Population Density of Rice Root Nematode, *Hirschmanniella oryzae* (Luc and Goodey, 1964) in Nay Pyi Taw Union Territory

Ei Ei Mon[1], Myat Lin [2*], Yu Yu Min[3], Phyu Thaw Tun[4], Tin Aye Aye Naing[5]

Abstract

Soil and root samples from 44 rice fields were collected on 5 summer rice varieties (Manawthukha, Sinthukha, Shwethweyin, Palethwe and Yet-90) in 5 townships (Lewe, Tatkon, Pyinmana, Zabuthiri and Dekkhinathiri) to determine the population density of *Hirschmanniella oryzae*. It was observed that 98.89 % out of 44 fields sampled were infested with the rice root nematode, *H. oryzae*. Based on the prominence value (a combination of the frequency of occurrence and abundance) of *H. oryzae*, Tatkon Township was the most infested region and the lowest population was found in Lewe Township. The highest population of *H. oryzae* from soil and root was observed in Sinthukha and the lowest population was found in Shwethweyin. All summer rice varieties surveyed were observed to be either susceptible or highly susceptible to *H. oryzae*. In two different cropping sequences, rice-blackgram-rice cropping sequence had the lower nematode population than that of rice-rice cropping one. Moreover, the lower nematode population was also found in direct seeding than in transplanting method.

Key words: *H. oryzae*, prominence value, rice varieties, susceptible

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[1]Master student, Department of Plant Pathology, Yezin Agricultural University
[2]Division of Post-Harvest Technology, Advanced Centre for Agricultural Research and Education
[3]Department of Agricultural Microbiology, Yezin Agricultural University
[4]Department of Agronomy, Yezin Agricultural University
[5]Department of Plant Pathology, Yezin Agricultural University
*Corresponding author: myatlin73@gmail.com

Introduction

Rice (*Oryza sativa* L.) is the staple food crop for a large part of the world's human population (Sharif 2014). It is important for the food security of the majority of the population as well as for a source of cash income for smallholders who sell their harvest on the local markets and in the urban areas (Maung 2011). Diseases are considered as the major constraints in rice production and responsible for losses in quantity and quality of harvested produce (Wasihun and Flagote 2016). Of these, plant-parasitic nematodes are major biotic constraints to higher productivity (Bridge *et al*. 2005). Root nematodes belonging to the genus *Hirschmanniella* infest 58% of the world's rice fields and cause 25% yield reduction. *H. oryzae* is considered as the most important rice root nematode species in most of the rice growing areas in Asia such as India, Pakistan, Bangladesh, Sri Lanka, Nepal, Thailand, Vietnam, Indonesia, Philippines, China, Korea and Japan (Bridge *et al*. 2005). It is completely adapted for irrigated lowland rice in which the plants are continuously flooded (Fortuner and Merny 1979).

In Myanmar, ufra, root rot, root knot, and white tip are the most destructive nematode diseases in rice production (Mya Mya *et al*. 1983; Aung *et al.* 1993). Presently root rot caused by *H. oryzae* is the second most important disease among rice nematode diseases in Myanmar. It had been reported that this disease became widely distributed in Western Bago Region including, Pyi, Paukhaung, Thegone, Natalin, Zigone and Paungte Townships. It was also observed that the disease was most commonly found in Kyaukse, Pyinmana and Patheingyi Townships (Myint *et al*. 2004). All 12 regions surveyed and 90% of the rice fields were infested by *H. oryzae* in the major rice production regions (Bago, Ayeyarwaddy, Yangon and Mandalay Division) (Maung 2011). At present, detailed information on the occurrence and distribution along with the damage and yield loss caused by *H. oryzae* is not available. Therefore, this study was conducted to determine the population density of *H. oryzae* in Nay Pyi Taw Union Territory.

Materials and Methods

Survey site and samples selection

The survey was carried out during 2017 summer rice growing season (March-June) in five townships (Lewe, Tatkon, Pyinmana, Zabuthiri and Dekkhinathiri) of Nay Pyi Taw Union Territory. A total of 44 rice fields were visited, and soil and root samples of 5 summer rice varieties (Manawthukha, Sinthukha, Shwethweyin, Palethwe and Yet-90) were collected from the fields in different townships. All the sampling was done at the maximum tillering stage of the rice plants.

Sampling procedure

In each rice field, a survey area of 20 × 20 m was marked off with a measuring tape in the middle of the field and then soil and root samples were collected from each rice hill at nine sampling points roughly in equal distance from one another on the two cross diagonal lines. The selected plant was uprooted and the soil from rhizosphere (about 100 g soil from each sampling point) was collected up to a depth of 15 cm. The composite soil and root samples from each rice field were placed in different plastic bags, labelled and kept at room temperature for one night before extraction for determination of nematode population density.

Determination of nematode population density

In the laboratory of Plant Pathology Department, Yezin Agricultural University, the soil samples from each rice field were pooled and the nematodes were extracted from a 150 g sub-sample using Whitehead’s tray method (Whitehead and Hemming 1965). The root samples were washed again with tap water, pooled, chopped into approximately 1 cm pieces and thoroughly mixed. A 50 g sub-sample of chopped root pieces was taken from each pooled sample and the nematodes were extracted by using Whitehead’s tray method. After 24 hours, the nematodes which had moved through the sieve into the water were collected in a beaker. And then the suspension was allowed to settle for 1 hour and concentrated into a

200 ml suspension. 1 ml nematode suspension was taken by 5 ml syringe and one syringe was used for one sample. The juvenile and adult *H. oryzae* were counted under the compound microscope (OPTIMA, Model: G-206) with 5 ml counting dish for 10 times and calculated the average value for each rice variety and for each field.

Data recording

Agricultural practices and field record were collected from the farmers. Nematode population density of soil and root samples, frequency of occurrence, prominence value of *H. oryzae*, cropping sequences and sowing methods were recorded.

Frequency of occurrence and prominence value for each township and variety were calculated according to the formula as follows (Orisajo 2013).

$$\text{Frequency of occurrence} = \frac{\text{Number of samples containing a species}}{\text{Number of samples collected}} \times 100$$

$$\text{Prominence value (PV)} = \text{Nematode population density} \times \sqrt{\text{frequency of occurrence}/10}$$

Disease reactions of the summer rice varieties to *H. oryzae* were categorized according to the disease rating scale by de Man (1880) [Nematode population per gram root at maximum tillering stage is 0 = Immune (I), 1-10 = Highly resistant (HR), 11-50 = Moderately resistant (MR), 51-100 = Susceptible (S), >100 = Highly susceptible (HS)].

Statistical analysis

Survey data were analyzed by using Microsoft Excel. Descriptive statistics was employed for the analysis of frequency of occurrence, prominence value and population of *H. oryzae* related to different rice varieties among five townships.

Results and Discussion

It was found that 98.89 % out of 44 fields sampled were infested with the rice root nematode, *H. oryzae*. The highest frequency of occurrence (100%) was observed in Tatkon and Pyinmana Townships although the lowest frequency of occurrence (88.89%) occurred in Lewe Township. The number of *H. oryzae* found in the soil averaged 115 per 150 g soil. The lowest nematode soil population density (40 per 150 g soil) was found in Kyarpin Village, Dekkhinathiri Township and Yonepin Village, Lewe Township and the highest (273 per 150 g soil) in Khayansatkone Village, Tatkon Township. The number of *H. oryzae* found in the roots was 7128 per 50 g roots in average. The lowest average root nematode population density (3687 per 50 g roots) occurred in Kyarpin Village, Dekkhinathiri Township and the highest (12,913 per 50 g roots) in Nyaungdoneai Village, Tatkon Township. Maung *et al.*. 2010 also found that 98.2% of field sampled in Pyinmana region were infested by *H. oryzae*. The highest prominence value (863) of soil was found in Khayansatkone Village, Tatkon Township and the lowest (103) in Yonepin Village, Lewe Township. The highest prominence value (40,834) of root was found in Nyaungdoneai Village, Tatkon Township and the lowest (11,659) in Kyarpin Village, Dekkhinathiri Township (Table 1). Based on the prominence value of *H. oryzae*, Tatkon Township was the most infested region and the lowest nematode population was found in Lewe Township (Figure 1). In Tatkon Township, the rice-rice cropping sequence was the most common one and the farmers used the same rice variety for the monsoon and summer rice growing seasons. These factors as well as other condition such as a long history of rice cultivation might have contributed to the high prominence value. Bridge (1996) mentioned that the continuous growing of a highly susceptible host as a monocrop will drastically increase the population density of nematode. Where there is a long history of rice cultivation, *H. oryzae* is likely to be prevalent and abundant (Bridge *et al*. 2005). The fields sampled in Tatkon Township were mostly established with transplanted rice plants. Sato *et al*. (1970) mentioned that there was more adult and juvenile population of *H. oryzae* in the roots of transplanted rice. In the present study, rice-blackgram-rice cropping sequence was practiced in all rice fields surveyed in Lewe Township. Bridge *et al*. (2005) stated that the population density of *H. oryzae* is always low as a result of the combination of dry soil and non-host dry season crops. Rotation with non-host crops can decrease the population density of *H. oryzae* and improve rice plant growth and yield (Maung 2011). Among 5 summer rice varieties surveyed, the lowest soil population was observed in Yet-90 and the lowest root population in Shwethweyin. The rice varieties sampled in Lewe Township were Shwethweyin and Yet-90. Therefore, the rice variety might be one of the factors contributing to the lowest population occurred in this township. All rice fields sampled in Lewe Township were established with direct seeding method. Direct seeding reduces initial infection of *Hirschmanniella* spp. (Sato *et al*. 1970).

It was observed that 96.58% out of five summer rice varieties surveyed were infested with the rice root nematode, *H. oryzae*. The frequency of occurrence of *H. oryzae* in different summer rice varieties ranged from 88.46% (Yet-90) to 100% (Sinthukha, Shwethweyin and Palethwe). The average number of *H. oryzae* in soil was 127 per 150 g soil. The highest average nematode soil population density (240 per 150 g soil) was observed in Sinthukha and the lowest (72 per 150 g soil) in Yet-90. The average number of *H. oryzae* in roots was 7240 per 50 g roots. The highest average nematode root population density (10,070 per 50 g roots) was observed in Sinthukha and the lowest (4260 per 50 g roots) in Shwethweyin. Among the different summer rice varieties, the highest prominence value (759) of *H. oryzae* in the rhizosphere soil was found in Sinthukha and the lowest value (200) in Yet-90. In the roots, the highest prominence value (31,844) of *H. oryzae* was found in Sinthukha and the lowest value (13,471) in Shwethweyin (Table 2). Among five rice varieties, the highest nematode population was found in Sinthukha and the lowest population in Shwethweyin based on average prominence value in both soil and roots population (Figure 2). Nant (2016) found that Shwewarsan and Sinthukha had the highest *H. oryzae* population in roots and the lowest in Manawbaykyar. The present study agreed with the findings of Myat *et al*. (2004) and Hlaing *et al*. (2005) who observed that Shwethweyin had the lowest number of *H. oryzae* in the roots.

Host reaction of different summer rice varieties was evaluated at maximum tillering stage against the infection of the rice root nematode, *H. oryzae*. According to de Man (1880) rating scale, four summer rice varieties - Manawthukha, Sinthukha, Palethwe and Yet-90 were highly susceptible and Shwethweyin was susceptible to *H. oryzae*. Of these varieties, the highest nematode population (201 *H. oryzae* per g root) was observed in Sinthukha and the lowest population (85 *H. oryzae* per g root) in Shwethweyin. In this study, the average root population density of *H. oryzae* was over 100 *H. oryzae* per g root in four rice varieties except Shwethweyin. Park *et al.* (1970) rated the varieties, which had more than 100 nematodes per g root as susceptible to *H. oryzae.* In all varieties surveyed, the average root population density of *H. oryzae* exceeded 50 *H. oryzae* per g root (Table 3). In China, 15 *H. oryzae* per g root at the end of the maximum tillering stage was considered as an acceptable economic threshold level to control this nematode (Ying *et al*. 1996).

In two different cropping sequences, the higher frequency of occurrence of *H. oryzae* was observed in rice-rice cropping sequence (96.88%) than in rice-blackgram-rice cropping one (91.67%). The average nematode population density in both soil and roots was higher in rice-rice cropping sequence than in rice-blackgram-rice cropping one. Moreover, the higher prominence value in both soil and roots was also found in rice-rice cropping sequence than in rice-blackgram-rice cropping one (Table 4). Rice-blackgram-rice cropping sequence was practiced only in Lewe Township. The higher nematode population was observed in rice-rice cropping sequence than in rice-blackgram-rice cropping one. Maung (2011) revealed that *H. oryzae* cannot reproduce on the most common varieties of sesame, mungbean and blackgram cultivated in Myanmar. It is well recognized that the population of plant-parasitic nematodes in a field can drastically increase when the same host plant is grown in the same field year after year. The build-up of this population can be prevented or restricted by crop rotation with non-host plants, less susceptible or resistant varieties of the same crop or a completely different crop (Bridge 1996; Maung 2011).

The higher frequency of occurrence of *H. oryzae* was found in transplanting method (100%) than in direct seeding (92.86%). On average, *H. oryzae* population density in both soil and roots was higher in transplanting method than in direct seeding. The prominence value in both soil and roots was also higher in transplanting method than in direct seeding (Table 5). Nakazato *et al*. (1964) stated that the nematode population was higher in transplanted rice roots than in directly sown ones. It could be suggested that the transplanted rice roots suffered damage when they were uprooted and they need more time to recover from transplanting shock. This condition can increase the probability of soilborne pathogen, *H. oryzae* invasion and also favours substantial damage from *H. oryzae*.

Conclusion

Based on the prominence value of *H. oryzae*, the most infested region in Nay Pyi Taw Union Territory was Tatkon Township and rice production in this township may be the most at risk to undergo important yield losses due to *H. oryzae*. Therefore, it is necessary to firstly investigate yield losses of rice due to *H. oryzae* in Tatkon Township. The highest population of *H. oryzae* from soil and root was observed in Sinthukha and the lowest in Shwethweyin. For that reason, popular variety, Sinthukha, probably should not be grown where there is a potential for natural infection of rice root rot disease. In rice-based cropping sequences, the use of a resistant rice variety or dry season crops can reduce the soil population density of *H. oryzae* compared with continuous rice cropping sequences with susceptible varieties. The only economical way to control rice root nematode is the use of resistant rice varieties and avoidance of monocropping and transplanting practices.

References

Aung, T., H. Yi and M.M. Khin. 1993. Incidence of white tip nematode, *Aphelenchoides besseyi* Chrislie., 1942, in Myanmar. Identification, culture and pathogenicity tests. *Myanmar Journal of Agriculture* 2 (5): 77-81.

Bridge, J. 1996. Nematode management in sustainable and subsistence agriculture. *Annual Review of Phytopathology* 34: 201-225.

Bridge, J., R.A. Plowright and D. Peng. 2005. Nematode Parasites of Rice. In: Luc, M., R.A. Sikora and J. Bridge (Eds*). Plant parasitic nematodes in subtropical and tropical agriculture*, 2nd edition. Wallingford, UK, Commonwealth Agricultural Bureau International (CABI) Publishing. pp: 87-130.

de Man, J.G. 1880. The natives live freely in the pure earth and in the fresh water of living nematodes. Tijdschr. Ned. Dierk. Vercen., 5: 1-104.

Fortuner, R. and G. Merny. 1979. Root-parasitic nematodes of rice. *Review of Nematology* 2 (1): 79-102.

Hlaing, N.K., M. Win, K.M. Hein, M.M. Zin, K.S. Lin, A.Z. Latt and A.K. Soe. 2005. Effect of *Hirschmanniella oryzae* on the growth of four rice varieties. *A report submitted in partial fulfillment of the requirements for the B.Agr.Sc. Degree*, Yezin Agricultural University. 13 p.

Maung, Z.T.Z. 2011. Occurrence, Damage Potential and Sustainable Management of the Rice Root Nematode *Hirschmanniella oryzae* on Monsoon Rice in Myanmar. Ph.D (Thesis). Catholic University of Leuven, Belgium. pp: xii-19; 64-132.

Maung, Z.T.Z., P.P. Kyi, Y.Y. Myint, T. Lwin and D. De Waele. 2010. Occurrence of the rice root nematode *Hirschmanniella oryzae* on monsoon rice in Myanmar. *Tropical Plant Pathology* 35: 3-10.

Mya, M., Y.Y. Myint and T. Hlaing. 1983. Initial survey and identification of soil and plant-parasitic nematodes in Burma (1). Research Policy Direction Board. Agricultural Science Research Division, Burma Research Congress. pp: 1-3.

Myat, A.M., T.M. Win, A.M. Aung, M.M. Latt, N.N. Sein, T. Naing, H.A. Kyaw and Z.L. Oo. 2004. Reaction of twenty rice varieties to root-rot disease caused by *Hirschmanniella oryzae*. *A report submitted in partial fulfillment of the requirements for the B.Agr.Sc. Degree,* Yezin Agricultural University. 14 p.

Myint, Y.Y., T. Lwin and K.H. Thwe. 2004. Report on the occurrence of serious nematode diseases of rice, sesame and orange in some areas of Myanmar during 2003. Yezin Agricultural University, Yezin, Myanmar.

Nakazato, H., K. Kawashima and T. Kurosawa. 1964. Seasonal occurrence of the rice root nematode. *Proceedings Kanto-Tosan Plant Protection Society* 11: 106.

Nant, S.Z.O. and H.H. Maw. 2016. Investigation of rice root nematode *Hirschmanniella oryzae* (Luc and Goodey, 1964) in Pyarkatat cultivated rice fields at Hinthada Township, Hinthada University Research Journal 7: 1.

Orisajo, S.B. 2013. Effect of plant-parasitic nematodes associated with Tea in Nigeria. African Journal of Basic and Applied Science 5 (4): 184-187.

Park, J.S., S.C. Han and Y.B. Lee. 1970. Studies on the ecology and feeding preference of *Hirchmanniella oryzae*. *Research reports of the office of rural development* (*Plant and Environment*)*, Korea* 13: 93-98.

Sato, T., T. Koyoma and T. Koshihara. 1970. Relation between the occurrence of rice root nematodes *(Hirschmanniella oryzae* Luc and Goodey and *Hirschmanniella imamuri* Sher) and the cultivating practices of paddy rice plant. *Bulletin of the Tohoku National Agricultural Experiment Station* 39: 207-219.

Sharif, M.K., M.S. Butt, F.M. Anjum and S.H. Khan. 2014. Rice bran: a novel functional ingredient. US National Library of Medicine, National Institutes of Health, Critical Reviews in Food Science and Nutrition 54 (6): 807-16.

Wasihun, Y.W. and A.B. Flagote. 2016. Assessment of diseases on rice (*Oryza sativa* L.) in major growing fields of Pawe district, Northwestern Ethiopia. Ethiopian Institute of Agricultural Research (EIAR), Pawe Research Centre, Ethiopia, World Scientific News 42: 13-23.

Whitehead, A.G. and J.R. Hemming. 1965. A comparison of some quantitative methods of extracting small vermiform nematodes from soil. *Annals of Applied Biology* 55: 25-38.

Ying, Y., Z. Huijuan, X. Gao and F. Zhixin. 1996. The relationships between the infection of *Hirschmanniella oryzae,* rice growth and yield loss. *Journal of South China Agricultural University* 17: 14-17.

Table 1. Population density of *Hirschmanniella oryzae* in different townships of Nay Pyi Taw Union Territory

Township	Village	No. of fields (n)	Frequency of occurrence (%)		Population density				Prominence value (PV)	
			Soil	Root	No. of *H. oryzae* per 150 g soil		No. of *H. oryzae* per 50 g roots		Soil	Roots
					Min-max	Mean±SE	Min-max	Mean±SE		
Zabuthiri	Aungzabu	3	100	100	60-160	107±29	2560-8740	5873±1798	338	18572
	Taegyikone	3	100	100	20-180	80±50	3800-10420	6733±1948	253	21292
	Ahlyinlo	3	66.67	100	0-200	120±61	4600-9560	6707±1480	310	21209
Dekkhinathiri	Kyarpin	3	100	100	20-60	40±12	3380-4020	3687±185	126	11659
	Ywarma	3	66.67	100	0-260	120±76	4160-16320	8947±3741	310	28293
	Kyuntatpae	3	100	100	40-200	100±50	5120-6860	5900±510	316	18657
Pyinmana	Zephyupin	3	100	100	40-140	87±29	4620-6140	5493±453	275	17370
	Maezalikone	2	100	100	60-280	170±110	9060-10800	9930±870	538	31401
	Kan Oo	3	100	100	80-280	160±61	8500-12840	10687±1253	506	33795
Tatkon	Khayansatkone	3	100	100	40-600	273±168	2620-6000	4680±1043	863	14799
	Nyaungdoneai	3	100	100	20-220	100±61	10400-15120	12913±1371	316	40834
	Yaeaye	3	100	100	40-160	107±35	4580-13360	9093±2537	338	28755
Lewe	Padaukchaung	3	100	100	80-240	180±50	3700-8840	5673±1599	569	17940
	Yaekar	3	66.67	100	0-100	47±29	1940-11660	5733±3002	121	18129
	Yonepin	3	66.67	100	0-60	40±20	4120-5720	4867±465	103	15391
Total (range)	**15**	**44**			**0-600**		**1940-16320**			
Mean			**97.78**	**100**		**115 ± 16**		**7128±670**	**352**	**22540**

Frequency of occurrence: (Number of samples containing a species / Number of samples collected) ×100

PV: nematode population density × $\sqrt{\text{frequency of occurrence}/10}$

Table 2. Population density of *Hirschmanniella oryzae* in different summer rice varieties in Nay Pyi Taw Union Territory

Variety	No. of fields (n)	Frequency of occurrence (%)		Population density				Prominence value (PV)	
		Soil	Root	No. of *H. oryzae* per 150 g soil		No. of *H. oryzae* per 50 g roots		Soil	Roots
				Min-max	Mean±SE	Min-max	Mean±SE		
Manawthukha	9	88.89	100	0-200	84±21	4160-10420	6678±732	250	21118
Sinthukha	6	100	100	20-600	240±79	2620-16320	10070±2379	759	31844
Shwethweyin	7	100	100	40-240	126±32	2560-6140	4260±425	398	13471
Palethwe	9	100	100	20-280	111±33	4620-13360	9247±1047	351	29242
Yet-90	13	76.92	100	0-200	72±19	1940-11660	5943±761	200	18793
Total (range)	**44**			**0-600**		**1940-16320**			
Mean		**93.16**	**100**		**127±30**		**7240±1071**	**392**	**22894**

Table 3. Reaction of rice varieties to *Hirschmanniella oryzae*

No.	Rice varieties	Nematode population per g root	Reaction [x]
1.	Manawthukha	134	Highly susceptible (HS)
2.	Sinthukha	201	Highly susceptible (HS)
3.	Shwethweyin	85	Susceptible (S)
4.	Palethwe	185	Highly susceptible (HS)
5.	Yet-90	119	Highly susceptible (HS)

[x] Based on nematode population per gram root at maximum tillering stage is 0 = Immune (I), 1-10 = Highly resistant (HR), 11-50 = Moderately resistant (MR), 51-100 = Susceptible (S), > 100 = Highly susceptible (HS), (de Man 1880)

Table 4. Population density of *Hirschmanniella oryzae* in different cropping sequences

Cropping Sequence	No. of fields (n)	Frequency of occurrence (%)		Population density				Prominence value (PV)	
				No. of *H. oryzae* per 150 g soil		No. of *H. oryzae* per 50 g roots			
		Soil	Root	Min-max	Mean±SE	Min-max	Mean±SE	Soil	Roots
Rice-Rice	32	93.75	100	0-600	124±21	2560-16320	7673±665	380	24264
Rice-Blackgram-Rice	12	83.33	100	0-240	88±22	1940-11660	5442±745	254	17209

Table 5. Population density of *Hirschmanniella oryzae* in different sowing methods

Sowing method	No. of fields (n)	Frequency of occurrence (%)		Population density				Prominence value (PV)	
				No. of *H. oryzae* per 150 g soil		No. of *H. oryzae* per 50 g roots			
		Soil	Root	Min-max	Mean±SE	Min-max	Mean±SE	Soil	Roots
Direct Seeding	28	85.71	100	0-280	104±15	1940-12840	6038±540	304	19094
Transplanting	16	100	100	20-600	131±38	2620-16320	8860±1028	414	28018

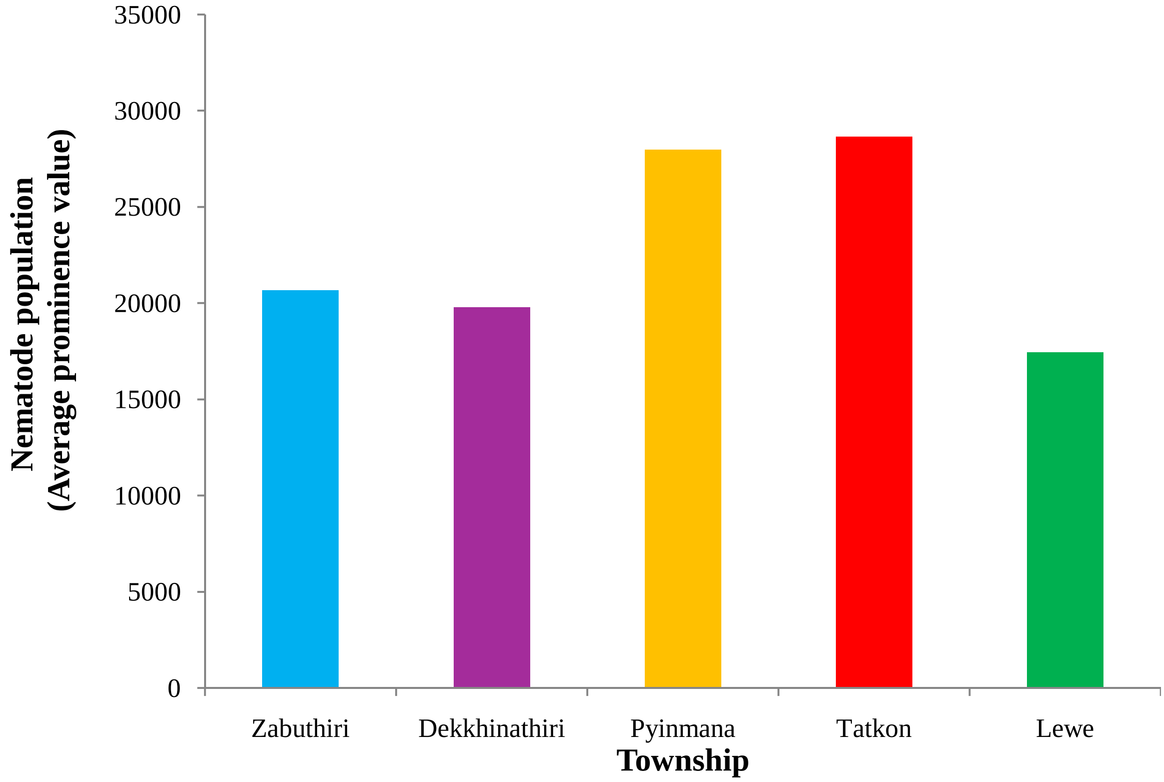

Figure 1. Nematode population in different townships of Nay Pyi Taw Union Territory

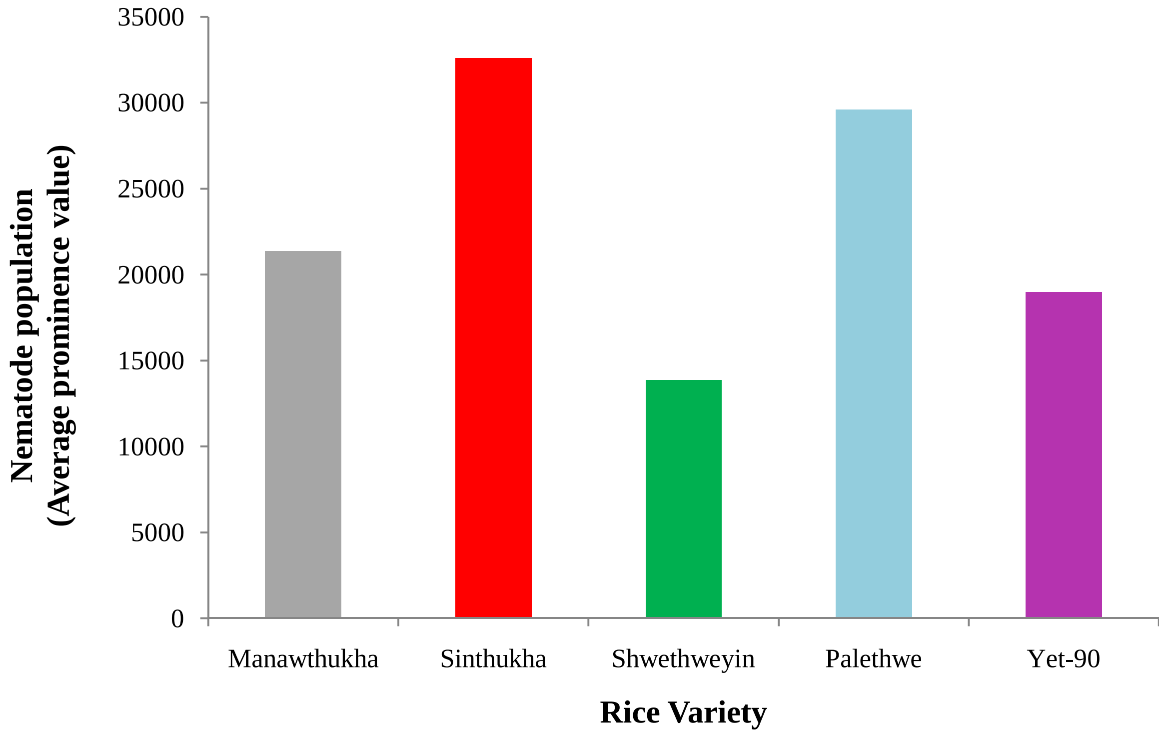

Figure 2. Nematode population in different summer rice varieties in Nay Pyi Taw Union Territory