In addition to that the cultivar is also drought tolerant, suitable in dry areas and for sandy soils [12]. *Zafira* cultivar has maximum leaf number when planting in the month September [13] and younger seed tubers produced higher foliage than older seed tubers [2]. *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} [14].

EXPERIMENTAL DESIGN

The experiment was conducted with three potato cultivars (*Ajiba, Zafira* and *Picasso);* two broad spectrum pesticides (Deltamethrin and Dimethoate) and two botanicals [Neem Seed Extract (NSE) and Tobacco Leaf Extract (TLE)] in two way factorial experiment design with three replications 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.

TREATMENT COMBINATION:

V1=*Picasso*	C0=Zero
V2=*Zafira*	C1=Dimethoate (0.06% of concentration)
V3= *Ajiba*	C2=Deltamethrin (0.0025% of concentration)
	C3=Neem Seed Extract (5% of solution)
	C4=Tobacco Leaf Extract (6.2% of solution)

DATA ANALYSIS

Disease incidence: The data for early blight and collar rot were collected at 40 days and 60 days after germination and a uniform application of fungicide (mancozeb) for all the experimental units were applied to down the incidence of the disease. Incidence of the diseases was calculated as follows:

$$\text{Percent of incidence} = \frac{\text{Number of infected plants/plot}}{\text{Total number of plants in the plot}} \times 100$$

The yield: The yield was taken into consideration to evaluate the of treatments effect. The yield was measured by weighing the tubers of 10 sample plants from each plot in kilogram and divided in to the number of sampled plants to get the average tuber weight per plant [15]. Later, the yield in kilogram per plant was converted to tons per hectare. In addition to that tubers from the sample plants were graded as marketable and unmarketable and weighed separately.

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.

RESULTS AND DISCUSSION

Diseases Incidence

During the study period various diseases caused by fungi (early blights, collar rots), viruses (leaf curling) and insect pests whiteflies were identified on three cultivars of potato. The leaf curl virus might have been transmitted by whiteflies.

Early bight: Early blight caused by fungi (*Alternaria solani*) recorded in three cultivars of potato. The incidence in the cultivars differed at 5% level of significance at 40 and 60 days after planting. The Ajiba cultivar was found to be the most susceptible among the cultivars in which the mean incidence 46.6% at 40 days and 98.9% at 60 days after planting with the averaged mean of 72.75%. This was followed by Zafira cultivar with 42.6% and 97.1% incidence at 40 and 60 days after planting respectively, with the average mean of 69.85%. The cultivar Picasso had lowest incidence of 34.4% and 49.8% at 40 and 60 days respectively and averaged mean of 42.1% (Figure 1). The Picasso cultivar had shown the minimum percentage incidence which was found significantly different as compared the Ajiba and Zafira cultivars. Both of these cultivars were statistically at par for blight incidence at 40 and 60 days after planting. This result is contradictory to the finding by [10], reported that the Ajiba cultivar as resistant to leaf blight fungus but it was in conformity for Zafira cultivar was reported sensitive to blight.

Collar rot: Percentage incidence of collar rot disease on the cultivars was recorded; as it was abundant in the field. All the three cultivars were found very susceptible for the collar rot disease. Since it is a soil borne disease, the plant got infected at the collar portion of the stem and was getting damaged because of translocation bundles got either clogged or collapsed. The infected plant wilted and the infection was extended up to the tubers. The difference of the disease incidence is very low among the cultivars from 16.18% to 19.85%. Based on the analysis carried out the three cultivars Picasso, Zafira and Ajiba were not significantly different at 5% level of significance at 40 and 60 days after planting for collar rot (Figure 1). The causal organisms of this complex disease were *Rhizoctonia solani*, species of Phytophthora, Veritcillium spp. and Sclerotium spp. identified through the symptoms that appeared on the plants and studies in the laboratory by culturing of the fungus from the soil, leaf, stem and tubers. [16] Pritchard and Porte, (1921), also observed collar rots on stems of potato; and reported that three fungi produced typical collar-rot lesions. The percentage of infections was much higher for *Verticillium lycopersici* and *Macrosporium solani* than for *Rhizoctonia solani*.

Leaf curl virus: The percentage incidences of leaf curl virus on the three cultivars were recorded during the course of the experimental period. The incidence occurred due to the infestation of white fly in the experimental field as they are known as carriers of the leaf curl virus. The present finding is supported by [17]. The well-known symptoms on potato leaves were curling and yellowing which lead to photosynthesis reduction. Similar symptoms were seen by [15]. The results indicated that the incidence of leaf curl in different cultivars varied significantly at 5% level of significance. Among the cultivars the maximum incidence was recorded from Ajiba cultivar (20.95%) which showed significant difference from the Picasso cultivar 16.89% (Figure 1). This was because of the lowest whitefly population count in Picasso cultivar as compared to Ajiba cultivar. However, there was no significant variation between Ajiba (20.95%) and Zafira (18.65%) cultivars and similarly between Zafira and Picasso cultivars in the leaf curl virus incidence no variation between Ajiba and Zafira was recorded, it was due to the equal occurrence of whitefly population count on these varieties.

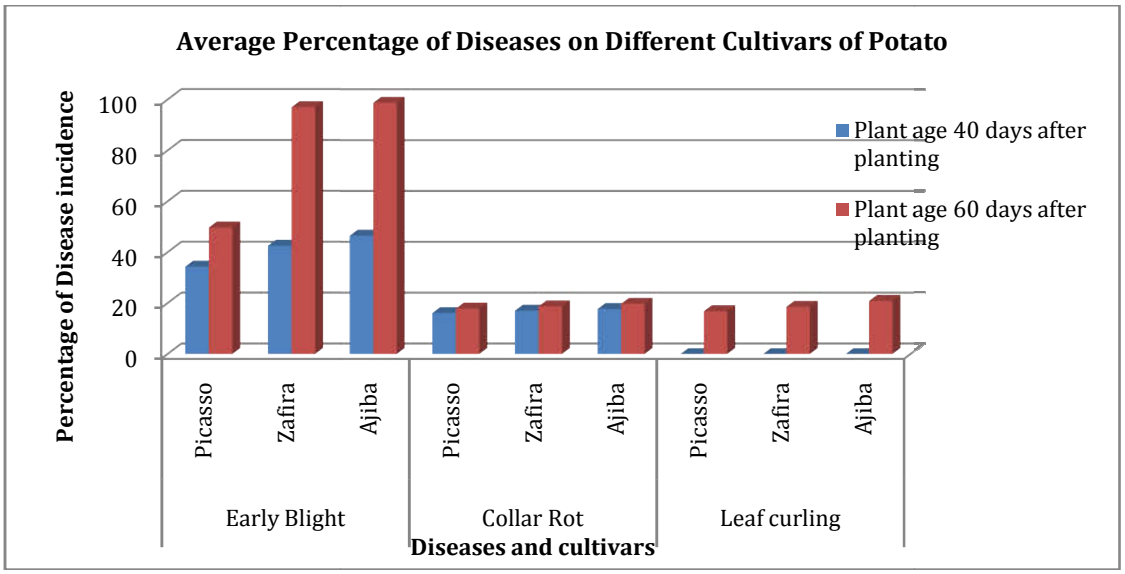

Figure 1. Average percentage of disease incidence in three cultivars of potato after 40 and 60 days of planting

Yield Parameters:

The Effect of Cultivar; Chemical and (Cultivar x Chemical) on Total Yield:

The total yield was recorded in ton per hectare to compare the response of the three cultivars. From the ANOVA table the cultivars showed highly significant difference due to cultivars effects at 5% level of significance in yield production. This result was in agreement with the report given by [4]. Maximum yield was obtained from the Ajiba (29.33 ton/ha) followed by Zafira (27.99 ton/ha). More or less similar results from Zafira cultivar (26 ton/ha) were reported from [11]. Based on the field observation it was noticed that the Ajiba and Zafira cultivars maintained vigorous vegetative growth despite the high incidences of diseases. Both the cultivars found at par but showed significantly higher yields to the Picasso cultivar which had minimum production (19.49 ton/ha). This was probably because of the late emergence and poor performance of the Picasso cultivar in the study area. Even though Ajiba cultivar gave the maximum production, the production was found lower as compared to the result reported by [13] which was 73.5 ton /ha The lower the yield in Ajiba in the present investigations was due to the high incidences of insect pests and diseases; which occurred due to different ecological conditions.

In case of the chemical effects on the total yield, the chemicals did not show significant difference at 5% level of significance, but the highest and lowest yield were recorded from Neem seed extract (C3=28.25 ton/ha) and control (C0=23.07 ton/ha) respectively. There was no significant difference among the treatment combination of (cultivar x chemical) for the total yield production at 5% level of significance but the maximum and minimum yield was obtained from the combination effects of Ajiba x Neem extract (35.87 ton/ha) and Picasso x Tobacco leaf extract (16.19 ton/ha) respectively (Table1).

The Effect of Cultivar; Chemical and (Cultivar x Chemical) on Marketable Yield:

The total marketable yield was recorded in ton per hectare to know the response of the three cultivars. The cultivars showed highly significant difference due to varietal effects at 5% level of significance. Maximum marketable yield was obtained from the Ajiba (26.61 ton/ha) followed by Zafira (26.16 ton/ha). Both the cultivars behaved equally and showed significant difference from the Picasso cultivar which gave minimum production (17.77 ton/ha). In spite of the high incidences of pests to the Ajiba and Zafira cultivars, they gave maximum production as compared the Picasso cultivar. This might be because of the high vegetative growth of these cultivars in the field condition and their early emergence to Picasso which helped them to become resistant for pest incidences (Table1).

The chemicals did not show significant difference at 5% level of significance so far as marketable yield is concerned. However the maximum and minimum marketable yield were recorded from Neem seed extract (C3=26.35 ton/ha) and control (C0=21.05 ton/ha) respectively. Due to the interaction effects the treatment combinations were not significantly different at 5% level of significance. However the highest marketable yield was obtained from the combination effects of Ajiba x Neem seed extract (33.33 ton/ha) and the lowest result was recorded from Picasso x Tobacco leaf extract (14.59 ton/ha).

The Effect of Cultivar; Chemical and (Cultivar x Chemical) on Unmarketable Yield:

Various differences were recorded on the total unmarketable yield due the effects of cultivar, chemical and their interaction. Depending on the analysis results there was significant difference in unmarketable

yield of the cultivars at 5% level of significance. The Maximum unmarketable yield was recorded from the Ajiba cultivar (2.72 ton/ha) which was significantly different from the cultivars Zafira (1.84 ton/ha) and Picasso (1.724 ton/ha). However Zafira and Picasso cultivars were at par. The high unmarketable produce from Ajiba cultivar was due to the high percentage incidences of collar rots and blight fungus.
Though the difference in the unmarketable produce of the cultivars due to chemicals was not found significant at 5% level of significance, the maximum unmarketable yield was recorded from Dimethoate (C1=2.43 ton/ha) and control (C0=2.02 ton/ha) as compared to Neem seed extract which scored the lowest value (C3=1.90). Cultivars did not show significant difference in the interaction effects at 5% level of significance. However, the peak and lowest value of unmarketable yield was recorded from interaction effects of Ajiba x Dimethoate (3.17 ton/ha) and Zafira x Neem seed extract (1.27 ton/ha) respectively (Table 1).

Table 1. The Effect of Cultivar, Chemical and Cultivar + Chemical on Total Yield, Marketable and Unmarketable Yield in ton/ha

	Unmarketable Yields in ton/ha						Marketable Yield in ton/ha						Total Yield in ton/ha					
Treatments* / Cultivars	C0	C1	C2	C3	C4	Mean	C0	C1	C2	C3	C4	Mean	C0	C1	C2	C3	C4	Mean
Picasso	1.94	1.59	1.59	1.9	1.6	1.724	19.33	17.14	19.05	18.73	14.59	17.77	21.27	18.73	20.63	20.63	16.19	19.49
Zafira	1.9	2.54	1.59	1.27	1.9	1.84	21.27	24.76	26.67	26.98	31.11	26.16	23.17	27.3	28.25	28.25	33.02	27.99
Ajiba	2.22	3.17	3.11	2.54	2.54	2.716	22.54	28.25	25.46	33.33	23.49	26.61	24.76	31.43	28.57	35.87	26.03	29.33
mean	2.02	2.43	2.10	1.90	2.013		21.05	23.38	23.73	26.35	23.06		23.07	25.82	25.82	28.25	25.08	
Interaction	Chemical and Cultivar						Chemical and Cultivar						Chemical and Cultivar					
LSD 5%	**NS**						**NS**						**NS**					
CV %	**51.4**						**24.2**						**21.5**					

*C0=control; C1= Dimethoate (0.06% of concentration); C2= Deltamethrin (0.0025% of concentration); C3=Neem Seed Extract (5% of solution); C4= Tobacco Leaf Extract (6.2% of solution)

Cost Benefit Analysis

During the study period cost benefit analysis of the experiment was calculated to determine the profits that were obtained by applying the chemical treatments to control the insect pests. All the possible costs

which were expensed during the study were totaled and deducted from the gross profit to provide the net profit or income (Table 2). Generally all the chemicals used were come up with a profit as compared to the control. The highest profit was recorded from the combination treatments of *Ajiba* and neem seed extracts (V3C3).

TABLE 2. cost benefit (c: b ratio) analysis of the experiment

Treatment Combination	Costs										Income	
	Labour (Nkf/ha)	Seeds (Nkf/ha)	Fertilizers (Nkf/ha)		Tractor (Nkf/ha)	Additional costs (Nkf/ha)	Fungicide (Nkf/ha)	Treatment Chemical (Nkf/ha)	Total Cost (Nkf/ha)	Total yield/ha	Gross income	Net income
			Urea	DAP								
V1C0	325000	112500	6750	4800	1500	17616	1100	0	469266	21.27	638100	168834
V1C1	325000	112500	6750	4800	1500	17616	1100	1425	470691	18.73	561900	91209
V1C2	325000	112500	6750	4800	1500	17616	1100	950	470216	20.63	618900	148684
V1C3	325000	112500	6750	4800	1500	17616	1100	1000	470266	20.63	618900	148634
V1C4	325000	112500	6750	4800	1500	17616	1100	562	469828	16.19	485700	15872
V2C0	325000	112500	6750	4800	1500	17616	1100	0	469266	23.17	810950	341684
V2C1	325000	112500	6750	4800	1500	17616	1100	1425	470691	27.3	955500	484809
V2C2	325000	112500	6750	4800	1500	17616	1100	950	470216	28.25	988750	518534
V2C3	325000	112500	6750	4800	1500	17616	1100	1000	470266	28.25	988750	518484
V2C4	325000	112500	6750	4800	1500	17616	1100	562	469828	33.02	1155700	685872
V3C0	325000	112500	6750	4800	1500	17616	1100	0	469266	24.76	866600	397334
V3C1	325000	112500	6750	4800	1500	17616	1100	1425	470691	31.43	1100050	629359
V3C2	325000	112500	6750	4800	1500	17616	1100	950	470216	28.57	999950	529734
V3C3	325000	112500	6750	4800	1500	17616	1100	1000	470266	35.87	1255450	785184
V3C4	325000	112500	6750	4800	1500	17616	1100	562	469828	26.03	911050	441222

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COMPETING INTERESTS

"The authors have declared that no competing interest exists".

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