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Response of Major Insect Pests of Potato Towards Plant Extracts and a Synthetic Insecticide at District Swat

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Abstract
The study was conducted to check the response of major insect pests of potato towards plant extracts and a synthetic insecticide and their effect on yield of potato crop at district swat, during 2023. Six treatments including control, four different botanicals and a synthetic insecticide i.e. T_1 (Neem seed extract), T_2 (Fresh red chili extract), T_3 (Moringa leaf extract), T_4 (Chinaberry fruits extract), T_5 (Chlorpyrifos 40% EC) and T6 (Control) were used. Plant extracts were applied at 10% each while chlorpyrifos was applied at recommended dose. The outcomes revealed that after the application of 1st and 2nd spray the lowest mean number of aphids population plant^{-1} were observed in the plot treated with chlorpyrifos (4.76 and 1.68) whereas in plant extracts moringa leaf extract was found to be the most effective with (6.23 and 3.51) mean aphids population plant^{-1}, subsequently followed by chinaberry fruit extract (7.04 and 4.54), red chilli extract (7.46 and 5.12), neem seed extract (7.73 and 5.65) and the highest mean number for aphid population plant^{-1} was recorded from control plot (8.53 and 7.26). Similarly after the 1st and 2nd application of treatments against jassids, minimum jassid population was recorded for plots treated with Chlorpyrifos (5.26 and 2.23), while in plant extracts plots treated with moringa leaf extract revealed minimum jassid population plant^{-1} (6.86 and 3.90), followed by chinaberry fruit extract (7.80 and 5.47), red chilli extract (8.50 and 6.16), neem seed extract (8.81 and 6.80) number of jassids population plant^{-1} were recorded. The plot treated with chlorpyrifos has shown highest yield (12859 kg/ha) followed by moringa leaf extract with (10840 kg/ha), chinaberry fruit extract (9181 kg/ha) and the minimum yield (6171 kg/ha) was observed for control plot. Highest cost benefit ratio (1:53) was observed for Chlorpyrifos treated plots followed by moringa leaf extract (1:46), chinaberry fruit extract (1:32) and red chili extract (1:26) and lowest CBR was recorded for neem seed extract (1:17). Based on the above findings it is concluded that among plant extracts moringa leaf extract and chinaberry fruit extract was the most effective against the population of the above mentioned pest and subsequently increases crop yield. Therefore it is recommended to use moringa leaf extract in future IPM strategies for the effective management of aphids, jassids population and to enhance yield.

INTRODUCTION

Potato (*Solanum tuberosum L.*) holds economic significance as a valuable cash crop and plays a crucial role in maintaining worldwide food security[1]. It holds the fourth position in terms of significance among crops, trailing behind rice, maize and wheat, especially concerning food consumption[2]. Internationally China stands as the leading contributor to potato production, with China and India jointly accounting for approximately one-third of the total global output. As per the estimates provided by the Food and Agriculture Organization[3], global potato production reached more than 368 million metric tons in the year 2018, from approximately 17.58 million hectares[4]. Potato is produced in more than 140 countries[5]. The potato is classified as a tuber crop belonging to the Solanaceae family. In terms of nutritional composition, the potato tuber comprises starch (18%), protein (2%), water (70%) and a small quantity of vitamins, minerals and trace elements (1%)[6]. In Pakistan, potato ranks as the fourth most significant crop in terms of production volume and offers lucrative returns for farmers[7]. The potato holds significant agricultural importance in Pakistan, being one of the most valuable vegetable crops. It spans across 176.2 thousand hectares, contributing to an annual production of approximately 4,134.6 metric tons[8]. The potato can be cultivated in three seasons: Spring, summer and autumn[9]. In the fiscal year 2006-07, Pakistan witnessed a substantial growth in potato exports, reaching 0.16 million tons valued at 26 million US dollars. This marked an impressive increase, surpassing the figures from 2012-13 by more than three times[10]. Adoption of environmentally friendly pest management strategies as part of Good Agricultural Practices (GAP) may further increase potato yields and profits. However insect pests can result in yield losses ranging from 35-40%, with potential peaks reaching 60-70%[11]. Aphids likely hold more economic significance as pests in the global cultivation of potatoes compared to defoliators or pests affecting the tubers. Aphids on potatoes primarily function as carriers of viruses, although elevated aphid populations can also result in direct harm to plants and substantial reductions in crop yields the green peach aphid is the main aphid pest that affects potatoes. It has a broad range of spans over 400 species across 40 plant families. This includes numerous economically significant crop plants[12]. Aphids are insects that feed on phloem by using their thin mouthparts, known as stylets, to pass between the mesophyll cells. They arrive to and pierce the sieve components, where they take phloem sap from a single feeding point for a number of hours. The life cycle of M. persicae is influenced by climatic conditions, the presence of its main winter host Prunus spp., with a particular emphasis on P. persica (peach), and the specific genotypic lineage[12]. M. persicae is a widespread pest that may infect a wide range of plants from different plant families, diminishing its appetite for phloem sap and that a first infestation can impact subsequent colonization[12]. Widespread feeding by M. persicae leads to the deformation of young leaves and shoots, resulting in subsequent reductions in yield[13]. Aphids produce a sugary substance known as honeydew, which has the potential to attract other insects and fungi, leading to further harm to the plant[14]. M. persicae is a vector for viruses including Potato Virus Y (PVY) and Potato Leaf Roll Virus (PLRV), its relevance has grown dramatically[12] and have been responsible for yield reductions ranging from 13.9-20.1% in autumn potato crops and 44.0-52.2% in spring crops, as well as 7.5-15.7% and 38.8-60%, respectively. According to Jensen[15], the noteworthy vectoring capability suggests a remarkably low treatment threshold for managing the M. persicae population in potato fields. Nevertheless, the thresholds differ, ranging from 2.5 to 100 aphids per 25 leaves. This variance is contingent on factors such as potato variety, the prevalence of Myzus-related diseases, the stage of plant growth and the intended use of the potato[16]. In potatoes, aphids have the potential to result in yield reductions ranging from 10-80%. In severe infestation losses may reach up to 100%[17]. Jassid (Amarasca devastance) belong to the order Hemiptera and possess mouthparts adapted for piercing and sucking. They inflict harm on the plants, both directly and indirectly, particularly during the early stages of growth. Nymphs, as well as adult insects, extract sap from the undersides of leaves using their piercing and sucking mouthparts In addition, They interfere with transportation within conducting vessels and reportedly introduce a toxin that hinders photosynthesis, with the extent of impairment corresponding to the quantity of their feeding[18]. Both the nymph and adult stages of Jassid pose a threat to the well-being of potato crop As they introduce their harmful saliva into the leaf tissues, it results in plant weakness, leaf scorching, drying and the shedding of both leaves and young buds. Severe infestation can diminish the plant's ability to produce fruits, hinder fruiting and impede overall plant growth[19]. Jassids are found extensively across tropical, sub-tropical and temperate regions. They exhibit a high level of polyphagy, feeding on various vegetables such as okra, tomatoes, potatoes, peppers, cucurbits, as well as on field crops[20]. The degree of harm fluctuates based on weather conditions, pest population and the presence of alternative host. The implementation of chemical pesticides and other insecticides proved beneficial for farmers and cultivators in mitigating the harm caused

by external agents. These insecticides and pesticides, derived from chemical sources, effectively managed and controlled damage. Pesticides serve as a rapid remedy for insect management and play a crucial role in enhancing agricultural yields[21]. Fruit and vegetable crops in Pakistan get around one-third of all pesticide applications[22]. The application of insecticides, a crucial component of Integrated Pest Management (IPM), can increase crop output by reducing losses brought on by insect damage. However, these compounds' indiscriminate administration is having negative consequences on environmental creatures that are not their intended targets as well as human health[23] found in quantities that exceeded the maximum residual limit for pesticides set by Codex[24] in fruits and vegetables sold in Pakistani marketplaces. Over time, the previously unnoticed impacts of chemically synthesized pesticides became apparent and the revelation was astonishing. It seemed unbelievable, but the environment was indeed being adversely affected by these chemically manufactured insecticides and pesticides. The pesticides that played a crucial role in managing crop damage were, in turn, harmful and causing degradation to both soil quality and the environment[25]. Considering the environmental and health concerns, scientists and researchers are focusing on biopesticides due to their safety and eco-friendly characteristics. Many attempts have been made to use biopesticides to manage insect pests on many crops other than Based on these crucial approaches, bio-pesticides may be roughly.

Classified into Three Primary Classes, which Include:

- Bio-chemical agents such as insect sex hormones, Phyto-inserted protectants comprising botanical pesticides like neem oil, rotenone, tobacco suspension, etc.
- Plant-assisted pesticides such as agrocin extracted from Metarhizium anisopliae and Trichoderma[26].

Neem-based insecticides, which come in neem oil, neem extract and even neem seed water extract, are useful for controlling a variety of insects (Jacobson, 1988). They have been proven to be successful in controlling pests such as jassids, aphids, whiteflies, flea beetles, spider mites and fruit borers[27,28]. They are also well-known for their safety and high performance (Schmutterer, 2002). Compared to synthetic insecticides, botanical insecticides offer a safer option for the environment, non-target species and human health. They constitute a bio-rational method to managing insect pests[29]. Some plant species are rich sources of bio active substances, such as secondary metabolites, which shield plants from insect pests[30]. Many substances produced from plants and botanical extracts have demonstrated the capacity to impede development, discourage feeding and ward off a wide variety of insect pests, such as jassids and aphids. Moreover, The benefits of employing insecticidal plant extracts cover its rapid and easy manufacture by local farmers, financial effectiveness and less toxicity to animals[29]. Furthermore, synthetic pesticides depend on a certain active component. Plant-based insecticides are made up of a variety of substances that target insect pests' biochemical and behavioural mechanisms. Therefore, It is less likely for pests to acquire resistance to these compounds[31]. In order to minimize the environmental and human health hazards linked to the application of pesticides, for numerous years, the U.S. Department of Agriculture (USDA) and various agricultural universities have promoted the adoption of integrated pest management (IPM)[11]. Various alternative strategies for managing aphids and jassids have been suggested concerning plant physiology (i.e., increases in host plant resistance) and insect life cycle (i.e., conservation biological control)[32]. Integrated Pest Management (IPM) is a systemic approach for safeguarding crops that combines diverse technologies for pest control, encompassing biological, chemical and cultural controls[11]. The Integrated Pest Management (IPM) approach employing an Action Threshold (AT) relies on monitoring pest populations, triggering treatment only when there is a projection that the pest level will economically harm crops by the time spraying is feasible. The concept of threshold ideas was first introduced in 1959[33], IPM research and outreach rooted in AT (Agricultural Technology) received its initial federal support in 1971[34]. Integrated Pest Management (IPM) employs an optimal combination of control strategies tailored to a specific pest issue, considering factors such as crop yield, profitability and safety in comparison to alternative approaches[11]. Ultimately, IPM involves the strategic choice and implementation of pest control measures to guarantee positive economic, ecological and sociological outcomes[35]. The production of potato in Pakistan is mainly affected insect pests. Formers has been using different synthetic insecticides against insect pest of potato which results in resistance of different pest against chemicals and also have negative effect on environment and human health. The present research is based on finding an environmentally safe and easily available control to minimize pest attack on potato and increase yield by using different botanical extracts.

MATERIALS AND METHODS

A field experiment on “Response of major insect pest of potato towards plant extracts and synthetic insecticide at district Swat” was carried out at

Agriculture Research Institute Mingora Swat during 2023. Locally available variety raja was used.

Experimental Design: Experiment was carried out by using Randomized Complete Block Design (RCBD) with Six treatments, three replications and four number of rows per plot. Plant to plant distance was kept at 10 cm and row to row distance was 75cm. In order To assess the efficacy of various plant extracts such as Moringa (Moringa oleifera), Neem (Azadirachta indica), Chinaberry (Melia azedarach) and Red chili (Capsicum spp) against major insect pest of potato was tested. The results obtained from plant extracts were compared with those of synthetic insecticide and control plot.

Treatments: The following treatments were used.

Table 1: Treatments Plant Parts Concentration

Treatments		Plant parts	Concentration/Dose
T_1	Neem	Seed	10%
T_2	Red Chili	Fresh Red chilli	10%
T_3	Moringa	Leaf	10%
T_4	Chinaberry	Fruit	10%
T_5	Chlorpyrifos 40% EC	-	2.5ml/liter
T_6	Control		-

The treatment mentioned in (Table 1) was applied at the recommended dosage against the major insect pest effecting potato crop. Second applications of treatments will be repeated after in interval of 14 days.

Plant Extracts Preparation:

Red Chili Extract (Capsicum Spp): We adopted the approach outlined by Reddy and Sasikala in 2013 to derive the solution of Red Chilli Extract. Crush 30 grams of fresh red chilli and combine it with 500 milliliters of hot water and 4 milliliters of vegetable oil. Allow the mixture to steep for 24 hours. Oil was added to increase the solubility of capsaicin. Followed by the addition of the remaining 500ml of water to the solution after 24hrs. The mixture was then filtered and 6ml of soap liquid was added to serve as an adhesive. Mixture was then be strained by using a fine cloth to acquire a refined solution[36].

Chinaberry (Melia Azedarach): The fruits of chinaberry tree (Melia azedarach), weighing 200 grams in their dry state, was ground and mixed in 1 liter of distilled water. This mixture was soaked for 48 hours at room temperature. Then the mixture was filtered and stock solution was obtained (Jazzar et al., 2003, Hammad *et al.,* 2000, Banchio *et al.,* 2003).

Neem Seed Extract (Azadirachta Indica): According to Shah[37] 0.5 kilograms of neem seed extract was grind by using a grinding machine and combine it with ten grams of detergent. Five liters of water was added to the solution thereafter and placed for 24hrs to get stock solution of neem seed extract.

Moringa Leaf Extract (Moringa Oleifera): 50 grams of dried leaves and soak them in half liter of water for 24 hours. The mixture was undergo filtration using muslin cloth and 1.5 litre of water was added to the mixture to make a stock solution[38].

Parameters: The following parameters was study during the present Research.

Insect Pest Plant^{-1}: Insect pest population was recorded by selecting 5 plants randomly per plot in each replication plant was divided into three portion upper, middle and lower population was recorded leaf-1 one day before spray application and then 1,2, 3, 7 and 14 days after application of treatments.

Percent Reduction Over Control:

$$\textbf{Reduction (\%)} = \frac{\text{Control-Treatment}}{\text{Control}} \times 100$$

Yield Kg/ha: After picking tuber weight (kg) in each treatment was noted. Each treatment yield will be transformed into kg per hectare with formula:

$$\textbf{Yield Kg per h} = \frac{\text{Yield per plot (Kg)}}{\text{Plot area (m2)}} \times 10000$$

Percent Increase in Yield Over Control: After picking tuber weight of treated plots was compared with control plot to find percent increase in yield over control.

$$\textbf{Increase (\%)} = \frac{\text{Treatment-control}}{\text{Treatment}} \times 100$$

Cost Benefit Ratio: CBR was determined based on the methodology used by[39] to identify the most effective treatment.

Statistical Analysis: The recorded data on different parameters was analysed by using statistical software (Statistic 8.1) using Analysis of Variance (ANOVA) and through LSD Test at 5% Probability Level.

RESULTS AND DISCUSSIONS

The present research study was conducted to check the response of major insect pest of potato towards plant extracts and a synthetic insecticide during the cropping season 2023. The results revealed that two insect pest i.e. aphid and jassid were recorded from the field. The outcomes obtained from the study are presented as follows:

Table 2: Mean Number of Aphid Plant^{-1} on Potato Crop Before and After First Application of Different Plant Extracts and a Synthetic Insecticide at District Swat

		Post Spray Data					
Treatments	**Pre-Spray**	**1 Day after Application**	**2 Day after Application**	**3 Days after Application**	**7 Days after Application**	**14 Days after Application**	**Mean**
Neem	9.10 a	8.50 b	7.75 ab	7.17 ab	6.31 ab	7.54 ab	7.73 ab
Chilli	9.46 a	8.38 b	7.37 ab	7.03 ab	5.70 ab	6.82 ab	7.46 b
Moringa	9. 03 a	7.10 bc	6.18 bc	5.70 b	4.35 b	5.02 c	6.23 c
Chinaberry	8.96 a	7.90 b	7.16 ab	6.53 ab	5.45 ab	6.23 bc	7.04 bc
Chloropyrifos	9.30 a	5.94 c	4.98 c	2.90 c	2.30 c	3.13 d	4.76 d
Control	9.10 a	10.28 a	8.43 a	7.90 a	7.43 a	8.01 a	8.53 a
LSD Value	1.74	1.67	1.68	1.81	2.03	1.75	0.92

Mean value in columns with different latters are significantly different at p=0.05 using LSD

Table 3: Percent Reduction in Aphid Population Over Control After 1st Spray Application

Treatment	**After 24 hrs**	**48 hrs**	**72 hrs**	**7 day**	**14 day**	**Mean**
Neem	17.31	8.06	9.24	15.07	5.80	9.37
Chilli	19.06	12.57	11.01	23.28	14.85	12.54
Moringa	30.9	26.69	27.84	41.45	37.32	26.96
Chinaberry	23.15	15.06	17.34	26.64	32.33	17.46
Chloropyrifos	42.21	40.9	63.29	69.04	60.9	44.19
Control	-	-	-	-	-	-

Table 4: Mean Number of Aphid Plant^{-1} on Potato Crop Before and After Second Application of Different Plant Extracts and a Synthetic Insecticide at District Swat

		Post Spray Data					
Treatments	**Pre-Spray**	**1 Day after Application**	**2 Day after Application**	**3 Days after Application**	**7 Days after Application**	**14 Days after Application**	**Mean**
Neem	7.53 ab	6.42 ab	5.63 b	4.92 b	3.60 b	5.80 b	5.65 b
Chilli	6.82 ab	5.93 abc	5.10 b	4.48 b	3.23 b	5.16 b	5.12 bc
Moringa	5.02 c	4.20 cd	3.83 b	2.96 c	1.86 cd	3.20 c	3.51 d
Chinaberry	6.23 bc	5.33 bc	4.64 b	3.80 bc	2.56 bc	4.66 b	4.54 c
Chlropyrifos	3.13 d	2.16 d	1.93 c	1.12 d	0.63 d	1.08 d	1.68 e
Control	8.01 a	7.74 a	7.53 a	7.17 a	5.56 a	7.56 a	7.26 a
LSD Value	1.75	2.13	1.83	1.32	1.35	1.17	0.83

Mean value in columns with different latters are significantly different at p=0.05 using LSD

Table 5: Percent Reduction in Aphid Population Over Control After 2nd Spray Application

Treatment	**After 24 hrs**	**48 hrs**	**72 hrs**	**7 day**	**14 day**	**Mean**
Neem	17.05	25.23	31.38	35.25	23.28	22.17
Chilli	23.38	32.27	37.5	41.9	31.74	29.47
Moringa	45.73	49.1	58.71	66.54	57.67	51.65
Chinaberry	31.25	38.37	47.00	53.95	38.35	37.46
Chlorpyrifos	72.09	74.36	84.37	88.66	85.71	76.85
Control	-	-	-	-	-	-

Table 6: Mean Number of Jassid Plant^{-1} Before and After First Application of Different plant Extracts and Synthetic Insecticide on Potato Crop at District Swat

		Post Spray Data					
Treatments	**Pre-Spray**	**1 Day after Application**	**2 Day after Application**	**3 Days after Application**	**7 Days after Application**	**14 Days after Application**	**Mean**
Neem	8.90 a	7.31 ab	7.04 b	6.89 ab	4.16 b	6.52 ab	6.80 b
Chilli	8.02 ab	6.93 b	6.53 b	5.77 ab	3.70 bc	6.02 b	6.16 bc
Moringa	6.12 c	4.96 c	4.13 c	3.25 c	1.59 d	3.32 c	3.90 d
Chinaberry	7.17 bc	6.25 bc	6.02 b	5.21 b	2.76 c	5.38 b	5.47 c
Chlorpyrifos	3.96 d	2.86 d	2.36 d	1.80 c	0.84 d	1.52 d	2.23 e
Control	9.62 a	8.82 a	8.95 a	7.61 a	5.32 a	7.82 a	8.02 a
LSD Value	1.67	1.87	1.64	1.86	1.005	1.55	0.82

Mean value in columns with different letters are significantly different at p=0.05 using LSD

Table 7: Percent Reduction in Jassids Population Over Control After 1st Spray Application

Treatment	**After 24 hrs**	**48 hrs**	**72 hrs**	**7 day**	**14 day**	**Mean**
Neem	16.07	1.33	8.04	12.01	7.48	6.17
Chilli	18.25	6.09	9.28	19.47	17.04	9.47
Moringa	31.69	23.50	27.74	38.10	39.81	26.94
Chinaberry	21.98	8.75	15.74	25.12	25.46	16.93
Chlorpyrifos	44.77	43.34	57.75	63.46	58.83	43.98
Control	-	-	-	-	-	-

Table 8: Mean Number of Jassid Plant^{-1} Before and After Second Application of Different Plant Extracts and Synthetic Insecticide on Potato Crop at District Swat

		Post Spray Data					
Treatments	**Pre-Spray**	**1 Day after Application**	**2 Day after Application**	**3 Days after Application**	**7 Days after Application**	**14 Days after Application**	**Mean**
Neem	8.90 a	7.31 ab	7.04 b	6.89 ab	4.16 b	6.52 ab	6.80 b
Chilli	8.02 ab	6.93 b	6.53 b	5.77 ab	3.70 bc	6.02 b	6.16 bc
Moringa	6.12 c	4.96 c	4.13 c	3.25 c	1.59 d	3.32 c	3.90 d
Chinaberry	7.17 bc	6.25 bc	6.02 b	5.21 b	2.76 c	5.38 b	5.47 c
Chlorpyrifos	3.96 d	2.86 d	2.36 d	1.80 c	0.84 d	1.52 d	2.23 e
Control	9.62 a	8.82 a	8.95 a	7.61 a	5.32 a	7.82 a	8.02 a
LSD Value	1.67	1.87	1.64	1.86	1.005	1.55	0.82

Mean value in columns with different letters are significantly different at p=0.05 using LSD

Table 9: Percent Reduction in Jassids Population Over Control After 2nd Spray Application

Treatment	After 24 hrs	48 hrs	72 hrs	7 day	14 day	Mean
Neem	17.12	21.34	9.46	21.8	16.62	15.2
Chilli	21.42	27.03	24.17	30.45	23.01	23.2
Moringa	43.76	63.68	57.29	70.11	57.54	51.37
Chinaberry	29.13	32.73	31.53	48.12	31.2	31.7
Chloropyrifos	67.57	73.63	76.34	80.9	80.5	72.2
Control	-	-	-	-	-	-

Table 10: Effect of Different Plant Extracts and Chemical Insecticide on Yield of Potato Crop at District Swat

Treatments	Yield kg / ha	% Increase over control
T1: Neem seed extract	7811 c	21.00
T2: Fresh red chilli extract	8222 c	24.95
T3: Moringa leaves extract	10840 b	43.07
T4: Chinaberry fruit extract	9181 c	32.79
T5: Chlorpyriphos 40% EC	12859 a	52.01
T6: Control	6171 d	_
LSD	1534.2	_

Table 11: Cost Benefit Ratio of Different Plant Extracts and a Synthetic Insecticide Against Insect Pests of Potato Crop

Treatments	Marketable Yield kg/ha	Gross income	Cost of control	Return over control	Net increase over control	CBR
Neem seed extract	7811	390550	4800	82000	77200	1:17.08
Red chilli extract	8222	411100	3900	102550	98650	1:26.29
Moringa leaves extract	10840	542000	5000	233450	228450	1:46.69
Chinaberry fruit Extract	9181	459050	4600	150500	145900	1:32.72
Chlorpyrifos	12859	642950	6200	334400	328200	1:53.94
Control	6171	308550				

Effect of Different Plant Extracts and a Synthetic Insecticide on Aphids and Jassid Population: The plant extracts and chlorpyrifos were applied twice to the field, with 14 days of interval to check their effect on the population density of aphid and jassid.

Aphids Population After 1st Application of Spray: (Table 2) shows that mean number of aphids plant^{-1} was significantly affected by all treatments except control. Significant difference was recorded in aphid population before and after the spray in all plots. In pre spray data the population ranges between (8.96-+9.46 plant^{-1}) with no significant difference. Data recorded after first day of spray application significant difference were recorded in all plots except control, the minimum number of aphids plant^{-1} was observed in a plot treated with chlorpyrifos (5.94) and the maximum number of aphids plant^{-1} was recorded from control (10.28), while in plant extracts significant difference was recorded from moringa leaf extract (7.10) and all other three treatments were found non-significant i.e. chinaberry fruit (7.90), fresh red chilli (8.38) and neem seed (8.50) accordingly. The data recorded on second day of application shows further decrease in aphid population plant^{-1} the minimum population was recorded from chlorpyrifos(4.98) and maximum population was observed from control plot, while in plant extract moringa leaf was found to be the most effective against aphid population on second day of application. Similar trend was observed in the data recorded on third day after spray application. The aphids population on 7th day after application showed further decrease and the minimum population in all plots was recorded on 7th day as compare to all other days on which data is recorded. The minimum number of aphids plant^{-1} was recorded from clorpyrifos (2.30), while the maximum number of aphids plant^{-1} was recorded from control (7.43), among plant extract the minimum number of aphids plant^{-1} was recorded from moringa leaf extract (4.35), followed by chinaberry fruit extract (5.45), fresh red chilli (5.70) and neem sead extract (6.31). After 14 days of treatment application a slight increase in population of aphids were observed, however minimum number was still recorded from chlorpyrifos, followed by moringa leaf extract and maximum population was recorded from control plot.

Mean column of (Table 2) shows that minimum number of aphids plant^{-1} was recorded from clorpyrifos (4.76) and maximum number of aphids (8.53) was recorded from control. Among plant extracts the moringa leaf was found to be the most effective in mean column against aphids population and (6.23) number of aphids plant^{-1} was observed, followed by chinaberry fruit extract (7.04) aphids plant^{-1}, fresh red chilli extract (7.46) aphids plant^{-1} and (7.73) aphids plant^{-1} was recorded from neem seed extract.

Percent Reduction in Aphids Population After 1st Spray Application: The percent reduction in aphids population after first spray application on potato crop under field condition, is presented in (Table 3) shows that a significant percent reduction over control was observed. After 1st day of treatment application maximum percent reduction over control was recorded in chlorpyrifos (42.21%), followed by moringa leaf extract (30.90%), chinaberry fruit extract (23.15%), fresh red chilli (19.06%) and the minimum percent reduction (17.31%) was observed in neem seed extract treated plot. After 2 days of treatment application on potato crop the aphids population further declined and the percent reduction over control was observed

between (40.9%-8.6%). The highest percent reduction was recorded from chlorpyrifos (40.9%), while among plant extract the minimum percent reduction (8.06%) was recorded for neem seed extract and the highest percent reduction over control among plant extract was observed in moringa leaf extract (26.69%) followed by chinaberry fruit extract (15.06%) and fresh chilli extract show (12.57%) reduction over control after 2 days. Data recorded after 3 days of treatment application the percent reduction over control ranges from (63.29-9.24%). The minimum percent reduction was calculated for neem seed extract while the maximum percent reduction was recorded for chlorpyrifos. The data recorded after 7 days of treatment application shows that maximum percent reduction over control was recorded for chlorpyrifos (69.40%) followed by moringa leaf extract (41.45%), chinaberry fruit extract (26.64%), fresh red chilli (23.80%) and the minimum percent reduction (15.70%) was observed in neem seed extract. Above mentioned results on 7th day after application revealed that a significant percent reduction was observed in chlorpyrifos and moringa leaf extract while all other treatment were found non-significant. Data recorded after 14 days of treatment application on potato crop the percent reduction in aphid population over control reduced slightly in botanical extract which shows that the effect of botanicals decrease with time. On 14 day after field application percent reduction over control ranges from (60.90%-5.80%) the maximum percent reduction (60.90%) was recorded for chlorpyrifos, while among plant extract the minimum percent reduction (5.80%) was recorded from neem seed extract plot and the highest percent reduction over control among plant extract was observed in moringa leaf extract (37.32%) followed by chinaberry fruit extract (32.33%) and fresh chilli extract shows (14.85%) reduction over control. Mean data of percent reduction in aphids population over control recorded in (Table 3) revealed that the maximum percent reduction (44.19%) was calculated for chlorpyrifos, while in plant extract the highest percent reduction (26.96%) was recorded in moringa leaf extract followed by chinaberry fruit extract (17.46%), fresh red chili extract (12.54%) and minimum percent reduction over control was recorded for neem seed extract (9.37%).

Aphids Population After 2nd Spray Application: (Table 4) shows that mean number of aphids plant^{-1} was significantly affected by all the treatments except control. Significant difference was recorded in aphid population after second spray application in all treated plots. The data observed before 2nd spray of application shows that population ranges from (8.01-3.13 plant^{-1}). The population of aphids recorded after 1st day of application shows that minimum number of aphids population (2.16) was recorded from plot treated with chlorpyrifos followed by moringa leaf extract (4.20), chinaberry fruit extract (5.33), fresh red chilli extract (5.93), Neem seed extract (6.42) and maximum number of aphids plant^{-1} (7.74) was recorded from control plot. Observation recorded after 2nd day of application shows further decrease in aphids population and minimum number of aphids plant^{-1} was found in chlorpyrifos treated plot (1.93) and the maximum number of aphids was observed in control plot. Subsequently, on 3rd day after application of spray the data shows further declined in aphids population and minimum number was recorded in chlorpyrifos plot, while in plant extract minimum population was observed from moringa leaf extract treated plot followed by chinaberry fruit extract, fresh red chilli extract and neem seed extract and the maximum number of aphids was recorded from control plot. The minimum population of aphids plant^{-1} was observed on 7th day after application of second spray. Data recorded after 7th day of application revealed that minimum number of aphids (0.63) was recorded from the plot treated with chlorpyrifos and the highest number of (5.56) aphids was recorded from control. While among plant extract the minimum population was observed (1.86) aphids plant^{-1} followed by chinaberry fruit extract (2.56), fresh red chilli (3.23) and neem seed extract shows (3.60) aphids plant^{-1}. On 14th day after application of second spray data shows increase in aphids population in all plots which indicates that efficacy of the treatments have declined.

Mean column of (Table 5) shows that the minimum number of aphids (1.68) plant^{-1} was recorded from plot treated with chlorpyrifos followed by moringa leaf extract (3.51), chinaberry fruit extract (4.54), fresh red chilli extract (5.12), Neem seed extract (5.65) and the maximum number of aphids plant^{-1} (7.26) was recorded from control plot. A significant difference was observed among treatments. Chlorpyrifos, moringa leaf extract and chinaberry fruit was found significantly different from each other. No significant difference was observed in fresh red chilli extract and neem seed extract.

Percent Reduction in Aphids Population After Second Spray Application: The mean column of (Table 5) shows that a significant percent reduction over control in aphids population on potato crop was observed in all applied treatments. The mean percent reduction over control ranges from (22.17-76.85%) in all treated plots. Maximum percent reduction in mean column was recorded for chlorpyrifos (76.85%) subsequently, followed by moringa leaf extract (51.65%), chinaberry fruit extract (37.46), fresh red chilli extract (29.47%) and neem seed extract (22.17%) mean percent reduction over control was calculated after second

application of treatments. After 1st day of second application of treatments on potato crop the maximum percent reduction in aphids population over control was recorded (72.09%) in chlorpyrifos treated plot, followed by moringa leaf extract (45.73%), chinaberry fruit extract (31.25%), fresh red chilli (23.38%) reduction and minimum percent reduction (17.05%) was observed in neem seed extract treated plot. The data recorded after 2 days of second treatment application on potato crop the aphids population further declined and the percent reduction over control observed ranges from (25.23%-74.36%). The highest percent reduction was recorded from chlorpyrifos (74.36%), while among plant extract the minimum percent reduction (25.23%) was recorded from neem seed extract plot and the highest percent reduction over control among plant extract was observed in moringa leaf extract (49.10%) followed by chinaberry fruit extract (38.7%) and fresh chilli extract shows (32.27%) reduction over control after 2 days. On 3rd day after second field application of treatments similar trend was observed. Percent reduction over control ranges from (31.38-84.37%). The minimum percent reduction was calculated for neem seed extract while the maximum percent reduction was recorded for chlorpyrifos. The maximum reduction in aphids population over control was observed on 7th day after application of treatments. The data shows that the percent reduction of aphids population ranges from (35.25%-88.66%), Where the minimum percent reduction (35.25%) was recorded for neem seed extract followed by fresh red chilli extract (41.90%), chinaberry fruit extract (53.95%), moringa leaf extract (66.54%) and the maximum (88.66%) percent reduction in aphids population was calculated for chlorpyrifos treated plot. Data recorded 14 days after treatments application on potato crop the percent reduction in aphid population over control reduced slightly in botanical extract which shows that the effect of botanicals decrease with time. On 14 day after field application percent reduction over control ranges from (23.28%-85.71%) maximum percent reduction (85.71%) was recorded for chlopyrifos, while among plant extract minimum percent reduction (23.28%) was recorded from neem seed extract plot and the highest percent reduction among plant extract was observed in moringa leaf extract (57.67%) followed by chinaberry fruit extract (38.35%) and fresh chilli extract shows (31.74%) reduction over control.

Jassids Population After 1st Spray: (Table 6) shows that mean number of jassids plant^{-1} was significantly affected by all the applied treatments except control. Before spray application no significant difference was observed where the population ranges from (10.80-9.10). Jassids population decreases after application of first spray. Significant reduction in jassids population was recorded after 1st day of treatment application. Lowest population of jassids plant^{-1} (6.80) was recorded from chlorpyrifos and maximum number of jassids (11.01) was observed in control plot. While no significant difference was observed among plant extracts and the lowest population of (7.52) jassids plant^{-1} in plant extracts was recorded from the plot treated with moringa leaf extract after 1st day of spray application. On 2nd day after application the population of jassids further decreased and the minimum population of jassids plant^{-1} was recorded from chorpyrifos treated plot (5.11) followed by moringa leaf extract (6.90) , chinaberry fruit extract (8.23), fresh red chilli extract (8.47), neem seed extract shows (8.90) jassids population plant^{-1} and the maximum population was observed from control (9.02). Among plant extract moringa leaf extract was found significantly different from all other plant extracts. Similar trend was observed on 3rd day after application of treatments. The minimum population of jassids was recorded on 7th day after application of first spray. Minimum population was recorded from chlorpyrifos(3.04) jassids plant^{-1} followed by moringa leaf extract (5.15), chinaberry fruit extract (6.23), fresh red chilli extract (6.70), neem seed extract shows (7.32) jassids population plant^{-1} and the maximum population was observed from control (8.32) were recorded. After 14 days of application the population of jassids has shown a slight increase, which means the effect of treatments has been decreases with time. In mean column of (Table 6) the observed data shows that the highest mean data (9.30) was recorded for control, while the minimum mean data (5.26) was recorded for chlorpyrifos. Among plant extracts the mean data recorded for moringa leaf extract (6.86) and chinaberry fruit extract (7.80) was significantly different from each other, while on other hand no significant difference was observed between fresh red chilli (8.50) and neem seed extract (8.81).

Percent Reduction in Jassids Population After First Spray Application: The percent reduction in jassids population after first spray application on potato crop under field condition, as presented in (Table 7) shows that a significant percent reduction over control was observed. After 1st day of treatment application maximum percent reduction was recorded in chlorpyrifos (44.77%), followed by moringa leaf extract (31.69%), chinaberry fruit extract (21.98%), fresh red chilli (18.25%) and the minimum percent reduction (16.07%) was observed in neem seed extract treated plot. After 2 days of treatment application on potato crop the jassids population further declined and the percent reduction over control observed ranges from (1.33%-43.34%). Highest percent reduction was

recorded from chlorpyrifos (43.34%), while among plant extract the minimum percent reduction (1.33%) was recorded from neem seed extract plot and the highest percent reduction was observed in moringa leaf extract (23.5%) followed by chinaberry fruit extract (8.75%) and fresh chilli extract shows (6.09%) reduction over control. On 3rd day after field application the percent reduction over control ranges from (8.04-57.75%). Minimum percent reduction was calculated for neem seed extract while maximum percent reduction was recorded for chlorpyrifos. The data recorded after 7 days of treatment application shows that maximum percent reduction over control was recorded for chlorpyrifos (63.46%) followed by moringa leaf extract (38.1%), chinaberry fruit extract (25.12%), fresh red chilli (19.47%) and the minimum percent reduction (12.01%) was observed in neem seed extract. Above mentioned results on 7th day after application revealed that a significant percent reduction was observed in chlorpyrifos and moringa leaf extract while all other treatment were fond non-significant. 14 days after treatment application on potato crop the percent reduction in jassids population over control reduced slightly in botanical extract which shows that the effect of botanicals decreased with time. On 14 day after field application percent reduction over control ranges from (7.48% -58.83%) the maximum percent reduction (58.83%) was recorded for chlopyrifos, while among plant extract the minimum percent reduction (7.48%) was recorded from neem seed extract plot and the highest percent reduction was observed in moringa leaf extract (39.81%) followed by chinaberry fruit extract (25.46%) and fresh chilli extract shows (17.04%). The mean data of percent reduction in jassids population over control recorded in Table 4.6 revealed that the maximum percent reduction (43.98%) was calculated for chlorpyrifos, while in plant extract the highest percent reduction (26.94%) was recorded in moringa leaf extract followed by chinaberry fruit extract (16.93%), fresh red chili extract (9.47%) and the minimum percent reduction over control was recorded for neem seed extract (6.17%).

Jassids Population After 2nd Spray Application: (Table 8) shows that mean number of jassids plant-1 was significantly affected by all the applied treatments except control. Significant difference was observed in jassids population before and after 2nd application of treatments. The observation recorded after 1st day of second spray application shows significant difference and the minimum population was recorded from chorpyrifos (2.86) followed by moringa leaf extract (4.96), chinaberry fruit extract (6.25), fresh red chilli extract (6.93) and neem seed extract shows (7.31) jassids population plant^{-1} and the maximum population was observed from control (8.82). mong plant extract moringa leaf was significantly different from the rest i.e. chinaberry fruit extract, fresh red chilli extract and neem seed extract. Similar trend was observed on 2 days after application of treatments and the lowest population was recorded for chlorpyrifos which was (2.36) jassids plant^{-1} and the highest population was recorded for control plot (8.95). After 3 days of field application of spray the jassids population was further declined. The maximum population was recorded in control plot (7.61) jassids plant^{-1} and the minimum population was recorded for chlorpyrifos (1.80). Among plant extract the maximum population was recorded for neem seed extract (6.89) followed by fresh red chilli extract and chinaberry fruit extract, while moringa leaf extract has shown the lowest population of jassids plant^{-1}. In plant extract moringa leaf extract and chinaberry fruit extract were found significantly different, while there was no significant difference between fresh red chilli and neem seed extract. The recorded data after 7 days of application shows minimum number of jassids plant^{-1} in all plots compare to all other days on which data has been recorded. The minimum population was recorded for chorpyrifos (0.84) followed by moringa leaf extract (1.59), chinaberry fruit extract (2.76), fresh red chilli extract (3.70), neem seed extract shows (4.16) jassids population plant^{-1} and the maximum population was observed from control (5.32). Subsequently after 14 days of application the population of jassids plant^{-1} has been increased and the maximum population was recorded in control plot (7.82) and minimum population (1.52) was observed in chlorpyrifos treated plot. In mean Table all treatments shows signification difference except control. The minimum mean number of population was calculated for chlopyrifos (2.23) followed by moringa leaf extract (3.90), chinaberry fruit extract (5.47), fresh red chilli extract (6.16), neem seed extract shows (6.80) mean number were calculated accordingly. And the maximum mean number of jassids plant^{-1} (8.53) was recorded in control plot.

Percent Reduction in Jassids Population After Second Spray Application: The mean column of (Table 9) shows that a significant percent reduction over control in jassids population on potato crop was observed in all applied treatments. The mean percent reduction over control ranges from (15.20%-72.20%) in all treated plots. Maximum percent reduction over control in the mean column was recorded for chlorpyrifos (72.20%) subsequently followed by moringa leaf extract (51.37%), chinaberry fruit extract (31.7%), fresh red chili extract (23.20%) and neem seed extract (15.20%) mean percent reduction over control was calculated after second application of treatments .After 1st day of

second application of treatments on potato crop the maximum percent reduction in jassids population over control was recorded (67.57%) in chlorpyrifos treated plot, followed by moringa leaf extract (43.76%), chinaberry fruit extract (29.13%), fresh red chilli (21.42%) and the minimum percent reduction (17.12%) was observed in neem seed extract. The data recorded after 2 days of second treatment application on potato crop the jassids population further decreased and the percent reduction over control observed ranges from (21.34%-73.63%). The highest percent reduction was recorded from chlorpyrifos (73.63%), while among plant extract the minimum percent reduction (21.34%) was recorded from neem seed extract and the highest percent reduction over control among plant extract was observed in moringa leaf extract (63.68%) followed by chinaberry fruit extract (32.73%) and fresh chilli extract shows (27.03%) reduction over control. On 3rd day after second field application of treatments similar trend was observed. The percent reduction over control ranges from (9.46-76.34%). The minimum percent reduction was calculated for neem seed extract while the maximum percent reduction was recorded for chlorpyrifos. The maximum reduction in jassids population over control was observed on 7th day after application of treatments. The data shows that the percent reduction of jassids population ranges from (21.80%-80.90%),Where the minimum percent reduction (21.80%) was recorded for neem seed extract followed by fresh red chilli extract (30.45%), chinaberry fruit extract (48.12%), moringa leaf extract (70.11%) and the maximum (80.90%) percent reduction in jassids population was calculated for chlorpyrifos treated plot. Data observed 14 days after treatments application on potato crop the percent reduction in jassids population over control reduced slightly in botanical extract, which shows that the effect of botanicals decreased with time. On 14 day after field application percent reduction over control ranges from (16.62%-80.5%) the maximum percent reduction (80.5%) was recorded for chlopyrifos, while among plant extract the minimum percent reduction (16.62%) was recorded from neem seed extract and the highest percent reduction over control among plant extract was observed in moringa leaf extract (57.54%) followed by chinaberry fruit extract (31.20%) and fresh chilli extract (23.01%).

Yield (Kg ha^{-1}): The effect of different plant extracts and a synthetic insecticide on the yield of potato crop at district swat is presented in (Table 10). Results revealed that all treatments had a significant effect on the yield of potato crop. Maximum yield was recorded from chlorpyrifos treated plot (12859 kg ha^{-1}) and minimum yield is recorded from control plot (6171 kg ha^{-1}), while among plant extracts the highest yield was observed for moringa leaf extract (10840 kg ha^{-1}). Furthermore chinaberry fruit extract (9181 kg ha^{-1}), fresh red chilli extract (8222 kg ha^{-1}) and neem seed extract (7811 kg ha^{-1}) was statistically at par with each other. The percent increase column in (Table 10) revealed that the maximum percent increase over control was calculated for chlorpyrifos (52.01%) followed by moringa leaf extract (43.07%), chinaberry fruit extract (32.79%), fresh red chilli extract (24.95%) and the minimum percent increase was calculated for neem seed extract (21.00%).

Cost Benefit Ratio: (Table 11) shows cost benefit ratio for different plant extracts and a synthetic insecticide applied against aphid and jassid in potato crop at district swat. From the results it is observed that all treatments were found profitable having CBR value >1. Maximum CBR value was recorded for chlorpyrifos (1:53.94) while among plant extracts maximum CBR was recorded for moringa leaf extract (1:46.69) followed by chinaberry fruit extract (1:32.72), red chilli extract (1:26.29) and minimum CBR was calculated for neem seed extract (1:17.8). These findings revealed that the application of moringa leaf extract should be encourage, as it is economically feasible and environmentally suitable. The findings of (Table 11) are applicable only in the district swat and can vary with time, availability of the applied treatments and region. Average price of potato kg^{-1}=Rs.50, Labour cost on preparation of plant extracts Rs. 1000/extract, Moringa grind leaf cost=Rs.1400 (1200 kg^{-1}), Neem seed cost=Rs. 1200 (600kg^{-1}), Red chilli cost=300rs, China berry fruit collection cost Rs.1000, Spray pump charges Rs.600 (300 per day), Spray charges Rs.2000 (Rs.1000/spray), chorpyrifos per ha cost =Rs.3600rs (3600/spray).

The results of the research titled Response of major insect pests of potato towards plant extracts and a synthetic insecticide at district swat are discussed in this section. During the observational period two insect pests were recorded i.e. aphids and jassids[40] were also recorded these insect pests in potato crop. Different plant extracts were used to manage the population of sucking insect pests in comparison with chemically treated plot Sana[41] also applied plant extracts against sucking insect pests to minimize the excessive use of chemicals in agriculture field. Statistically all applied treatments were found effective against aphid and jassid as compare to control. In this study chlorpyrifos was observed to be the most efficient against the population of sucking insect pests of potato as compare to all other treatments. These results are in agreement with the findings of Bhatnagar[42] where they found chlorpyrifos to be the most effective in management of sucking insect pests of potato as compare to other insecticides he used in his study. The

study evaluated by Xiao[43] improving pesticide uptake modeling into potatoes: considering tuber growth dynamics where the found chorpyrifos more effective than the rest of treatments. Similar study was performed by sohail[44] where the synthetic insecticide was found more efficient than botanical extracts. Among plant extracts moringa leaf extract was found to be the most effective in minimizing insect pest population followed by chinaberry fruit extract, fresh red chilli extract and neem seed extract were found to be the least efficient against aphid and jassid. The study conducted by Songwe[45] are in agreement with this results where they used moringa extracts as insecticide in comparison with chemicals and they observed no significant difference between them. The results of this study are in line with research conducted by Manzoor[46] they study potential of moringa as plant growth regulator and bio-pesticide against wheat aphids. Our results was also supported by Choga[47] in their research study effect of botanical extract against late blight, used moringa as plant extract and found it significantly effective. The results obtained from chinaberry fruit extract in this research were also considerably good from the rest i.e. fresh red chilli and neem seed extract this result was similar to the results of Arokyaraj[48]. The findings of our study were also supported by Hussain[49] where they studied the effect of different plant extracts against whitefly on round chilli and found chinaberry fruit extract significantly effective in their research. Subsequently, Hussain[50] in their research study ecofriendly management of green pea and found fresh red chilli effective against pea leafminer and they found that chinaberry fruit extract was highly significant in insect pest management the results are in line with our findings. The study by Mehmood *et al* (2014) also revealed that bio-pesticides are significant for the management of aphids and jassids population however their effectiveness did not go beyond 72hrs. Iqbal *et al.* (2015) also studied that plant extracts plays essential role in the management of aphid, jassid, whitefly and thrips. Their results revealed that neem seed extracts provided better results in comparison to other extracts he used in his study. This result is in disagreement with our findings as neem seed extracts treated plot shows minimum reduction in population of aphid and jassid as compare to all other plant extracts applied. Similarly the findings of our study was also supported by Hussain[50] in their research study ecofriendly management of green pea found fresh red chilli effective against pea leafminer. The present study was also supported by Islam[51] in their research study efficacy of some botanical extracts on the control of late blight disease in experimental potato field where they used different botanicals extracts against late blight disease and their results revealed that all applied botanicals extracts shows significant effect on potato late blight disease. Maximum yield of potato was observed in plot treated with chlorpyrifos the results was in agreement with Xiao[43] where they found maximum yield in the chlorpyrifos treated plot. The obtained results was also in line with the findings of Bhatnagar[42]. Similar study was performed by sohail[44] where the synthetic insecticide was found more efficient than botanical extracts. Among plant extracts moringa leaf extract shows higher yield the revealed results are in agreement with Songwe[45] and Manzoor[46]. Yield obtained from chinaberry fruit extracts was significantly higher than control the obtained results are in line with Arokyaraj[48] and Hussain[49]. Subsequently, our findings were in agreement with Hussain[50-60] in their research study ecofriendly management of green pea and they obtained higher yield from the plot treated with chinaberry fruit extract[60-70].

Summary: A study was conducted to evaluate the response of major insect pest of potato against different plant extracts and a synthetic insecticide under field conditions at Agriculture research institute, Swat, during 2023[71-75]. The study was designed in randomized complete block design (RCBD) with three replications, plot size of 9 meters with four rows in each plot, R to R distance was kept 75cm and P to P distance were 10 cm accordingly. The field was prepared and the tubers of local verity Raja were sown at the prepared field in September, 2023. Six treatments including control, four different botanicals and a synthetic insecticide i.e. T_1 (Neem seed extrat), T_2 (Fresh red chilli extrat), T_3 (Moringa leaf extract), T_4 (China berry fruits extract), T_5 (Chlorpyrifos 40% EC), T_6 (Control) were used. Plant extracts were applied at 10% each while chlorpyrifos was applied at recommended dose. The above mentioned treatments were applied twice to the field with the interval of 14 days. The data was observed before spray and on 1st, 2nd, 3rd, 7th and 14th day after application. The yield was observed separately for each plot and converted into yield kg ha^{-1} and the CBR was calculated for each treatment accordingly[76-78]. The results revealed that after first and second application of spray, all the treatments were found significant for minimizing aphid population. The lowest population density was observed from the plot treated with Chlorpyrifos, while among botanicals moringa leaf extract was found more effective against aphid population followed by chinaberry fruit extract, fresh red chilli and neem seed extract, whereas the maximum population density was observed from untreated plot (control). Correspondingly, after first and second application of the treatments the population density of jassid was effectively reduced. Chlorpyrifos was found to be the

most effective, while in botanicals moringa leaf extract was found more effective against jassids population followed by chinaberry fruit extract, fresh red chilli and neem seed extract, whereas the maximum population density was observed from untreated plot (control) Above all mentioned treatments the plot treated with chlorpirofos has shown the highest marketable yield with 12859kg/ha and among botanical extracts the highest yield was recorded from the plot treated with moringa leaf extract with 10840kg/ha followed by chinaberry fruit extract 9181kg/ha, fresh red chili 8222kg/ha and neem seed extract 7811kg/ha whereas the lowest yield was observed from the control plot 6171kg/ha[79-82]. In Cost benefit ratio the highest CBR was calculated for chlorpyrifos, while among the botanical extracts the highest CBR was recorded for moringa leaf extract followed by chinaberry fruit extract and fresh red chilli extract whereas Neem seed extract was found with the lowest CBR. Based on the results, it has been concluded that all the tested treatments had a significant impact on reducing the population of aphids and jassids on potato crops as compared to untreated plot. Moreover Chlorpyrifos has shown high impact on reducing pest population. While in plant extracts moringa was found to be the most effective against potato aphids and jassids, while in all tested treatment neem seed was found to be least effective in aphid and jassid management. According to the effective results of plant extracts, particularly moringa, It is recommended to be incorporated in future IPM programs. The effect of the botanicals should also be investigated on the natural enemies. Further studies should be conducted on the application of the tested botanicals in different concentrations to evaluate their efficacy.

CONCLUSION

It is concluded from our studies that all the applied treatments have a significant effect on the population density of aphids and jassids. Minimum insect pest density was recorded for Chlorpyrifos, while among plant extracts moringa was found to be the most effective against potato aphids and jassids. It is also revealed from our study that maximum yield was recorded for chlorpyrifos, followed by moringa and minimum yield was recorded for control, furthermore maximum CBR value was recorded for chlorpyrifos and among plant extracts maximum CBR was recorded for moringa, followed by chinaberry fruit extract and minimum CBR was recorded for neem seed extract.

Recommendation:

- Based on the effective results of plant extracts, particularly moringa leaf extract, in reducing aphid jassid population and enhanced yield of potato crop, it is recommended to incorporate moringa leaf extract in future IPM programs.
- The effect of the plant extracts should also be investigated on the natural enemies.
- Further studies should be conducted on the application of the tested plant extracts in different concentrations to evaluate their efficacy against targeted insect pests with minimal effect on environment and enhanced crop yield.

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