

Research Article

Insecticidal Potential of some Fermented Native Plant Extracts for the Management of White Grub (Scarabaeidae: Coleoptera) Infestation on Potato Tubers in Skardu Baltistan

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Abstract | Potato (*Solanum tuberosum* L.) is the fourth major food crop of the world and it is gaining status of cash crop in Gilgit Baltistan. White grub is most destructive insect pest damaging potato tubers and causes economic loss of Gilgit-Baltistan. The study was conducted with an aim to develop eco-friendly management of white grub. Fermented extracts of four herbs *Sophora alopecuroides*, *Artemisia sieversiana*, *Peganum harmalla* and *Tagetes minuta* were evaluated against white grub under field conditions for two consecutive growing seasons during 2018 and 2019. The minimum per cent infestation, number of white grubs per plot, yield loss and maximum tuber yield was recorded in plots treated with *S. alopecuroides* fermented extract and Refree. The fermented extract of *S. alopecuroides* significantly reduced percent infestation, number of white grub per plot and yield losses as compared to the control plot, however efficacy of the fermented extract of *A. sieversiana*, *P. harmala* and *T. minuta* was significantly low as compared to Refree. Our current field study indicated that the fermented extract of *S. alopecuroides* has potential to develop eco-friendly approach for management of white grub.

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Introduction

Potato (*Solanum tuberosum* L.) is the fourth major food crop of the world. In Pakistan, currently potato is grown on 109.7 thousand hectares producing 1938.1 thousand tonnes annually with an average yield of 17.7 tons/ha. (Agricultural Statistics of Pakistan, 2003-2004).

Potato is now gaining status of cash crop after Apricot

in Gilgit Baltistan (Food and Agriculture Division, 2012). Its annual production is estimated 76,125.00 tonnes from an area of 3,045 hectares (Hashmi and Shafiullah, 2003). Potato crop is attacked by a number of insect pests including wireworms, white grub, aphids, cutworm and others adversely affecting the yield of crop (Shakur et al., 2007). Among these insect pests, white grub is the most destructive pest damaging potato tubers and causes significant economic loss to potato growers of Gilgit-Baltistan.

White grubs are larvae of a Scarabid beetle in the order Coleoptera. There are about 1300 North American species and the world fauna of white grub exceeds 30,000 species (Mittal and Pajni, 2000). Several species of white grubs or scarabs are root feeding pests of grasses, grains, sugarcane, strawberry, potato tubers and young nursery plants (Crocker *et al.*, 1996).

True white grubs are the larvae of May beetles (also called June Beetles) found in the genus *Phyllophaga*, of which there are over 100 different species. *Phyllophaga* larvae and other larvae of the family Scarabaeidae are often referred to as “white grubs”, including larvae of the Japanese beetle (*Popillia japonica* Newman), annual white grubs (*Cyclocephala* spp.) and the green June beetle (*Cotinis nitida* Lin.) (Selmen, 1998).

White grubs are root feeders and their adult beetles feed on the leaves of host plants (Musthak *et al.*, 2013). White grubs are the most destructive and troublesome soil insects, impeding potato production especially in hilly states of India. The infected tubers have scooped out holes or half-eaten tubers which are rendered unfit for marketing (Chandel *et al.*, 2015).

Reliance on injudicious use of synthetic pesticides to control pests has also given rise to a number of problems such as destruction of non-target beneficial organisms (parasitoids and predators) affecting food chain and biological diversity, secondary outbreaks of pests that are normally under natural control resulting in their rapid proliferation (Ouedraogo *et al.*, 2011). There have also been cases of pests becoming tolerant to insecticides resulting in the use of double and triple rate of application (Stoll, 2000).

Although synthetic insecticides are used as the main controlling agent, optimal control cannot be obtained probably due to the development of insecticide resistance. Also, the uses of synthetic insecticides pollute the environment and can seriously affect the health of the farming communities. Therefore, search for natural product-based insecticides (botanicals), which are biodegradable and economically has become an area of extensive research. Resistance to botanicals does not develop as rapidly as to synthetic insecticides due to the structural complexity of natural toxicants (Silva *et al.*, 2008). About 250,000 plant species in the world have been reported to possess compounds with insecticidal properties (Rafael, 2001).

The chemical insecticides are not effective in the white grub management system and these chemical pesticides are hazardous for human health and other organisms. Green plants are reservoir of effective and valuable natural source of pesticide (Hostettmann *et al.*, 1997).

Interest in the use of bio-pesticides with selectivity towards phytophagous insects has increased in recent years, particularly in cropping systems that rely on natural enemies as a major component of integrated pest management (Rausell *et al.*, 2000). In Gilgit-Baltistan (G-B) farmers are using toxic chemical insecticides injudiciously to control white grub.

Floral diversity in Gilgit-Baltistan is rich with wide spectrum of medicinal values but no effort has been made in this region to isolate, identify, and develop botanical pesticides. Rich biodiversity in G-B has potential opportunities to develop botanical pesticides formulation unit as in most parts of the Gilgit-Baltistan plant materials are also used traditionally to control insect pests (Ismail *et al.*, 2014). *Sophora alopecuroides* found in Skardu (Baltistan) abundantly has the potential to commercialize as a natural pesticide against various insect pests (Rizvi *et al.*, 2019).

In the area where this study has been conducted, farmers rely on toxic chemical insecticides injudiciously to control white grub. The massive use of synthetic insecticides in pest management program exerts hazardous effects on human health and environment. There is a dire need to adopt eco-friendly approach for pest management, therefore in this study fermented extracts of four readily available local plants were evaluated for their insecticidal potential against white grub infestation on potato crop.

Materials and Methods

Preparation of fermented plant extract

The aerial parts of native plants *Sophora alopecuroides* (called Khampa in local language “Balti”), *Artemisia sieversiana* (Khahuro), *Peganum harmala* (Isman) and *Tagetes minuta* (Suna Mindoq) were harvested at pre-blooming stage. The plant materials were washed thoroughly and then dried in shade. The dried plant materials were grinded to form fine powder and stored in hermetically sealed jars. Fermented extracts of four plants were prepared by dipping their powder

in stream water in 25 kg capacity drums at 1: 9 w/v. Openings of drums were wrapped with muslin cloths and then placed in semi-shade for fermentation. Plant materials in drums were stirred daily. After two weeks fermented extracts were filtered through muslin cloth and then filter paper (Whatman No.1). These extracts were stored in glass jars placed in a cool dark place until field application.

Field application

Field experiments to evaluate the insecticidal effects of fermented extracts derived from four native plants against white grub were carried out at PARC, Agricultural Research Station, Skardu during two successive seasons of 2018 and 2019 under Randomized Complete Block Design with 13 treatments and 3 replications. Potato variety “Flamenco” was planted maintaining a plot size of 6.67m² for each treatment with two 45 cm wide ridges of 5 meters length. Serial concentrations of fermented extracts were prepared by diluting @ 1, 3 and 5ml/ liter of water and drenching of this diluted extract was carried out @ 1000 l/ha on top of potato ridges in the evening hours whereas control plots were left untreated. Refree granules (Active Ingredient- Fipronil 0.3% G.) were applied during 2019 as standard control. Drenching was carried out twice in a season at one-month interval. First application of extracts was given on tuber formation initiated after one month of planting in mid-June. Total number of tubers and damaged tubers were recorded to determine % infestation. Number of white grubs found in each plot and weight of tubers per plot were recorded at harvesting time for assessment of yield and % yield loss.

Statistical analysis

All the statistical tests were conducted by using SPSS 17.0; *P*-values of less than 0.05 were considered significant. For the percent infestation, damage and yield data under field conditions were subjected to repeated measured analyses were subjected to simple analyses of variance. PROC GLIMMIX (SAS Institute, 2010) was used. All statistical analyses were conducted at the 0.05 level of significance.

Results and Discussion

Results obtained during 2018

Statistical analysis indicated highly significant difference in % tuber infestation between plots treated

with *S. alopecuroides* fermented extracts at doses 3 and 5 ml/l and other plots. In plots treated with 1, 3 and 5 ml/l doses of *T. minuta*, *A. sieversiana* 1, 3 ml/l *P. harmala* and 1 ml/L *S. alopecuroides* fermented extracts moderate tuber infestations of 10.84 to 21.60 % were recorded. Results of this study revealed that drenching of *S. alopecuroides* fermented extract twice significantly reduced the white grub infestation on potato tubers to 1.67% and 4.05 % at concentrations of 5 and 3ml/l compared to untreated control plots and *P. harmala* extract 5 ml/l dose treated plots with significantly highest infestation of 24.06% (Table 1, Figure 1).

In case of number of white grub counted per plot at time of harvesting, there was significant difference among treatments (*P*=0.005) but there was no difference between treatments of *S. alopecuroides* extract doses of 3 and 5 ml/l @ 1000 l/ha. As shown in Table 1 from plots treated with *S. alopecuroides* extract 3 mL/L and 5mL/L lowest number of white grub 0.33 and 0.00 were captured, which significantly differed from other treatments during 2018. Without statistical difference, higher number of white grubs 7.67, 7.00 and 5.67 were recorded from control and plots treated with *P. harmala* extract at doses of 1 and 3 ml/l.

Similarly, there was significant difference in tuber yield obtained from plots treated with four fermented plant extracts and untreated control plots. Two applications of *S. alopecuroides* fermented extract at 5 ml/l significantly increased the tuber yield to maximum 27.64 t/ha followed by 19.74 t/ha tuber yield recorded from plots treated with 3 ml/l of same extract. Among other treatments including control, no significant difference was observed in tuber yield which ranged from 11.74 t/ha to 15.49 t/ha.

Results of this study revealed that infestation of white grubs on potato tuber caused significant loss of potato yield i.e., up to 58.40% but drenching of *S. alopecuroides* fermented extracts at 3 and 5 ml/l significantly reduced tuber yield loss to 28.58% and 5.31%.

Results obtained during 2019

Minimum infestation (3.47%) was recorded in standard control plots treated with Refree (Active Ingredient Fipronil 0.3% G) which did not differ significantly from 5.75, 3.85% infestation observed in plots treated with 3 and 5 ml/l of *S. alopecuroides*

fermented extracts as shown in Table 2. Results indicate that the effect of synthetic pesticide used in the study has no significant difference with fermented extract of *S. alopecuroides* and *A. sieversiana* on reduction in white grub infestation. Statistically, %infestation in plots treated with fermented extracts of *T. minuta*, *A. sieversiana* and *P. harmala* did not vary significantly with each other but significantly differed from plots treated with *S. alopecuroides* fermented extracts (3 and 5 ml/l), *A. sieversiana* (5 ml/l), Refree (45 kg/ha) and control plots with significant difference receiving maximum infestation of 34.82%.

With no significant difference, lowest number of

white grub 0.00, 0.33 and 0.67 were recorded in plots treated with 1 and 5 ml/l *S. alopecuroides* extract and Refree. Highest number of white grub 7.67, 8.67 and 8.33 were found in plots treated with extract dose of *T. minuta* 3ml/l, and *P. harmala* extract doses 1 and 3 ml/l respectively with no statistical difference. Higher number of white grubs i.e., 5.00 were recorded in untreated control plots which did not significantly differ from plots treated with fermented extracts of *T. minuta*, *A. sieversiana*, *P. harmala* at 1, 3 and 5 ml/l and *S. alopecuroides* 3 ml/l but significantly differed from plots treated with Refree 45 kg/ha and *S. alopecuroides* extract at 1 ml/l and 5 ml/l concentrations.

Table 1: Effect of Fermented extracts of four native plants on white grub infestation on potato under field condition during 2018.

Fermented extract	Dose mL/L	% infestation	No. of white rub/6.67m ²	Yield t/ha	% yield loss
<i>S. alopecuroides</i>	1	10.84cde	3.00ab	15.49b	43.96a
	3	4.047de	0.33b	19.74ab	28.58ab
	5	1.667e	0.00b	27.64a	5.31b
<i>T. minuta</i>	1	20.07abc	3.67ab	11.74b	57.51a
	3	12.35bcd	4.00ab	14.24b	48.48a
	5	20.22abc	4.33ab	13.62b	51.93a
<i>Seiversiana</i>	1	20.75abc	4.00ab	12.75b	53.88a
	3	16.70abc	3.67ab	14.50b	58.40a
	5	14.97abc	3.00ab	14.74b	46.67a
<i>P. harmalla</i>	1	21.60ab	7.00a	12.39b	55.17a
	3	18.24abc	5.67a	14.49b	47.57a
	5	24.06a	3.67ab	13.99b	49.37a
Control	-	24.95a	7.67a	13.24b	52.88a

Data are the mean of three replicates and are represented as mean $\pm$ standard deviation. Means in the same column followed by the same lower-case letter are not significantly different at $P = 0.05$.

Table 2: Effects of Fermented extracts of four native plants on white grub infestation on potato tubers under field condition, 2019.

Fermented extract	Dose mL/L	% infestation	No. of white grub captured/plot	Yield t/ha	% yield loss
<i>S. alopecuroides</i>	1	15.00cde	0.33e	12.49c	50.51a
	3	5.75e	1.00de	18.49abc	26.74abc
	5	3.85e	0.67e	23.99ab	8.25bc
<i>T. minuta</i>	1	25.58abc	5.33abc	13.99c	44.56a
	3	24.62abcd	7.67a	12.99c	48.52a
	5	27.58abc	3.33bcde	11.10c	54.45a
<i>Sieversiana</i>	1	26.38abc	3.00bcde	11.64c	53.90a
	3	17.49bcde	2.33bcde	14.49bc	42.58ab
	5	10.52de	1.67cde	16.24abc	35.64abc
<i>P. harmalla</i>	1	31.35ab	8.67a	12.99c	48.52a
	3	32.09ab	8.33a	12.24c	51.49a
	5	29.64ab	6.33ab	12.10c	48.51a
Refree	45 kg/ha	3.47e	0.00e	25.24a	4.62c
Control	-	34.82a	5.00abcd	11.10c	56.03a

Data are the mean of three replicates and are represented as mean $\pm$ standard deviation. Means in the same column followed by the same

lower-case letter are not significantly different at $P = 0.05$.

In case of potato tuber yield, maximum tuber yield of 25.24 t/ha was obtained from plots treated with Refree which did not differ significantly from 18.49 t/ha, 23.99 t/ha and 16.24 t/ha tuber yield, respectively recorded from plots treated with *S. alopecuroides* extracts at 3 and 5 ml/l and *A. sieversiana* extract at 5 ml/l doses. Minimum tuber yield of 11.10 t/ha obtained from the control and *T. minuta* 5 ml/l treated plots was not significantly different from tuber yields of 11.64 and 18.49 t/ha obtained from plots treated with *S. alopecuroides* extract doses 1 and 3 ml/l and *T. minuta*, *A. sieversiana*, *P. harmala* extracts at 1 ml/l, 3 ml/l and 5 ml/l dose levels. Potato tuber yield of 16.24 ha/t obtained from *A. sieversiana* 5 ml/L extract treated plot was not significantly different from maximum tuber yield of 25.24 t/ha from plot treated with Refree, while minimum yield of 11.10 t/ha was obtained from the control plot and 23.99 t/ha yield was obtained from *S. alopecuroides* 5ml/l treated plot as shown (Table 2, Figure 2).

Assessment of potato yield loss indicated that white grub caused severe damage to tubers resulting in yield loss of up to 56.03%. Highest yield loss of 56.03% recorded control plots was not significantly different from 26.74% to 54.45% yield loss recorded in plots treated with 1 and 3 ml/l of *S. alopecuroides* extract and plots treated with 1, 3 and 5 ml/l of *T. minuta*, *A. sieversiana*, *P. harmala* extracts but significantly differed from lowest yield loss of 4.62% in plots treated with Refree, 26.74% and 8.25% from *S. alopecuroides* 3 and 5 ml/l and 35.64% yield loss from *A. sieversiana* 5 ml/l treated plot. However, yield loss of 26.74% and 35.64% recorded in plots treated with 3 ml/l *S. alopecuroides* and 5 ml/l *A. sieversiana* was not significantly different from highest yield loss of 56.03% from control and other plots. Results indicated that two applications of Refree at rate of 45kg/ha and *S. alopecuroides* 5 ml/l at rate of 100 l/ha significantly reduced the potato tuber yield loss to 4.62% and 8.27% from an economical yield loss of 56.03% caused by white grub attack during 2019.

White grub is an important agricultural root feeding pest widely distributed in different agro-climatic conditions of Pakistan and throughout the world. White grubs attack potato which is one of the four major staple foods having a significant contribution to national food consumption needs.

Results of present study revealed that *S. alopecuroides* fermented extract is most effective to manage white grub infestation reducing tuber damage under field conditions.

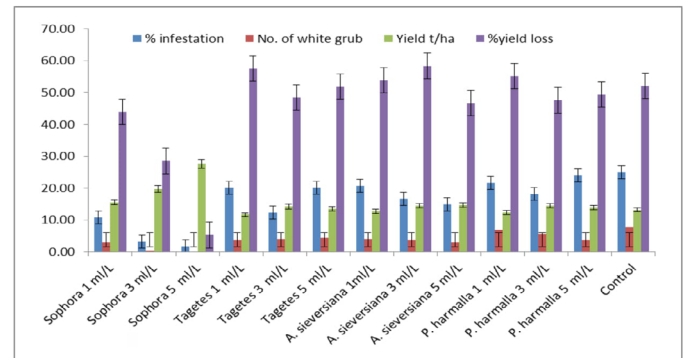


Figure 1: Effect of Fermented extracts of four native plants on white grub infestation on potato under field condition during 2018.

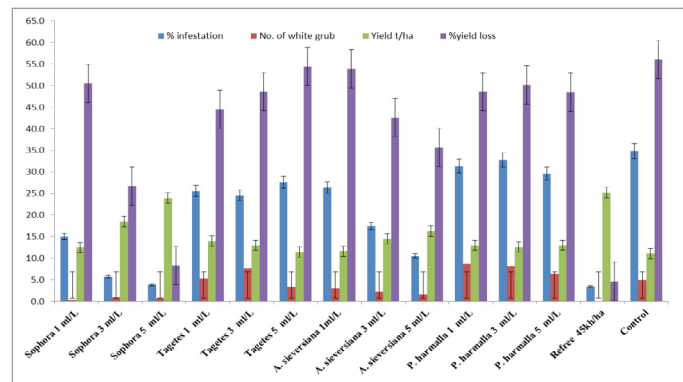


Figure 2: Effect of Fermented extracts of four native plants on white grub infestation on potato under field condition, 2019.

In concurrence with the results of present study, [Yadava and Sharma \(1995\)](#) reported that white grubs cause up to 70% damage to roots of commercial crops and one grub/m² caused 80-100 per cent plant mortality. Similar damage rate in potato tubers varying from 8.5 to 75.05% especially in hilly regions of India reported by [Chandel et al. \(2015\)](#). [Rani et al. \(2009\)](#) found fermented extracts of *Sapindus mukorossi*, *Chrysanthemum* sp., *Nerium oleander*, *Urtica dioica* and *Vitex negundo* in indigenous cow urine @ 5 mL/L were equally effective and the per cent tuber damage on tuber number basis in these treatments varied from 1.67-9.58% during 2007 and 5.08-7.46% during 2008 crop season. Similarly, the result of studies on effectiveness of fermented cattle urine (1:6) and natural products of *Nicotiana tabacum*, *Azadirachta indica*, *Capsicum annum* and *Allium cepa* in the management of barley aphid, *Diuraphis noxia* carried out in Ethiopia revealed that all the treatments were toxic to *D. noxia* and provided more

than double increase in yield (Tesfaye and Gautam, 2003). Furthermore, Sahayaraj *et al.* (2011) reported more than 90% larval mortality in *Spodoptera litura* released onto castor leaves treated with 13, 18 and 23 days old fermented extracts of *Calotropis gigantea* and *Pongamia pinnata* leaves. In another similar study, Baloc and Bulong (2015) reported that fermented extracts of *Azadirachta indica*, *Gliricidia sepium*, *Tagetes erecta* and *Tinospora rumphii* were equally effective as the synthetic pesticides in terms of final plant height, average number of white flies reduced after spraying and average number of 28-spotted beetles reduced after spraying.

Conclusions and Recommendations

Results of this study revealed that white grubs cause considerable infestation and potato tuber yield loss. Fermented extract of *S. alopecuroides* a readily available plant has the potential insecticidal activity against white grub infestation on potato crop and can be used as a novel alternative to synthetic insecticides for eco-friendly management of white grub, a polyphagous soil insect pest damaging all sorts of field crops, forest trees and ornamental plants. Further studies should be focused on different fermentation techniques, formulations, phytotoxicity and application methods.

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Novelty Statement

Every years tons of chemical insecticides are being used to control white grub in spite of serious health and environmental risks. Our current study emphasizes the insecticidal potential of native plants for eco-friendly cheaper management of white grub infestation on potato and other field crops to reduce the use of harmful synthetic insecticides

Author's Contribution

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Shahid Hussain contributed to overall management of the research work, data analysis and writing of the article. Munir Hussain, Sher Ahmad, Muhammad Qasim, Muhammad Din, Muhammad Ishaque Mastoi and Tajudin gave technical inputs and proofread the paper.

Conflict of interest

The authors have declared no conflict of interest.

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