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EFFECT OF INTERCROPPING OF GINGER WITH INDIGENOUS PLANTS AND SEED TREATMENT WITH FUNGICIDES TO CONTROL RHIZOME ROT OF GINGER

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ABSTRACT

Hossain SMM, Hassan SME, Islam ATMS (2015) Effect of intercropping of ginger with indigenous plants and seed treatment with fungicides to control rhizome rot of ginger. *Int. J. Sustain. Crop Prod.* 10(1), 40-46.

Two experiments were conducted in the research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur during 2013 to control rhizome rot of ginger. In the first experiment, ginger (*Zingiber officinale*) was intercropped with turmeric (*Curcuma longa*) and okra (*Abelmoschus esculentus*) as alternate row or alternate seed within the row. In the, second experiment, seed rhizome was treated with fungicides namely, Melody Duo, Dithane M-45, Folicur EW 250, Antracol 70 WP and Secure 600 DG before sowing of rhizome. Intercropping of ginger with okra and turmeric enhanced plant growth and healthy plants. The treatment where ginger was intercropped with okra as alternate row showed the best results by reducing the disease severity of ginger and improving the plant growth. Better yield of ginger was also obtained where ginger was intercropped with okra as alternate seed, which showed a total rhizome yield of about 1.69% more than the control plot. Fungicide Antracol, Folicur and Secure were effective in reducing the incidence and severity of rhizome rot and improved plant growth. Consequently, rhizome yield was much higher in Antracol and Folicur treated plants.

Key words: *rhizome rot, ginger, fungicides, intercropping*

INTRODUCTION

Ginger (*Zingiber officinale* Rosc., Zingiberaceae) is an important spices crop which is commercially grown in many tropical and subtropical countries including Bangladesh. It is widely cultivated in Rangpur, Panchagar, Nilphamari, Tangail, Khulna, Pabna, Jessore, Rangamati, Bandharban, Khagrachori, Chittagong and Chittagong hill tracts. Farmers in these districts cultivate this crop commercially as cash crop. The production of ginger was 74,841 metric tons from 22,403 hectare of land during the 2009-2010 cropping seasons (Anon. 2010). It has medicinal value, particularly in traditional medicines of India (Lawrence 1984; Selvan *et al*. 2002). It is also used as condiment, flavoring agent and used in the preparation of non-alcoholic beverages. Ginger is extensively used in Bangladesh as spices and is cultivated more or less all over the country.

The yield per unit area of ginger is not enough to fulfill the annual requirement/demand of the country. So, every year a large amount of ginger is imported by exchange of foreign currency. In our country, diseases are the major limiting factor for ginger cultivation. Ginger is attacked by various diseases, such as rhizome rot, bacterial wilt, leaf spot, anthracnose leaf spot, leaf blight, leaf blotch etc. Among them, rhizome rot is the most damaging one (Chattopadhaya 1997). Rhizome rot is a highly destructive disease of ginger causing the loss in some parts of the world to destroy 80 to 90% of the annual crop (Lawrence 1984; Dake 1995). The causal agent *Pythium* spp. thrives in soil for long period. Sometimes total production falls if infection initiates at early stage of plant growth. The situation drastically aggravates if water logging condition prevails. The disease symptom is characterized by producing slight fading of green color of leaves on above ground parts of the plant. The tip of the leaves turns yellow and the chlorosis proceeds from tip to the base of the plants ultimately resulting in withering and death of the leaf. The infection then becomes manifested on the shoot. The foot of the plant and the rhizomes turn pale. The portion just above the ground level becomes water soaked and soft. The rhizomes gradually decompose turning into a decaying mass of tissues enclosed by the comparatively tough rind. The disease is very important because it causes economic losses to growers resulting in increased price of products to consumers. Sometimes the infected rhizome become rotten and is completely destroyed (Baruah *et al*. 1980). There is no effective method available in the country to control rhizome rot disease of ginger. Very few research work has been done to control this disease. Available literatures indicate that the incidence of rhizome rot in the field can be minimized in different ways. Control measures such as seed treatment, soil treatment, soil amendment, sanitation, drainage etc have some effect in controlling the disease individually (Rahman 2001). But such information of control strategies is very much limited in Bangladesh. So, the present research work was taken to find out the effect of intercropping for reducing the severity of rhizome rot of ginger and to find out the effect of seed treatment with fungicides to control the disease.

MATERIALS AND METHODS

Experiment 1. Intercropping of ginger with indigenous plants to manage rhizome rot of ginger

The experiment was conducted in the research field, Department of Plant Pathology, Hajee Mohammad Danesh Science and Technology University, Dinajpur during 2013. The experimental field was thoroughly prepared by several hand spading and cross spading to obtain a good tilth. Recommended dose of fertilizer and manure suggested by Spices Research Center, BARI, Gazipur were applied in the experimental plot. Cowdung was applied in the soil at the rate of 15 t/ha during land opening. Urea, TSP and MP at the rate of 150, 350 and 300 kg/ha, respectively was applied. Full dose of TSP and MP were applied during final land preparation. Half of

urea was used as top dressing 50 days after sowing of rhizome. Rest half of Urea was applied in two installments at 80 days and 110 days after sowing as top dressing. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

The unit plot size was 2.75 x 2.50 m, block to block and plot to plot distance was maintained 1.0 and 0.5 m, respectively. Spacing of row to row (within plot) and seed to seed (within row) was 0.75 m and 0.25 m, respectively. Treatments used in the experiment were as T_1= Control (Only ginger), T_2= Intercropping of ginger with turmeric (alternate row), T_3= Intercropping of ginger with turmeric (alternate seed), T_4= Intercropping of ginger with okra (alternate row), T_5= Intercropping of ginger with okra (alternate seed). Apparently healthy approximately 40-50 g weight bearing 1-3 bud rhizome was sown in control plot (T_1) as well as intercropped with turmeric and okra. In case of treatment T_2, turmeric seed was sown in first row and ginger was sown in second row. Again, the third row was used for turmeric and the fourth was used for ginger seed. In such a way, turmeric and ginger were used as alternate row sowing. In case of treatment T_3, ginger and turmeric was sown as alternate seed in each row. Such as ginger then turmeric again ginger then turmeric seed was sown in first row. In the similar way, the entire each row contained 5 seeds of ginger and 5 seeds of turmeric. Considering the intercropping of ginger with okra in T_4 which was used as alternate row sowing following same as T_2, whereas T_5 was as same as T_3. Pieces of seed rhizome were sown in small furrow of about 4-5 cm depth which was done with the help of a stick. The seeds were placed individually in the furrows. Soil was then put to cover the furrow and then it was leveled. The plots were earthen up 20 cm high from the level of drain. Mulching was done at the time of planting with rice straw @10 t/ha to check weed emergence and conserves moisture during the latter part of the cropping season. Data were collected four times at an interval of one month starting from the seed germination to harvesting of the crop. Data recorded on plant height, number of tillers/plant, number of rhizome rot infected plant/plot, percent disease severity of plants and percent disease severity of rhizome and yield t/ha. The disease severity of rhizome was recorded after harvesting by using the 0-9 scale (Johnston 2000). Where 0 = No infection or discoloration on the rhizome, 1 = Rot in 10% area of the rhizome, 3 = Rot in 11-30% area of the rhizome, 5 = Rot in 31-50% area of the rhizome, 7 = Rot in 51-75% area of the rhizome, 9 = Rot in more than 75% area of the rhizome. Collected data were analyzed statistically using the MSTAT-C computer package program. Mean was compared by Duncan's Multiple Range Test (DMRT).

Experiment 2. Seed treatment with fungicides to control rhizome rot of ginger

The experiment was conducted to find out the effect of fungicides to manage rhizome rot of ginger. The treatments used in the experiment were T_1 = Control, where plain water was used, T_2 = Seed treatment with Melody Duo (2 g/L), T_3 = Seed treatment with Dithane M-45(4 g/L), T_4 = Seed treatment with Folicur (1 ml/L), T_5 = Seed treatment with Antracol (4 g/L), T_6 = Seed treatment with Secure (2 g/L). The required amount of the fungicides was mixed with water to prepare the treating solution. The seeds (rhizome of ginger) of ginger were dipped in fungicidal solution contained in a plastic tray for half an hour. Then the solution was drained out from the tray. The treated seeds were dried on blotting paper for two hours before planting of seed in the soil. Land preparation, application of fertilizer and manures, design of experiment, data collection and analysis was the same as in experiment1 except plant height and number of tillers/plant.

RESULTS

Experiment 1. Intercropping of ginger with indigenous plants to manage rhizome rot of ginger

Plant height

Height of the ginger plant was not influenced by the treatments at 90, 120 and 150 DAS. But it was significantly influenced at 180 DAS (Table 1). At 90 DAS, height of plants ranged from 51.16-64.72 cm, where the highest was found in T_5. where ginger was planted with okra as alternate seed and the lowest was in T_1 (control) treatments. Plant height ranged from 53.66-69.66 cm and 52.00-72.41 cm at 120 and 150 DAS, respectively where the highest was in T_2 and the lowest was in control T_1. The height of the plant was maximum 73.57 cm at 180 DAS in T_2, where ginger was planted with turmeric as alternate row, significantly differ from other treatments. The lowest plant height was observed in T_3, where ginger was planted with turmeric as alternate seed. In that treatment, ginger height may be suppressed due to vigorous growth of turmeric (Table 1).

Table 1. Plant height at different dates of sowing as influenced by intercropping with turmeric and okra

Treatments	Plant height (cm)				
	90 DAS	120 DAS	150 DAS	180 DAS	Average
T_1:Control	51.16 ns	53.66 ns	52.00 ns	48.33 ab	51.29 ns
T_2:Ginger+Turmeric(alternate row)	53.05	69.66	72.41	73.57 a	67.17
T_3:Ginger+Turmeric(alternate seed)	54.05	54.72	55.24	45.33 b	51.09
T_4:Ginger+Okra (alternate row)	60.66	59.05	52.07	47.72 ab	54.88
T_5:Ginger+Okra (alternate seed)	64.72	66.22	61.60	50.17 ab	60.68

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Number of tillers

The results indicate that the number of tillers/plant was statistically similar to all the treatments, when data were recorded at 90, 120, 150 and 180 DAS (Table 2). At 90 DAS and 120 DAS the number of tillers/plant was recorded from 4.00 to 7.00 and 6.04 to 9.30, respectively. The maximum (7.00 and 9.30) number of tiller was found in T_1, control and minimum (4.00, 6.04) was in T_3, where ginger was planted with turmeric as alternate seed. When number of tillers/plant was recorded at 150 DAS, it was found that maximum (9.33) tiller was in T_4, where ginger was planted with okra as alternate row and minimum (6.0) in T_3, where ginger was planted with turmeric as alternate seed. Tiller number was comparatively reduced in all the treatments at 180 DAS due to severe infection of plant with the disease. In that stage of plant growth, maximum (7.66) number of tiller was recorded in T_4, where ginger was planted with okra as alternate row and minimum (5.30) number was in T_3, where ginger was planted with turmeric as alternate seed. When all the data recorded as average, the maximum (7.92) number of tillers/plant was found in T_4 and minimum (5.51) was in T_3.

Table 2. Number of tillers/plants at different dates of sowing as influenced by intercropping with turmeric and okra

Treatments	Tillers/plant				
	90 DAS	120 DAS	150 DAS	180 DAS	Average
T_1:Control	7.000ns	9.300ns	7.667ns	6.667ns	7.660ns
T_2:Ginger+Turmeric(alternate row)	6.833	7.887	7.333	5.833	6.973
T_3:Ginger+Turmeric(alternate seed)	4.700	6.043	6.000	5.300	5.513
T_4:Ginger+Okra(alternate row)	6.433	8.273	9.333	7.667	7.927
T_5:Ginger+Okra(alternate seed)	5.200	7.097	8.667	6.833	6.950

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Plants infected (%)

The highest 23.76% infected plant was recorded in control at 90 DAS, which was followed by T_3 and T_4 having 23.23% and 21.57% infected plant but the lowest infected plant was recorded 6.66% in T_4. At 120 DAS, infected plant was recorded the highest in T_3 (30.00%) which was followed by T_1 and T_2 having 25.01% and 24.16% infected plants, respectively and the lowest was in T_4 (10.14%). At 150 DAS, maximum 45.00% infected plant was obtained in T_3 followed by T_1 and T_2 having 38.35% and 36.75% infected plants, respectively while minimum 20.02% infected plant was in T_4. The data at 180 DAS revealed that maximum 85.94% infected plants was in T_3 while minimum 65.11% infected plants was in T_5 (Table 3).

Table 3. Infected plants (%) per plot at different dates of sowing as influenced by intercropping with turmeric and okra

Treatments	Infected plants (%)			
	90 DAS	120 DAS	150 DAS	180 DAS
T_1:Control	23.76 a	25.01 b	38.35 b	69.00 c
T_2:Ginger+Turmeric(alternate row)	21.57 b	24.16 b	36.75 b	76.34 b
T_3:Ginger+Turmeric(alternate seed)	23.23 ab	30.00 a	45.00 a	85.94 a
T_4:Ginger+Okra (alternate row)	6.66 d	10.014 d	20.02 c	52.54 e
T_5:Ginger+Okra (alternate seed)	11.70 c	16.19 c	23.36 c	65.1 d

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Severity of rhizome rot

The highest percentage of disease severity at 90 DAS was found in T_3 (38.62%) followed by T_1 (31.91%). The lowest percentage of severity was found in T_4 (10.16%). Considering 120 DAS, the maximum disease severity was found in T_3 (51.59%) treated plot followed by T_1 having 41.67% and the lowest severity was in T_4 (18.75%). At 150 DAS, maximum severity indices was found in T_3 (69.20%) and minimum was in T_4 (33.33%). The data at 180 DAS revealed that the maximum 89.00% severity indices was obtained in T_3 while the minimum 67.17% infected plant was in T_4 where ginger was planted with okra as alternate row (Table 4).

Table 4. Severity of rhizome rot at different dates of sowing as influenced by intercropping with turmeric and okra

Treatments	Disease severity (%)			
	90 DAS	120 DAS	150 DAS	180 DAS
T_1:Control	31.91 b	41.67 b	59.14 b	79.67 b
T_2:Ginger+Turmeric(alternate row)	29.10 c	35.16 c	48.49 c	79.17 b
T_3:Ginger+Turmeric(alternate seed)	38.62 a	51.59 a	69.20 a	89.00 a
T_4:Ginger+Okra (alternate row)	10.16 e	18.75 e	33.33 d	67.17 d
T_5:Ginger+Okra (alternate seed)	16.25 d	28.92 d	46.84 c	72.67 c

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Severity of rhizome rot and yield of ginger

Disease severity of rhizome was measured in terms of damaged (rotten) area of the rhizome and the highest was found in T_2 (63.01) followed by control T_1 (52.51) and T_3 (51.65). The lowest disease severity of rhizome was recorded in T_4 (25.25) followed by T_5 (37.31) where ginger was planted with okra as alternate seed. The highest yield 3.44 t/ha of rhizome was obtained from T_5 followed by T_4 and T_3 having 2.76 and 2.42 t/ha of ginger, respectively. On the other hand, the lowest yield 1.50 t/ha of ginger was from T_2, where ginger was planted with turmeric as alternate row, which was similar to control treatment T_1 having 1.75 t/ha of ginger (Table 5).

Table 5. Effect of intercropping on disease severity and yield of ginger

Treatments	Disease severity of rhizome	Yield (t/ha)
T_1:Control	52.51 b	1.75 c
T_2:Ginger+Turmeric(alternate row)	63.01 a	1.50 c
T_3:Ginger+Turmeric(alternate seed)	51.65 b	2.42 b
T_4:Ginger+Okra (alternate row)	25.25d	2.76 b
T_5:Ginger+Okra (alternate seed)	37.31 c	3.44 a

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Experiment 2. Seed treatment with fungicides to control rhizome rot of ginger

Effect of fungicides on infected plants

Data revealed that all the fungicides were effective to reduce percentage of infected plant compared to control at all the dates of data collection. The highest 23.76, 25.01, 38.33, 69.00% infected plant was recorded in control treatment T_1 at 90, 120, 150 and 180 DAS, respectively. On the other hand, the lowest 3.33, 6.67, 11.64 and 28.34% infected plant was recorded in Antracol treated plot at all the dates of data collection (Table 6).

Table 6. Infected plants (%) at different dates of sowing as influenced by fungicides

Treatments	Infected plants (%)/plot			
	90 DAS	120 DAS	150 DAS	180 DAS
T_1:Control	23.76 a	25.01 a	38.33 a	69.00 a
T_2:Melody Duo	20.00 b	25.00 a	30.67 b	60.16 b
T_3:Dithane M-45	6.66 d	11.64 c	31.67 e	58.66 b
T_4:Folicur	6.67 d	9.03 d	12.33 e	38.67 c
T_5:Antracol	3.33 e	6.67 e	11.64 e	28.34 e
T_6:Secure	13.33 c	15.00 b	15.00 d	32.69 d

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Effect of fungicides on disease severity

Disease severity was found minimum in fungicide treated plants compared to control. Fungicide Antracol was found as the most effective to control of rhizome rot diseases of ginger. Fungicide Secure also showed its better effectiveness to suppress the disease compared to other tested fungicide. Melody Duo and Dithane M-45 were less effective to manage the disease (Table 7).

Table 7. Disease severity at different dates of sowing as influenced by fungicides

Treatments	Disease severity (%)			
	90 DAS	120 DAS	150 DAS	180 DAS
T_1:Control	30.97 a	41.67 a	59.17 a	79.67 a
T_2:Melody Duo	19.22 b	33.33 b	38.33 b	59.00 b
T_3:Dithane M-45	10.16 d	11.67 de	29.17 c	38.35 c
T_4:Folicur	16.26 c	18.33 c	22.33 e	25.00 e
T_5:Antracol	3.33 e	10.22 e	19.00 f	21.67 f
T_6:Secure	9.00 d	13.33 d	25.83 d	35.17 d

Means followed by the same letter(s) within a column do not differ significantly at 5% level

Effect of fungicides on disease severity and yield of ginger

The highest disease severity (79.3%) was recorded in control treatment T_1 followed by T_2 (32.10) where seeds were treated with Melody Duo. The lowest disease severity (10.07%) of rhizome was found in T_5, where seeds were treated with fungicide Antracol which was followed by T_6 and T_4 having 13.33% and 16.67% disease severity, respectively.

The highest yield of ginger was recorded in T_5 (10.08 t/ha) followed by T_4, T_6 and T_3 having 7.37, 5.88 and 5.77 t/ha, respectively. On the other hand, the lowest yield of ginger was recorded in control treatment T_1 (1.75) followed by T_2 having 3.88 t/ha of ginger (Table 8).

Table 8. Effect of fungicides on disease severity of rhizome and yield of ginger

Treatments	Disease severity of rhizome	Yield (t/ha)
T_1:Control	79.3 a	1.75 e
T_2:Melody Duo	32.10 b	3.88 d
T_3:Dithane M-45	24.00 c	5.77 c
T_4:Folicur	16.67 d	7.37 b
T_5:Antracol	10.07 f	10.08 a
T_6:Secure	13.33 e	5.88 c

Means followed by the same letter(s) within a column do not differ significantly at 5% level

DISCUSSIONS

Experiment 1. Intercropping of ginger with indigenous plants to manage rhizome rot of ginger

The result of the present study reveals that the effect of intercropping of ginger with okra and turmeric to manage the rhizome rot of ginger caused by *Pythium aphanidermatum* have immense impact on plant height, number of tillers, infected plants(%), disease severity of plants and rhizome and yield of ginger. At the initial stage of plant growth variation of plant height among the treatment was statistically similar. But in mature plant significant differences was observed in plant height. Maximum plant height was recorded when seed was sown with turmeric as alternate row. But in case of treatment T_3, where ginger was planted with turmeric as alternate seed showed the minimum plant height. Vigorous growth of turmeric and okra may suppress the growth of ginger. But in case of alternate row planting competition between the two crops were minimum. It may hamper the growth of ginger at minimum level. Similar result was also reported by Anon. (2006), where they observed that intercropping maize with ginger cultivated in every alternate intra row space of ginger produced the highest plant height. The tiller per plant was varied among the treatments. But the variation was not significant. In general, it was observed that control treatment produced maximum tiller than intercropped plot. Among the intercropped plot, minimum tiller was found in T_3 where ginger was planted with turmeric as alternate seed. In such a planting system ginger plant was grown in between the turmeric or in between okra plant. So, there was high competition for the space. This is why ginger failed to produce tiller as its potentiality. The highest infected plant was found in T_3, where ginger was planted with turmeric as alternate seed and the lowest was found in T_5, where ginger was intercropped with okra as alternate row. This gave early competition for nutrients, light and space, which hampered the early growth of ginger. Though from the findings of Ali *et al*. (2005) it was mentioned that ginger cultivated under gammar and guava resulted better plant growth, suppressed disease and increased rhizome. However, from the findings of Aclan (1973), it is found that too much shading i.e. 75% light attenuation reduces yield. Intercrop can suppress the diseases of many crops and showed lowest number of rhizome rot infected plants. Among the treatments in the experiment, T_3 where ginger was intercropped with turmeric as alternate seed perform the best results by reducing the disease severity of ginger plants and rhizome than that of control. Jaswal *et al*. (1993) reported that both ginger and turmeric performed better as intercrops than as sole crops. The findings also supports the reports of Nwaogu and Echendu (2005) and Aliyu *et al*. (2011). The highest yield and consequently the best result was obtained, where ginger was intercropped with okra as alternate seed, which showed a total rhizome yield of about 1.69% more than the control plot. Under the study, the control treatment had 1.75 t/ha rhizome yield and the treatment T_2 had the poorest yield of 1.50 ton/ha. One of the main reasons for higher yield in intercropping is that component crops are able to use growth resources differently, so that when grown together they complement each other and make better overall use of growth resources than grown separately. The findings support the reports of Willey (1979), Anon. (2006), Anon. (2009) and Hossain (2011), who reported the better yield of intercropped of ginger with different indigenous crops under shade.

Experiment 2. Seed treatment with fungicide to control rhizome rot of ginger

The present study was carried out to manage the rhizome rot of ginger by seed treatment with five fungicides. The fungicides used in the experiments were Melody Duo (0.2%), Dithane M-45 (0.2%), Folicur (0.2%), Antracol (0.2%) and Secure (0.2%). The result of the study revealed that all the fungicides have good impact on plant growth, rhizome yield and reduced the incidence and severity of rhizome rot disease. Percent infected plant was found minimum in Secure and Antracol treated plot at different dates of observations. This result indicates the use of Secure and Antracol as seed treatment which decreased the number of rhizome rot infected plants. Similar results were also observed by Ramachandran *et al*. (1989) and Rahman and Sarker (2009). They reported that five systemic fungicides namely Fosetyl aluminium, Metalaxyl, Oxadiaxyl 25 WP, Propamocarb and Ethazole gave the best control of rhizome rot of ginger. There was remarkable differences were observed among the treatment in level of disease severity of plants. Fungicide treated plots were always showed the better result by reducing the incidence, severity and the lowest number of rhizome rot infected plants. Among the fungicides used in the experiment, Folicure, Antracol and Secure perform the best result by reducing the rhizome rot severity of plants. Ichitani (1980) reported that rhizome rot incidence was reduced by seed treatment with fungicides namely Echlomezol and soil with Methyl bromide. The lowest number of infected rhizome was

recorded with Antracol treated plot. The control plot had the highest rotted rhizome. All other fungicides also reduced the severity of rhizome. Considering the yield, all the treatments significantly produced more yield than control. It was found that Antracol significantly produced the highest 10.08 t/ha rhizome of ginger. These findings support the reports of Ghorpade and Ajri (1982), Dohroo and Sharma (1983), Rathaiah (1987), Sharma and Dohroo (1991), Nath (1993), Jayasekhar *et al*. (2000) and Singh *et al*. (2004), who reported the highest seed germination, the lowest disease incidence and more yield were obtained through the application of Ridomil.

CONCLUSION

From this study, it may be concluded that ginger may be intercropped with turmeric or okra as alternate row for reducing rhizome rot of ginger. Intercrop of the crop as alternate seed was not found suitable. Before final recommendation, experiment should be taken for standardization of spacing between crops. The study also indicated that Antracol and Secure is very much effective in reducing rhizome rot of ginger.

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