Identification of Organic Alternative to Chemical Pesticides for Red Ant Management in Potato.

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Received on: 4-7-2017, revised on: 25-8-2017, accepted on: 30-8-2017

Abstract

A study was carried out to find out the best alternative against chemical pesticide (Chloropyriphos) for controlling potato red ant. The experiment was conducted at Regional Agricultural Research Station, Lumle during winter season of two consecutive year 2015/16 and 2016/17. Eight different treatments including chemical method and biological method were tested in Randomized Complete Block Design with three replications. Treatments were Chloropyriphos 50% EC @750 ml/ha, Fipronil granules @ 6.25 kg/ha, Fenvelarate dust @ 250 kg/ha, Bacillus Thuringensis (Bt) @ 1 kg/ha, Bakaino (Melia azadirachta) seed powder @ 1040 kg/ha, Ketuki (Agave Americana) leaves @ 2080 kg/ha, Banmara (Ageratina adenophora) leaves @ 2080 kg/ha and Farmer practice. The highest weight of non-damaged tuber, minimum weight of red ant damaged tuber, maximum total tuber yield per plot and minimum tuber loss (%) were observed from Chloropyriphos application followed by Banmara leaves and Ketuki leaves application. Due to the residual effect of chemical insecticide, use of biological control becomes crucial. To address the human health, soil health and environment health, using the Banmara and Ketuki leaves against Chloropyriphos can be the alternatives.

Keywords: *Banmara, Chloropyriphos, Ketuki, Potato, Red-ant*

Introduction

Potato (*Solanum tuberosum*) is the most important staple food in the high hills and a major vegetable crop in the rest of Nepal. In high hills potato has been taken on priority for cash generating crop. It occupies fifth position in terms of area coverage and 2nd place in production as well as 1st position in productivity (NPRP Annual report, 2016). It is second most important crop and major component of hill farming system of Nepal. The area coverage under potato in Nepal is 199971 hectare with production of 2805582 metric ton and productivity of 14.03 t/ha (ABPSD, 2016) where as the area, production and productivity of Potato in India is 2085000 ha, 48096000 mt and 23.07 t/ha respectively (NHRDF, 2016). The several factors responsible for low productivity could be due to inadequate supply of quality seed, and occurrence of pest and disease causing damage up to $13.5 billion per annum in developing countries (Sharma *et al.,* 2011). Potato crop is attacked and damaged by a number of insect pests which directly cause damage to the tubers. Among these, Red ants (*Dorylus orientalis*) is one of the most important soil pests of potato reducing the yield every year. It damages the potato stems and tubers by chewing and making holes reducing tuber yield as well as market quality. In case of severe attack plants wilt in direct sunlight and will eventually dry up (Trivedi and Rajagopal, 1999). It attacks potato crop just after tuber formation and infestation in continued upto harvesting of potato unless any management approach is taken. Red ant has long been known as an important pest of potato in middle and higher hills of Nepal (G.C. *et al.,* 1997). It causes serious damage to potato, radish, carrot, cauliflower, cabbage and many solanaceous and cruciferous vegetables in Nepal (Joshi, 1998).

It is reported that red ant severely damaged the potato and reduced the marketable tuber yield in Nepal (Bhandari, 2011). There is lack of information on the bio-ecology of red ant. So, its effective control and management are lacking. This pest is generally controlled by the application of pesticides in the soil. Chloropyriphos (an organophosphate chemical) has widely been used on red ant management for many years (G.C. *et al.,* 1997). Spraying of infested potato fields with chlorpyriphos 20 EC @ 2.5 l/ha checked the further spread of infestation (Yein, 1984). Due to

the use of such systemic insecticide in potato, its residual effects cause the problems in human health as well in environment. There is a need to develop an eco-friendly strategy for the control of red ant. Therefore, the study was carried out to find out the best alternative against chemical pesticide (Chloropyriphos) for controlling potato red ant.

Materials and Methods

The experiment was conducted in the field of Regional Agricultural Research Station, Lumle during the winter season of two consecutive year 2015/16 and 2016/17. The experimental site was at an altitude of 1760 masl. Eight different treatments including chemical method and biological method were tested in Randomized Complete Block Design (RCBD) with three replications. Each treatment was tested in 4.8 m^2 plot area with 60 cm × 25 cm spacing, accommodating 32 plants per plot.

Table 1. Treatment details

S.N	Treatments	Application method	Applied dose
1	Chloropyriphos 50% EC @ 750 ml/ha	Soil drenching at 60 and 75 Days After Planting (DAP)	19.98ml/13.32 litre/plot/ application
2	Fipronil granules @ 6.25 kg/ha	Soil application at 60 and 75 Days After Planting (DAP)	1.5 gm/plot/application
3	Fenvelarate dust @ 250 kg/ha	Soil application at 60 and 75 Days After Planting (DAP)	600 gm/plot/application
4	*Bacillus thuringensis* (Bt) @ 1 kg/ha	Soil drenching at 60 and 75 Days After Planting (DAP)	25.32gm/12.66 litre/ plot/application
5	Bakaino (*Melia azadirachta*) (seed powder) @ 1040 kg/ha	Soil application during planting time. The riped seed of Bakaino were collected and allowed to dry in sun for few days. Dried seed were grinded in mortar and pistel and shieved to get fine powder.	0.5 kg/plot
6	Ketuki (*Agave americana*) (chopped leaves) @ 2080 kg/ha	Placement inside furrow during planting. The freshly cut ketuki leaves were chopped into small pieces and kept in furrow.	1 kg/plot
7	Banmara (*Ageratina adenophora*) (chopped leaves) @ 2080 kg/ha	Placement inside furrow during planting. The leaves and twigs of banmara were harvested and make small pieces for application inside furrow.	1 kg/plot
8	Farmers practice (Control)	No use of any chemical pesticides and botanicals.	-

Variety Kufri Jyoti was used in the experiment for both years 2015-16 and 2016-17. Potato seed of 25-50 gm was used as planting materials. Fertilizers were applied @ 100: 100:60 kg NPK/ha and FYM 20 t/ha. Other cultural practices including irrigation, weeding and earthing up were done according to the recommendations.

The parameters including Emergence Uniformity, Ground cover, Main stem per plant, Plant vigor, Plant height, Weight of non damaged tuber, Weight of red ant damaged tuber, Total weight of potato per plot and Loss percentage due to red ant were recorded accordingly. Total weight and loss percentage were calculated by-

$$\text{Total weight (kg/plot)} = \text{Weight of non damaged tubers (kg/plot)} + \text{Weight of red ant damaged tuber (kg/plot)}$$

$$\text{Loss percentage (\%)} = \frac{\text{Weight of red ant damged tuber (Kg/plot)}}{\text{Total Weight (Kg/plot)}} \times 100$$

The collected data were entered on MS- Excel sheet and analyzed for analysis of variance by using MSTAT software and treatment means were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

The yield parameters show significant difference among the applied treatments. The summary of significant parameters is presented in the Table 2 and Table 3. Observation from both years was analyzed separately and also the combined analysis of both years was performed and tabulated. Parameters such as the combined weight of non-damaged tubers and weight of damaged tubers were found highly significant under different eight treatments at 5 % level of significance (Table 2). Combined total tuber yield was noted to be significant but pooled loss % of tuber yield was highly significant (Table 3).

From an evaluation performed by Entomology Division on "Levels of tuber damage of released and promising genotypes of potato caused by red ant" it was observed that Kufri Jyoti had medium damage with 0.42 TDI (Tuber Damage Index) (Entomology Division, 2016). Using this variety, treatments for red ant management showed significant difference.

Weight of non-damaged tuber (kg/plot)

The treatments differed significantly on this parameter in both years (Table. 2). In the year 2015-16, the highest weight of non-damaged tuber was recorded 9.98 kg/plot from Chloropyriphos applied plot. In 2016-17 also, same treatment gave the highest weight (7.93 kg/plot) followed by Bt (6.40 kg/plot), Ketuki (6.20 kg/plot) and Banmara (6.17 kg/plot). From the combined analysis of two years data, maximum weight recorded was 8.96 kg/plot in Chloropyriphos applied plot, whereas the lowest weight was 1.85 kg/plot in Farmers practice. Similar result was also observed by Dash et al., 2013 in which the application of Dursban 20 EC @ 5ml/lit around root zones gave the highest weight of marketable (undamaged) tuber. Chloropyriphos was the most effective chemical (organophosphate) widely used against red ant for healthy tuber production. Even though it gives the better result, using these chemical on ware potato production is not good regarding human health as well as environmental safety.

Weight of red ant damaged tuber (kg/plot)

The significant difference was recorded among applied treatments in both years (Table. 2). The red ant damaged more in the Bakaino seed powder applied plot having loss of 9.37 kg/plot and 10.50 kg/plot respectively in year 2015-16 and 2016-17 which were statistically at par with the farmers practice having 8.77 kg/plot and 8.87 kg/plot damaged tubers in respective years. It followed the same pattern in combined analysis also.

Weight of red ant damaged tuber was found to be minimum (2.60 kg/plot) in Chloropyriphos applied plot followed by Bt (3.47 kg/plot), Ketuki (4.63 kg/plot) and Banmara (4.90 kg/plot) applied plot in 2015-16. In year 2016-17, less weight of red ant damaged tuber (4.80 kg/plot) was recorded from Banmara application which was statistically at par with Bt (4.87 kg/plot), and Ketuki (5.03 kg/plot) applied plots. From the combined analysis, mimimum weight of red ant damaged tuber (4.17 kg/plot) was found in Bt application and also at par with Chloropyriphos (4.37 kg/plot), Ketuki (4.83 kg/pot) and Banmara (4.85 kg/plot).

Table 2. Effects of different treatments on the tuber production of potato var. Kufri Jyoti at RARS, Lumle in 2015-16 and 2016-17

Treatments	Weight of non-damaged tuber (Kg/plot)			Weight of red ant damaged tuber (Kg/plot)		
	2015-16	2016-17	Combined	2015-16	2016-17	Combined
Chloropyriphos 50% EC @ 750 ml/ ha	9.98^{a}	7.93^{a}	8.96^{a}	2.60^{c}	6.13^{bc}	4.37^{c}
1Fipronil granules @ 6.25 kg/ha	3.13^{bcd}	5.33^{abc}	4.23^{bcd}	6.97^{ab}	7.07^{bc}	7.02^{abc}
Fenvelarate dust @ 250 kg/ha	3.88^{bcd}	4.80^{abc}	4.34^{bcd}	6.37^{ab}	5.80^{bc}	6.09^{bc}
Bt @ 1 kg/ha	4.57^{bc}	6.40^{ab}	5.48^{bc}	3.47^{bc}	4.87^{c}	4.17^{c}
Bakaino seed powder @ 1040 kg/ha	0.67^{d}	2.47^{bc}	1.57^{d}	9.37^{a}	10.50^{a}	9.93^{a}
Ketuki @ 2080 kg/ha	4.67^{bc}	6.20^{ab}	5.43^{bc}	4.63^{bc}	5.03^{c}	4.83^{c}
Banmara @ 2080 kg/ha	5.63^{b}	6.17^{ab}	5.90^{ab}	4.90^{bc}	4.80^{c}	4.85^{c}
Farmers practice	1.63^{cd}	2.07^{c}	1.85^{cd}	8.77^{a}	8.87^{ab}	8.82^{ab}
Grand Mean	4.27	5.17	4.72	5.88	6.63	6.26
CV (%)	44.0	39.51	41.58	31.70	28.13	29.81
LSD $_{\text{at 5 \%}}$	3.29**	3.58*	3.28**	3.26*	3.27*	3.12**

Total tuber weight (kg/plot)

Total tuber weight/plot was found to be maximum (12.58 kg) and (14.07 kg) in the Chloropyriphos applied plot in both 2015-16 and 2016-17, respectively. In contrast, Bt @ 1 kg/ha firstly recorded the lowest total weight of tuber (8.03 kg/plot) followed insignificantly by ketuki @ 2080 kg/ha (9.30 kg//plot) and Bakaino seed powder @ 1040 kg/ha (10.03 kg/plot) in the year 2015-16. Next year in 2016-17, Fenvelarate dust @ 250 kg/ha produced the lowest followed insignificantly by Farmers practice (10.93 kg/plot) and Banmara @ 2080 kg/ha (10.97 kg/plot). Lastly, the combined analysis of both years 2015-16 and 2016-17 revealed the highest total weight of tuber with 13.33 kg/plot in Chloropyriphos 50 % EC @ 750 ml/ha followed insignificantly by 11.50 kg/plot in Bakaino seed powder @ 1040 kg/ha and 11.25 kg/plot in Fipronil granules @ 6.25 kg/ha, respectively (Table 3).

Loss percentage (%)

This parameter differed significantly among the applied treatments (Table 3). To begin with 2015-16, minimum loss (20.29%) was recorded from Chloropyriphos application which was statically at par with Banmara (48.37%), Ketuki (48.53%) and Bt (51.84%). Similarly in 2016-17, minimum loss (42.04%) was recorded from Ketuki application which was statically at par with Bt (43.28%), Chloropyriphos (44.86%) and Banmara (46.95%). Finally, from the combined analysis of both years' data, it was found that use of Chloropyriphos recorded the minimum loss with 32.57% which has been insignificantly followed by Ketuki (45.28%), Bt (47.56%), and Banmara (47.66%).

In contrast, the loss percentage due to red ant damage was recorded the highest in the Bakaino seed powder (93.58%) followed by Farmers practice (86.26%) in first year. But in second year, loss percent was the highest (81.34%) in Farmers practice followed by Bakaino seed power (80.46%). Thereafter, the result of combined analysis of both years (2015-16 and 2016-17) showed Chloropyriphos @ 50 % EC @ 750 ml/ha to have produced the lowest loss (32.57%) ; however it was not statistically different from Ketuki @ 2080 kg/ha (45.28 % per plot), Bt @ 1 kg/ha (47.56 % per plot) and Banmara @ 2080 kg/ha (47.66 % per plot) respectively.

Dash *et al*, 2013 conducted the trial for two years to develop the management strategy where in both years application of Dursban 20 EC @ 5 ml/lit gave the lowest tuber infestation i.e 17.28% in 2008-09 and 10.68% in 2009-10.

The data also showed that Bacillus thuriengensis (Bt), Ketuki and Banmara were also quite effective for red ant management. It helps to minimize the tuber damage and also helps to increase the healthy tuber yield significantly. The possible cause for this might be due to the smell and the taste of these materials (Bt, Ketuki and Banmara) which would create killing and repelling effect on red ant. This was also in agreement with G.C. et al., 1997.

Table 3. Effects of different treatments on the tuber loss due to red ant in potato var. Kufri Jyoti at RARS, Lumle in 2015-16 and 2016-17

Treatments	Total weight (kg/plot)			Loss percentage (%)		
	2015-16	2016-17	Combined	2015-16	2016-17	Combined
Chloropyriphos 50% EC @ 750 ml/ha	12.58^{a}	14.07^{a}	13.33^{a}	20.29^{c}	44.86^{b}	32.57^{c}
Fipronil granules @ 6.25 kg/ha	10.10^{ab}	12.40^{ab}	11.25^{ab}	71.09^{ab}	59.76^{ab}	65.42^{ab}
Fenvelarate dust @ 250 kg/ha	10.25^{ab}	10.60^{b}	10.43^{ab}	62.04^{ab}	54.73^{ab}	58.38^{abc}
Bt @ 1 kg/ha	8.03^{b}	11.27^{ab}	9.65^{b}	51.84^{bc}	43.28^{b}	47.56^{bc}
Bakaino seed powder @ 1040 kg/ha	10.03^{ab}	12.97^{ab}	11.50^{ab}	93.58^{a}	80.46^{a}	87.02^{a}
Ketuki @ 2080 kg/ha	9.30^{ab}	11.23^{ab}	10.27^{ab}	48.53^{bc}	42.04^{b}	45.28^{bc}
Banmara @ 2080 kg/ha	10.53^{ab}	10.97^{ab}	10.75^{ab}	48.37^{bc}	46.95^{b}	47.66^{bc}
Farmers practice	10.40^{ab}	10.93^{ab}	10.67^{ab}	86.26^{a}	81.34^{a}	83.80^{a}
Grand Mean	10.15	11.80	10.98	60.25	56.68	58.46
CV (%)	20.87	13.81	17.22	30.12	28.13	29.22
LSD $_{\text{at 5 \%}}$	3.71*	2.85*	3.16*	31.77**	27.92*	28.57**

Conclusion

Considering the performance of the treatments, it can be concluded that use of Banmara and Ketuki leaves could be an alternative instead of using Chloropyriphos. Due to long waiting period and the residual effect, Chloropyriphos is harmful for long term use. So, use of biological control becomes crucial in present context. To address the human health, soil health and environment health, using the biological means of pest control can be the best option. Banmara and Ketuki are widely available plants in the mid hills region. These can be easily used in the soil before potato plantation. It can give a good yield without having any residual effect. From environmental point of view, red ant management by using Banmara and Ketuki leaves is an eco-friendly management practice. This study has shown the potentiality of the different herbs in the insect-pest management including red ant. It has paved the ways for performing further studies to identify the exact dose of the locally available herbs for the control of red ant in future.

Acknowledgement

I want to thank Nepal Agricultural Research Council, Regional Agricultural Research Station, Lumle for providing necessary logistics to conduct the research. I am very much grateful to the staff and labour of Horticulture Research Unit of RARS, Lumle for their kind cooperation to conduct this research. NPRP, Khumaltar was highly acknowledged for providing the potato seed.

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