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Research Article

Effect of Higher Doses of Fertilizers and Spray of Urea, Zn and Kinetin on Damage Potential of *Heterodera avenae* in Wheat

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Abstract

Background and Objective: Purpose of experiment was to manage cereal cyst nematode (*H. avenae*) in wheat by using higher doses of fertilizers and spray of zinc, urea and kinetin (a growth regulator). Experiment was conducted for two years (2015 and 2016) in the screen house of Department of Nematology, CCS HAU, Hisar. **Materials and Methods:** All recommended fertilizers were applied at the time of sowing except nitrogen (urea) which was applied in two split doses i.e., at sowing and 30 days after sowing. Foliar sprays of urea (2.5%)+Zn (0.5%) and kinetin (100 ppm) were applied after 30 and 40 days after sowing in different combinations. **Results:** The maximum plant growth parameters i.e., plant height (73.8 cm) and plant weight (11.59 g) were observed in the recommended dose of fertilizers combined with urea (2.5%)+Zn (0.5%) spray 30 days after sowing followed by kinetin (100 ppm) spray 40 days after sowing. The nematode population i.e., no. of cyst/pot (152.5) was significantly reduced in 30% higher dose of fertilizers as compared to control. **Conclusion:** The present study has shown that the foliar spray of urea, zinc and kinetin has significant impact on plant growth and compensate the damage of cereal cyst nematode by adding different foliar spray as compared to infested control.

Key words: Cereal cyst nematode, *Heterodera avenae*, wheat, fertilizers, kinetin, foliar spray

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

About 90 species of plant parasitic nematodes have been reported to be associated with wheat crop. Among the all, Cereal cyst nematode, *Heterodera avenae* Woll. is the most important and the most widely studied plant-parasitic nematode on wheat[1]. Cereal cyst nematodes (*Heterodera avenae*) commonly known as CCN are found worldwide and cause significant economic yield losses in many countries, particularly where rainfed cereal systems predominate[2]. Damage to plant growth and grain yield is usually severe, although a yield loss of 100% can occur in some infested fields[3] after hatching the infective juveniles migrate in soil to locate the host roots and penetrate just behind the root tip. In case of heavy infestation, root growth is retarded and their water and nutrient absorption efficiency is adversely affected. This causes stunted growth, chlorosis or necrosis of photo synthetically active plant tissues leading to reduction in yield. The nematode establishes feeding sites (syncytia) in the host tissues by continuous secretions of esophageal glands. These syncytia interfere with the nutrient uptake by the plant resulting in disease symptoms[4].

Management of cyst nematodes is difficult as the nematode is endoparasite and forms hard covering of cyst to protect the inoculum. Prevention of spread and crop rotation are the best options for the management of cyst nematodes. Organic and inorganic nitrogen amendments have been added to soils for centuries to improve soil fertility and increase crop yields. Organic amendments have been found effective for the management of plant parasitic nematodes which reported by Muller and Gooch[5], Rodriguez-Kabana[6]. Alam[7] found Anhydrous ammonia has also been shown to reduce the soil populations of many plant-parasitic nematode species, including stunt, spiral, lesion and cyst nematodes. Studies on the effects of individual nutrients like, N (Swain and Prasad)[8], P (Price *et al.*)[9] and K (Terry and Das Gupta)[10] on nematodes are available to limited extent.

Present study was done to compensate the nematode damage with higher dosage of fertilizers and foliar sprays of urea and zinc alone or with kinetin on cereal cyst nematode and wheat growth.

MATERIALS AND METHODS

The experiment was conducted for two years (2015-16 and 2016-17) during Rabi season in screen house of the Department of Nematology, CCS HAU, Hisar, Haryana, India. (Lat: 29°10' N, long: 75°46' E, alt: 215.2 m).

Maintenance and use of pure culture: *Heterodera avenae*-infested soil was collected from wheat field of village Kharakheri, district Fatehabad, Haryana, India. This infested soil was used for experiment after mixing with sterilized auto clave at 121°C (1.0546 kg cm^{-3} pressure) for 1 h soil to obtain desired inoculum and same sterilized used in the treatments without nutrients. Nutrient status of soil was N = 116 kg ha^{-1}, P = 15 kg ha^{-1}, K = 165 kg ha^{-1} and Zn = 1.31 ppm.

Nematode extraction: Cysts from soil were collected on a 60 mesh sieve by Cobb's sieving and decanting method Cobb[11].

Experimental procedure: The experiment was conducted in 1 kg capacity earthen pots of 15 cm diameter. Initial population was maintained 14 eggs and J_2/g soil. The CCN susceptible wheat cultivar WH-1105 was used for experiment. Three wheat seeds were sown in each pot and one plant was maintained after germination. The experiment followed a completely randomized block design with four replications and 10 treatments (Table 1), sterilized soil without fertilizers, sterilized soil with recommended doses of fertilizers and infested soil without fertilizers. Recommended doses of fertilizers, 20 and 30% higher doses of fertilizers, recommended doses of fertilizers along with urea (2.5%), zinc (0.5%) and kinetin (100 ppm) spray were take as treatments. Calculated amounts of all the fertilizers were applied in pots as basal dose except urea which was applied in two split doses i.e., at the time of sowing and after 1 month. Foliar spray of urea, zinc and kinetin were done after 30 and 40 days after sowing. Controlled irrigation was applied and other practices were adopted as per crop requirement.

Statistical analysis: The data were analyzed by Completely Randomized Design (CRD) using OPSTAT programme available on-line at CCS HAU, Hisar University. The comparisons in treatments were made by Critical Difference (CD) at the 5% level of significance. Nematode population data were transformed to eliminate zero.

RESULTS

Application of fertilizers as soil and foliar spray increased the growth character of wheat and reduced nematode population than inoculated treatments without fertilizers. On perusal of data (Table 1) it is observed that during both the

Table 1: Effect of higher doses of fertilizers and foliar spray on wheat growth and *Heterodera avenae*

	2015-2016						2016-2017					
	Plant growth parameters				Nematode parameters		Plant growth parameters				Nematode parameters	
Treatments	Number of tillers	Plant height (cm)	Plant weight (g)	Grain weight (g)	Number of cyst/pot	Cyst content	Number of tillers	Plant height (cm)	Plant weight (g)	Grain weight (g)	Number of cyst/pot	Cyst content
T1: Sterilized soil without fertilizers	1.0	60.0	7.17	0.92	0.0 (1.0)	0.0 (1.0)	1.0	61.2	7.00	0.90	0.0 (1.0)	0.0 (1.0)
T2: Sterilized soil with fertilizers	2.8	74.2	12.00	2.61	0.0 (1.0)	0.0 (1.0)	3.0	74.2	12.29	2.78	0.0 (1.0)	0.0 (1.0)
T3: Soil without fertilizers	1.0	55.2	5.16	0.81	267.5 (16.4)	285.0 (16.9)	1.0	54.6	5.78	0.78	289.0 (17.0)	299.2 (17.3)
T4: Recommended doses of fertilizers	1.0	66.7	8.85	1.59	166.0 (12.9)	224.7 (15.0)	1.0	68.6	9.86	1.88	170.2 (13.1)	269.5 (16.5)
T5: 20% higher dose of fertilizers	2.3	72.8	10.43	2.16	159.0 (12.6)	208.7 (14.5)	2.5	72.5	11.20	2.18	153.2 (12.4)	210.5 (14.5)
T6: 30% higher dose of fertilizers	2.5	73.1	11.21	2.29	152.5 (12.4)	205.2 (14.4)	2.8	73.2	11.57	2.30	147.5 (12.2)	218.7 (14.8)
T7: RDF+urea+zinc spray after 30 DAS	1.3	68.9	9.63	1.63	172.5 (13.2)	253.0 (15.9)	1.8	69.0	10.02	1.75	171.7 (13.1)	254.5 (16.0)
T8: RDF+urea+zinc spray after 30 and 40 DAS	2.3	72.9	10.58	2.27	167.7 (13.0)	220.0 (14.9)	2.0	72.6	11.32	2.24	175.0 (13.3)	238.2 (15.5)
T9: RDF+kinetin spray after 30 DAS	2.0	70.1	9.71	1.91	168.7 (13.0)	232.7 (15.3)	1.8	70.9	10.45	1.90	169.5 (13.1)	224.2 (15.0)
T10: RDF+urea+zinc spray after 30 and kinetin after 40 DAS	2.8	73.8	11.59	2.44	168.2 (13.0)	219.2 (14.8)	3.0	73.7	11.81	2.58	166.2 (12.9)	231.2 (15.2)
CD at 5%	0.6	1.1	0.55	0.39	0.37	0.62	0.5	0.9	0.68	0.24	0.25	0.19

Figures in parentheses are n+1 square root transformed values , RDF: Recommended doses of fertilizers (N: 150 kg ha^{-1}, P: 60 kg ha^{-1}, K: 60 kg ha^{-1} and Zn: 25 kg ha^{-1}), T1 and T2: Without nematode, T3 to T10: soil infested with *H. avenae* (CCN)

years of experimentation, maximum and significantly higher plant height (73.8 cm) and plant weight (11.59 g) was observed in treatment with recommended doses of fertilizers along with urea and zinc spray at 30 DAS. Plant height (52.2 cm) and plant weight (5.16 g) reduced significantly in treatment where cereal cyst nematode infested soil without fertilizers was used. During both the years, tillering and grain weight was higher in the treatment where recommended fertilizers along with urea and zinc spray at 30 DAS and kinetin spray at 40 DAS were applied. All the doses of fertilizers and sprays showed increase in plant growth and reduced nematode population as compared to infested unfertilized check (Table 1). Among all treatments, plant growth was more in recommended doses of fertilizers combined with spray of urea (2.5%) and zinc sulphate (0.5%) at 30 days after sowing followed by kinetin spray (100 ppm) at 40 days after sowing. Foliar spray of fertilizers and growth regulator along with recommended doses of fertilizers improved the plant growth as compared to without fertilizers and spray in infested soil (control).

Foliar spray of urea, zinc and kinetin along with recommended doses of fertilizers improved the plant growth as compared to recommended doses of fertilizers. Single spray of urea and zinc or kinetin at 30 days after sowing did not significantly improved the plant growth over as recommended dose. However their foliar spray at 30 and 40 days after sowing significantly improved the plant growth as compared to recommended doses of fertilizers.

During both the years, number of cyst was significantly reduced by higher doses of fertilizers. In 2015-16 number of cysts per pot reduced significantly in all the treatment as compared to infested soil without any fertilizer. Maximum number of cyst (267) was observed in the treatment where infested soil was used without fertilizers. Average cyst content was lowest (205.2) in the treatment with 30% higher doses of fertilizers followed by 20% higher doses of fertilizers (209.7). All other treatments were at par with each other but statistically better than control. Maximum average cyst content (285) was observed in the treatment CCN infested soil was used without fertilizers. Similar results were obtained during 2016-2017.

Reproduction factor of cereal cyst nematode was reduced by the application of fertilizers and their higher doses along with their foliar sprays (Fig. 1). Minimum reproduction factor was calculated in treatments supplied with 30 and 20% higher doses of fertilizers combined with their foliar spray. Soil infested with cereal cyst nematodes without fertilizers supported maximum multiplication of nematodes as reproduction factors of 4.8 and 6.2 were calculated during

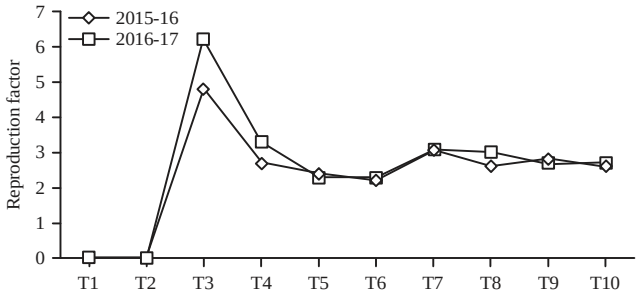

Fig. 1: Effect of higher doses of fertilizers and foliar spray on reproduction factor of *Heterodera avenae*

T1: Autoclaved soil without fertilizers, T2: Autoclaved soil with recommended fertilizers, T3: CCN infested soil without fertilizers, T4: Recommended dose of fertilizers, T5: 20% higher dose of fertilizers, T6: 30% higher dose of fertilizer, T7: T4+urea (2.5%)+zinc sulphate (0.5%) spray after 30 days of sowing, T8: T4+urea+zinc sulphate spray after 30 and 40 days of sowing, T9: T4+kinetin foliar spray at 100 ppm after 30 days of sowing, T10: T4+urea+zinc sulphate after 30 days of sowing followed by kinetin foliar spray at 100 ppm after 40 days of sowing

2015-16 and 2016-17. Maximum nematode populations were reduced in 30% higher dose of fertilizers. It also increased grain yield (grain weight) of wheat as compared to infested unfertilized control or recommended doses of fertilizers. But 20% higher doses of fertilizers did not significantly reduced the nematode population as compared to recommended doses of fertilizers.

DISCUSSION

The results revealed that all fertilizers and sprays show increased the plant growth and reduced nematode population as compared to infested unfertilized check. Among all treatments, plant growth was more in recommended doses of fertilizers combined with spray of urea (2.5%) and zinc sulphate (0.5%) at 30 days after sowing followed by kinetin spray (100 ppm) at 40 days after sowing. Foliar spray of fertilizers and growth regulator along with recommended doses of fertilizers improved the plant growth as compared to recommended dose of the fertilizer. Kinetin is a synthetic cytokinin used to mitigate the adverse effects of nematode stress on plant growth. Cytokinins are involved in various processes in the growth and development of plants including cell division, apical dominance, root formation, leaf senescence, stomatal behaviour and chloroplast development. Brault and Maldiney[12] and Hussain *et al.*[13] reported that foliar spray is a well-established tool to complete and to enrich plant nutrition. Foliar feeding can provide the nutrients needed for normal developments of crops in cases where absorption of nutrients from the soil is disturbed. As uptake of nutrients through the foliage is considerably faster than through roots, foliar spray is also the method of choice when prompt correction of nutrient deficiencies is required. Babalar and Pirmoradian[14] found that foliar application is a rapid solution for deficiency symptoms as well as for balance of nutritional elements of plants. Use of appropriate levels of NPK fertilizers has good effects on plant growth factors and potential in controlling *Meloidogyne javanica*. Irshad *et al.*[15] Oka *et al.*[16] reported that potassium phosphate applied to the aerial part was effective in controlling *Heterodera avenae* and *Meloidogyne marylandi* in wheat and oats. In a later study, phosphate or BABA inhibited development of cereal cyst nematodes *Heterodera avenae* and *H. latipons* on wheat and *Meloidogyne* spp. on oat when applied as a foliar spray or soil drench. Oka *et al.*[17], El-Bramaway and Shaban[18] reported that application of potassium in soil and as a foliar spray increased the plant height, number of branches, leaf chlorophyll, number of pods/plant, 100 grain weight (g) and grain yield of faba bean plant infected with chocolate spot and rust disease.

Rodriguez-Kabana[6] stated that the rates required to obtain significant suppression of nematode populations are generally in excess of 150 kg N ha^{-1}. Urea also suppresses several nematode species, including *Meloidogyne* spp., when applied at rates above 300 kg N ha^{-1}. Taya *et al.*[19] found that in *H. avenae* infected wheat; comparatively higher yield was obtained in the treatments where, combinations of NPK or P K were applied in optimum dose or in higher dose. Korayem and Mohamed[20] showed that yield of wheat infected with *H. avenae* were improved by adding additional dose from nitrogen fertilizer although they did not mentioned the effects on nematode population. Sharma and Khan[21] showed that minimum infestation of root knot nematode, *Meloidogyne incognita* was recorded with the application of all the three fertilizers (N, P and K) in combination on tomato seedlings. Dual effects of NPK in improving plant growth and suppressing nematode population is well documented by Sinha and Neog[22]. The results of present study also confirmed the results of Noweer and Hasabo[23] and Irshad *et al.*[15], who reported that application of chemical fertilizers reduced the damage of root knot nematodes.

Present study indicated that the use of inorganic fertilizers like sources of nitrogen, phosphorus and potash reduced the development of *H. avenae*. The findings are consistent with previous studies which showed that the nitrogen in ammonium form, present in fertilizers is more prejudicial to nematodes than in nitrate form Rodriguez-Kabana[6]. The

nematicidal property of ammonia is mainly attributable to its plasmolytic effect around the point at which it is applied to the soil Rodriguez-Kabana[6]. Plants become more resistant when supplied with sufficient quantities of phosphorus[24] as a result of increases in protein synthesis, cell activity and production of polyphenol, peroxidase and ammonia by Wang and Bergeson[25]. Perrenound[26] stated that Adequate plant nutrition with potassium helps in reducing the incidence of disease due to increased resistance to the penetration and development of pathogens. Fertilizer has been observed to boost tolerance of plants to diseases, cause nematode mortality[27,28] induce plant tissue to develop thicker cuticle and more sclerenchyma to make penetration of nematodes difficult. Additional doses of fertilizers and their foliar spray increased the plant growth (plant weight and grain weight) as compared to infested unfertilized control may be due to increased tolerance against *H. avenae*. Nutritional status of plants influences crop resistance to pests and diseases[6,29,30]. Nutrients indeed play an important role in plant health and pest and disease incidence, although the magnitude of probable interactions and relationships dependent upon several interacting factors was stated by Datnoff[31].

CONCLUSION

The present study has shown that the foliar spray of urea, zinc and kinetin has significant impact on plant growth and compensate the damage of cereal cyst nematode by adding different foliar spray as compared to infested control.

SIGNIFICANCE STATEMENT

This study discover that recommended dose of fertilizer+urea+zinc spray after 30 and kinetin after 40 DAS better for enhancing plant growth and 30% higher dose of recommended fertilizer is best for the reducing nematode population. Foliar application of fertilizers and growth regulator along with recommended doses of fertilizer will helpful for the farmers to compensate the losses caused due to cereal cyst nematode.

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