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Validation of Results on Dry Sowing of Wheat for the Management of Cereal Cyst Nematode *Heterodera avenae*

Sardul Singh Mann, Rambir Singh Kanwar, Bhagat Singh

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ABSTRACT

The cereal cyst nematode, *Heterodera avenae* is an economically important nematode pest world wide. Yield losses caused by this nematode may go up to 90% under nematode favorable environmental conditions. Fields trials were conducted during 2017-18 to 2020-21 for validation of results on effect of sowing of wheat crop in dry sown vis-a-vis in *Palewa* sown, under cereal cyst nematode infested condition. Our results revealed that nematode penetration and hatching at intial crop growth stage was less in dry sown than *Palewa* sown condition. Germination was not adversely affected in dry sowing whereas crop yield was better in dry sown than *Palewa* sown condition. Yield was significantly higher in dry sown than *Palewa* sown in all the years. It was 7.4 - 11.1% higher in dry sown than *Palewa* sown.

Keywords Cereal cyst nematode, *Heterodera avenae*, Dry sowing, Management, Wheat.

INTRODUCTION

The word sustainable agriculture has been resounded among international organizations over the past decades. Sustainable agriculture has become one of the fundamental needs to ensure food security worldwide (Glick 2012, Gupta *et al.* 2015). Wheat (*Triticum aestivum*) is one of oldest and predominant staple foods and a main cereal crop of 2.5 billion of world population. Global wheat production is 758.3 million tones (Anonymous 2020a). In India, wheat is cultivated in 30 million hectares (14% of global area) and production is 109 million tones constituting 13.64% of world production (Anonymous 2020b). The cultivation of wheat is affected by several biotic and abiotic stresses. Among biotic stresses, several fungi, bacteria and plant parasitic nematodes (PPNs) cause yield reduction. Several PPNs like *Heterodera* spp., *Anguina tritici* and *Pratylenchus* spp. act as pests of wheat. More than 80 species of plant parasitic nematodes are associated with wheat (Smiley and Nicol 2009). Among them the cereal cyst nematode (*Heterodera avenae*), is one of the most economically important PPN worldwide (Bonfil *et al*. 2004, Nicol *et al.* 2007). Yield losses caused by cereal cyst nematode may be up to 90% under nematode favorable environmental condition (Jones *et al.* 2013). This nematode is an important pest of wheat and barley

Sardul Singh Mann[1]*, Rambir Singh Kanwar[2], Bhagat Singh[3]
[1]DES (Nematology), [2]Retired Prof. and Head, [3]Assistant Scientist
[1]KVK, Fatehabad, CCS HAU 125050, India
[2,3]Department of Nematology, CCS HAU, Hisar 125004, India
Email : sardulmann74@gmail.com
*Corresponding author

Fig. 1. Sowing of wheat in *Palewa* sown (back ground) and dry sown condition (fore ground).

Fig. 2. Recording no. of plants per m² in *Palewa* sown and dry sown conditions

in India and present in North Indian states, Rajasthan, Haryana, Delhi, Himachal Pradesh, Jammu and Kashmir, Madhya Pradesh, Punjab and Uttar Pradesh (Kanwar and Bajaj 2012). An overall loss in India caused by cereal cyst nematode is 28.5% (Kumar *et al.* 2020). The annual loss caused in wheat has been estimated to Rs 688.7 million in Haryana alone (Kanwar *et al.* 2011).

This practice has been included in package of practices for *rabi* crops of Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 2021.

Crop rotation with non-hosts, resistant varieties of wheat and barley, use of nematicides at sowing time and early sowing of crop are some common practices in India for the management of this nematode. Dry sowing of wheat was found effective in reducing the nematode damage (Kanwar *et al.* 2013).

MATERIALS AND METHODS

Field trials on sowing of wheat in nematode infested fields, in dry and *Palewa* conditions were conducted for four years (2017-18 to 2020-21). Fields for trials were selected in villages Dharnia and Kharakheri of Fatehabad district, Haryana.

Details of locations, wheat varieties, date of sowing in different years are given in Table 1. Other agronomical practices were adopted as recommended for the area (Anonymous 2016). Trials were done in paired plot method (10 pairs of each treatment) and

Table 1. Location, wheat varieties and date of sowing in different years.

Year	Villages/ location	Wheat variety	Date of sowing
2017-18	Dharnia	HD 2967	Nov 15, 2017
	Kharakheri	HD 2967	Nov 25, 2017
2018-19	Dharnia	HD 2967	Nov 23, 2018
	Kharakheri	WH 711	Nov 30, 2018
2019-20	Kharakheri I	HD 2967	Nov 21, 2019
	Kharakheri II	HD 2967	Nov 25, 2019
2020-21	Kharakheri I	HD 3086	Nov 18, 2020
	Kharakheri II	HD 2967	Nov 12, 2020

Table 2. Nematode population and crop performance in dry and *Palewa* sown wheat in 2017-18. Plants/m² : T cal < T tab (2.26 @ 9 df)= NS. Final cyst population : T cal< T tab (2.26 @ 9 df)=NS, Yield : T cal (4.52) > T tab (2.26 @ 9 df) = S.

Location	Plants/m²			Final cyst population (200 cc soil)		Yield (q/ha)		
	Dry sown	*Palewa* sown	Initial cyst population (200 cc soil)	Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	Percent yield increase in dry over *Palewa*
Kharakheri	260	263	7	13	15	52.0	47.0	10.6
Dharnia	250	248	12	25	28	45.0	42.0	7.4
Average	255	255.5	9.5	19	21.5	49.5	44.5	9.0

Fig. 3. Wheat crop after one month dry sown (left) and *Palwea* sown (right).

plot size was taken 1000 m^2 at each location in all the years. Crop sowing was done on the same date in dry and *Palewa* conditions. For this, pre sowing irrigation was applied 8-10 days prior to sowing in Palewa sown, and irrigation was applied immediately after sowing in dry sown condition (Fig.1) . Observations on germination, plants/m^2 (Fig. 2), nematode penetration, final cyst population and crop yield were recorded. Cysts were extracted by Cobb's sieving and decanting method (Cobb 1918) and nematode penetration was taken after staining the roots in acid fuchsin lactophenol (Franklin and Goodey 1949). Data were compared by t-test separately for each year.

RESULTS AND DISCUSSION

During 2017-18 : Number of Plants/square meter were same in both conditions, however crop yield was higher in dry sown (49.5q/ha) than *Palewa* sown (44.5q/ha). Final cyst populations were statistically similar in both the treatments (Table 2).

During 2018-19 : Experiment was laid out at two locations i.e., in Kharakheri and Dharnia villages of district Fatehabad. Wheat variety i.e., WH 711 and HD 2967 was sown in Kharakheri and Dharnia villages, respectively. Germination was not hampered in dry sowing, as plants/square meter were at par in both the conditions. Yield in dry sown was 7.9% more at Kharakheri and 8.7% higher at Dharnia (Table 3) than *Palewa* sown conditions. Nematode penetration after one month of sowing was more in *Palewa* sown (45 and 34/root) than dry sown (25 and 20/root) respectively in village Kharakheri and Dharnia (Fig. 3). Final cyst populations were statistically similar in both the treatments (Table 3).

During 2019-20 : Experiment was laid out at two lo-

Table 3. Nematode population and crop performance in dry and *Palewa* sown wheat in 2018-19. Plants/ m^2: T cal.< T tab (2.26 @ 9 df) = NS. Final cyst population : T cal< T tab (2.26 @ 9 df)= NS, Yield : T cal. (2.39) > T tab (2.26 @ 9 df)= S.

	Plants/m^2			Nematode penetration after one month		Final cyst population (200 cc soil)		Yield (q/ha)		
	Dry sown	*Palewa* sown	Initial cyst population (200 cc soil)	Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	Percent yield increase in dry over *Palwa* sown
Kharakheri	209	203	22	25	45	39	42	48.0	44.5	7.9
Dharnia	230	220	16	20	34	38	40	50.0	46.0	8.7
Average	219.5	211.5	19	22.5	39.5	38.5	41.0	49.0	45.25	8.2

Table 4. Nematode population and crop performance in dry and *Palewa* sown wheat in 2019-20. Plants/m^2: T cal.< T tab (2.26 @ 9 df) = NS. Final cyst population : T cal < T tab (2.26 @ 9 df)= NS, Yield : T cal (3.29) > T tab (2.26 @ 9 df)= S.

	Plants/m^2			Nematode penetration after one month		Final cyst population (200 cc soil)		Yield (q/ha)		
	Dry sown	*Palewa* sown	Initial cyst population (200 cc soil)	Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	Percent yield increase in dry over *Palewa* sown
Kharakheri location I	232	225	18	10	21	43	40	45.5	42.0	8.3
Kharakheri location II	229	220	15	7	17	40	38	47.0	43.0	9.3
Average	230.5	222.5	16.5	8.5	19	41.5	39	46.2	42.5	8.8

cations in Kharakheri village of Fatehabad district and wheat variety HD 2967 was sown at both locations. Plants/square meter were similar in both conditions showing that germination was not affected adversely by dry sowing. Yield in dry sown was 8.3 and 9.3% higher at location-I and location-II, respectively (Table 4). Nematode penetration after one month of sowing was more in *Palewa* sown (21 and 17/ root) at loctation I and II, respectively than dry sown (10 and 7/root) at loctation I and II, respectively. Final cyst population was statistically similar in both the treatments.

During 2020-21: Experiment was conducted at two locations (I and II) in village Kharakheri of district Fatehabad. Wheat variety i.e., HD 3086 and HD 2967 was sown at locations I and II, respectively. Germination was not affected adversely by dry sowing. Yield in dry sown was 11.1% more at Kharakheri-I and 7.5% higher at Kharakheri-II (Table 5) than *Palewa* sown conditions. Nematode penetration after one month of sowing was more in *Palewa* sown than dry sown. Final cyst populations did not differ statistically in the both treatments. Pooled data (Table 6) show that final cyst population was similar in both treatments and yield was 8.8% higher in dry sown over *Palewa* sown. Average number of plants/m^2 was 229.6 in dry sown compared to 223.1 in *Palewa* sown.

Heterodera avenae survives in soil during off

Table 5. Nematode population and crop performance in dry and *Palewa* sown wheat in 2020-21. Plants/m^2 : T cal< T tab (2.26 @ 9 df) = NS. Final cyst population :T cal < T tab (2.26 @ 9 df) = NS, Yield : T cal (3.08) > T tab (2.26 @ 9 df) = S.

Location	Plants/m^2		Initial cyst population (200 cc soil)	Final cyst population (2 00 cc soil)		Yield (q/ha)		Per cent yield in dry over *Palewa* sown
	Dry sown	*Palewa* sown		Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	
Kharakheri location-I	203	192	8	22	24	40.0	36.0	11.1
Kharakheri location-II	224	214	6	18	21	43.0	40.0	7.5
Average	213.5	203.0	7	20	22.5	41.5	38.0	9.3

Table 6. Pooled data on effect of dry sowing on cereal cyst nematode and crop yield (2017-18 to 2020-21). ICP: Initial Cyst Population, FCP:Final Cyst Population.

Year/ location	ICP/200 cc soil	FCP/ 200 cc soil		Plants/ m^2		Yield q/ha		Per cent yield increase in dry over *Palewa* sown
		Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	Dry sown	*Palewa* sown	
2017-18								
Dharnia	12	07	25	13	28	15	250	260
Kharakheri	248	263	45.0	52.0	42.0	47.0	7.4	10.6
2018-19								
Dharnia	16	22	38	39	40	42	230	209
Kharakheri	220	203	50.0	48.0	46.0	44.5	8.7	7.9
2019-20								
Kharakheri I	18	15	43	40	40	38	232	229
Kharakheri II	225	220	45.5	47.0	42.0	43.0	8.3	9.3
2020-21								
Kharakheri I	8	6	22	18	24	21	203	224
Kharakheri II	192	214	40.0	43.0	36.0	40.0	11.1	7.5
Mean	13.0	29.7	31.0	229.6	223.1	46.3	42.6	8.8

season, in the form of J^2 enclosed in the cysts. Hatching of *H. avenae*, unlike *Globodera* species does not require host root exudates. Emergence of larvae from cysts and consequently disease development are influenced by soil moisture (Meagher 1970, Mathur *et al.* 1974), temperature (Hesling 1956, Mathur *et al.* 1974) and soil texture (Meagher 1972, Mathur *et al*. 1981). Moist and cool periods at the time of hatching and invasion and a dry period during active growing phase of crop causes severe crop damage (Dixon 1963, Fidler and Beawan 1963). In dry sowing, emergence of larvae from cysts is delayed due to unavailability of moisture. The initiation of hatching takes place in *H. avenae* in 15 days and continues up to 40 days (Kanwar 2009). Thus less inoculum in the form of infective juveniles is available in dry sown crop than *Palewa* sown at the time of germination and initial crop growth. Consequently, nematode penetration in the early crop stage is less, and tillering and yield are better than the *Palewa* sown crop. The final nematode populations in both the treatments are similar because the nematode juveniles emerging from cysts and attacked the crop are same during the crop season. Since, in dry sown condition, early growth stage escapes the nematode damage hence, gives better yield than *Palewa* sown. This cultural practice commonly adopted by farmers in Haryana for obtaining better yield in cereal cysts nematode infested condition and may also be useful at other places under similar conditions.

CONCLUSION

On the basis of four year's trials it was found that germination was 2-3 days earlier in dry sown as compared to *Palewa* sown condition. Germination was numerically better in dry sown (229.6 plants/m sq) than *Palewa* sown condition (223.1 plants/m sq) though it was statistically at par. Nematode penetration was more in *Palewa* sown than dry sown. Yield was significantly higher in dry sown than *Palewa* sown in all the years. It was 7.4-11.1% higher in dry sown than *Palewa* sown (Table 6) in spite of similar final cyst populations in both the treatments.

REFERENCES

Anonymous (2016) Package of practices for *rabi* crops, Chaudhary Charan Singh Haryana Agricultrual University, Hisar.

Anonymous (2020a) https://www.globaltrademag.com.

Anonymous (2020b) https://www.intechopen.com.

Bonfil DJ, Dolgin B, Mufradi I, Asido S (2004) Bioassay to forecast cereal cyst nematode damage to wheat in fields. *Precision Agric* 5: 329—344.

Cobb NA (1918) Estimating the nema population of soil. US Department of Agriculture, *Bur Pl Industry Agric Technol Cir* 1:1.

Dixon GM (1963) Relationship between intensity of cereal root eelworm (*Heterodera avenae* Woll, 1924) infestations and pH value of soil. *Irish J Agri Res* 2 : 105—110.

Fidler JH, Beawan WJ (1963) Some soil factors influencing the density of cereal root eelworm (*Heterodera avenae* Woll) population and their damage to the oat crops. *Nematologica* 9 : 412—420.

Franklin MT, Goodey JB (1949) A cotton blue lactophenol technique for mounting plant parasitic nematodes. *J Helminthology* 23 : 175—178.

Glick BR (2012) Plant growth-promoting bacteria : Mechanisms and applications. *Scientifica* 1—15.

Gupta G, Parihar SS, Ahirwar NK, Snehi SK, Singh V (2015) Plant growth promoting rhizobacteria (PGPR) : Current and future prospects for development of sustainable agriculture. *J Microbiol Biochem* 7 : 96—102.

Hesling JJ (1956) Some observation on heterodera major. *Nematologica* 1 : 56—63.

Jones JT, Haegeman A, Danchin EG J, Gaur HS, Helder J, Jones MGK (2013) Top ten plant parasitic nematodes in molecular plant pathology. *Mol Pl Path* 14 : 946—961.

Kanwar RS (2009) Viability of inoculums in and pattern of juvenile emergence from cyst *Heterodera avenae* stored in sand. *Ind J Nematol* 39 (1) : 109—111.

Kanwar RS, Bajaj HK (2012) Cyst nematode infestation in wheat. In : Nematode infestation part-I food crops. (eds.) Khan MR, Rajpuri Jai (ed), The National Academy Sci India, pp 192—217.

Kanwar RS, Mann SS, Singh B (2013) Management of *Heterodera avenae* in wheat by dry sowing. *Ann Pl Protec Sci* 21 (2) : 460—462.

Kanwar RS, Nandal SN, Paruthi IJ, Bajaj HK (2011) Status of *Heterodera avanae* woll and loses caused by it in wheat in Haryana state of India. *Haryana Agric Univ J Res* 1: 21—23.

Kumar V, Khan MR, Walia RK (2020) Crop loss estimations due to plant-parasitic nematodes in major crops in India. *Nat Acad Sci Letters* 43 : 409—412.

Mathur BN, Arya AC, Handa DK, Mathur RL (1974) The biology of cereal cyst nematode, *Heterodera avenae* in India. I. Effect of moisture and temperature on the survival of cyst contects. *Ind J Mycol Pl Path* 4 : 151—156.

Mathur BN, Arya AC, Handa DK, Mathur RL (1981) The biology of cereal cyst nematode, *Heterodera avenae* in India. II. Fectors affecting population level and damage to host crops. *Ind J Mycol Pl Path* 11: 5—13.

Meagher JW (1970) Seasonal fluctuations in numbers of larvae of the cereal cyst nematode (*Heterodera avenae*) and of *Pratylenchus minyus* and *Tylenchorhynchus brevidens* in soil. *Nematologica* 16 : 333—347.

Meagher JW (1972) Cereal cyst nematode (*Heterodera avenae* Woll) studies on ecology and control in victoria. Technical bullietin of department of agriculture. *Victoria* 1 : 24—50.

Nicol JM, Elecioglu IH, Bolat N, Rivol R (2007) The global importance of the cereal cyst nematode (*Heterodera* spp.) on wheat and international approaches to its control. *Commun Agric Appl Biol Sci* 72 (3) : 677—686.

Smiley RW, Nicol JM (2009) Nematodes which challenge global wheat production. In : Carver BF (ed.). Wheat Science and Trade, Wilay-Blackwell, Ames, IA, pp 171—187.