Study of population dynamics of Oribatid mites and their role in productivity of Black gram crop under conservation agricultural practices

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ABSTRACT

The goal of the current experiment was to assess how conservation agricultural methods affected oribatid mite population dynamics and their contribution to Black Gram crop productivity. Using a modified Berlese funnel, the soil-dwelling Oribatid mites were gathered, and the mean number of these mites per 100 g of rhizospheric soil was noted. Zero tillage soil treated with 50% paddy straw residue + 100% N.P.K (ZN4) and zero tillage soil treated with 0% paddy straw residue + 100% N.P.K (ZN1) had the highest mean population (93.00 and 97.00) in 2019 and 2020, respectively. According to estimates, oribatid mites play a beneficial function in improving the yield-attributing traits of the Black Gram crop. As a conclusion, it can be said that the population dynamics of Oribatid mites and the productivity of Black Gram crops both benefit from the implementation of conservation agricultural measures.

KEY WORDS: Black gram; Conventional tillage; Oribatid; Reduced tillage; Zero tillage

INTRODUCTION

Release of the bound nutrients and energy in the waste materials of living organisms is the most crucial for the long-term maintenance of the soil ecosystem. This essential need of the ecosystem is being fulfilled by the collective efforts of the detritivore's faunal components, particularly the arthropod community inhabiting the soil ecosystem. Arachnids have been identified as the most promising and abundant mediators of the process of decomposition in the soil (Tadros, 1976). Oribatid mites represent one of the active links in the decomposer food web by playing multiple roles in the decomposition process. They are the only group among the arachnid members that are contributing to the soil structure (Norton, 1985). The functional aspects of oribatid mites in the soil ecosystem were vividly reviewed by Haq (1994, 1996), and their involvement towards the degradation of plant litter and nutrient recycling and maintenance of soil fertility were identified as major roles in the soil (Haq, 2016). Among the oribatida lower taxonomic groups like Lohmannoid and Pthiracaroid are proven as more promising as decomposers of plant litters and other organic matter in soil ecosystems (Haq, 1982, 1994, 1996, 2007; Haq and Konikkara, 1988; Haq and Xavier, 2005). Augmentation of soil fertility through the enzymatic breakdown of organic matter and litter components by oribatid mites was reported by many research workers (Hartenstein, 1962; Hayes, 1963; Berthet, 1964; Luxton, 1966; Kowal, 1969; Kowal and Crossley, 1971; Hammer, 1972). Generally, these soil-dwelling mites with other soil fauna, overwhelmingly boost the soil ecosystem processes and services including organic matter breakdown and decomposition, nutrient cycling and release of essential nutrients of plants (Walters, 2000; Coleman, 2008; Ekschmitt *et al*., 2008) by their proficiency of direct ingestion and fragmentation of litter and indirectly by shifting biomass and community structure of microbial decomposers (Cortet *et al*., 2003; Coleman *et al*., 2004). Their capability of recycling nutrients like Calcium (Ca) and Potassium (K) has been brought to the limelight through the works of several research hands (Cornaby *et al*., 1975; Gist and Crossley, 1975; Werner and Dindal, 1987). Norton (1985) reported that feeding of organic components and plant litters additionally incorporate nitrogen in the soil system. Haq (1996) steered a quantitative analysis of certain macro and micronutrients of selected items of plant litter after its feasting by soil mites and conveyed that there was a general intensification of nitrogen and phosphorus content. The rhizophagous oribatid mites mend the drainage capacity, soil aeration and clear the dead mass of plant root and accelerate the plant growth (Rogers, 1939; Ghilarov, 1971). Oriculture farming a latest groundbreaking technology which is mainly based on nurturing and releasing of oribatid mites in crop field for increasing the crop yield. It has been reported that growth of okra plant increases about 20% which ultimately leads to higher yield (Haq, 2016). Due to feeding of litters, oribatid mites augment 0.48% nitrogen, 0.06% phosphorus and 0.05% potassium in soil which ultimately aggravate the crop yield (Haq, 2019).

MATERIALS AND METHODS

The present research was carried out in Balindi Research Complex (BRC), Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India, Latitude 22°95'N and 88°52', Altitude of 10 m above mean sea level (MSL).

Land preparation method

The entire field was divided into three tillage plots viz. Conventional tillage (CT), Zero tillage (ZT) and Reduced tillage (RT) depending on the tillage intensity. Conventional tillage plots were prepared by giving the primary tillage with a tractor-drawn disc plough followed by two passes of rigid-tyne cultivator and rotary tiller as secondary tillage to have an excellent tilt and uniform seed-bed. The plots for the reduced tillage were established after sequential tillage operations with two passes of wide Tyne cultivator and two passes of offset disc harrow.

Treatment details

The entire experimental field was divided into three tillage plots viz. Conventional tillage (CT), Zero tillage (ZT) and Reduced tillage (RT) and each tillage plot further subdivided into five subplots by application of N.P.K. fertilizers at their recommended dose and retention of paddy straw residue in different percentage levels. Each subplot is prepared with the dimension of 20 X 6.3 m² by the cultivation of Black gram crop with the cultivar Sarada during 2018-2019 and 2019-2020.

Tillage	Nutrient-residue combination
Conventional tillage (CT) Crop name: Black gram	CN1: 0% paddy straw residue+ 100% N.P.K
	CN2: 100% paddy straw residue+ 50% N.P.K
	CN3: 100% paddy straw residue+ 75% N.P.K
	CN4: 50% paddy straw residue+ 100% N.P.K
	CN5: 50% paddy straw residue+ 75% N.P.K
Zero tillage (ZT) Crop name: Black gram	ZN1: 0% paddy straw residue+ 100% N.P.K
	ZN2: 100% paddy straw residue+ 50% N.P.K
	ZN3: 100% paddy straw residue+ 75% N.P.K
	ZN4: 50% paddy straw residue+ 100% N.P.K
	ZN5: 50% paddy straw residue+ 75% N.P.K
Reduced tillage (RT) Crop name: Black gram	RN1: 0% paddy straw residue+ 100% N.P.K
	RN2: 100% paddy straw residue+ 50% N.P.K
	RN3: 100% paddy straw residue+ 75% N.P.K
	RN4: 50% paddy straw residue+ 100% N.P.K
	RN5: 50% paddy straw residue+ 75% N.P.K

Study of population dynamics of oribatid mites

Population dynamics of Oribatid mites was studied through the collection of mites from rhizospheric soil of Black gram crop at seven days interval throughout the crop duration. The collected soil samples were kept into modified Berlese funnel and oribatid mites are extracted in a test tube fitted under the funnel.

Evaluate the impact of oribatid mites on crop productivity

This study has been carried out by correlating the mean population of soil oribatid mites with the crop yield and yield attributing parameters the respective crop both the years (2018-2019 and 2019-2020).

Statistical Analysis

The statistical design of the experiment was Split plot design. All the statistical analysis viz. correlation, regression was done by using the IBM SPSS Software, Version 20.

Result and Discussion

Population dynamics of oribatid mites in Black gram crop

Rhizospheric soil was collected at different Days after sowing (DAS) from Black gram crop and collected soil sample was placed into Berlese Funnel for extraction of oribatid mites. Mean population of oribatid mites was estimated by counting the number of the mites extracted from the soil sample. In Black gram crop, mean oribatid mite population was recorded as (31.13 / 100 gm of rhizospheric soil) at 28 DAS and (84.2 / 100 gm of rhizoshperic soil) at crop maturity stage at 70 DAS in conventional tillage system during 2019, whereas, in the next year (2020) the mean population was reduced and it was recorded as (23.4 / 100 gm of rhizospheric soil) at 28 DAS and (71.73 / 100 gm of rhizospheric soil) at the maturity of the crop at 70 DAS in conventional tillage practice (**Fig. 1**) and (**Table. 1**). In zero tillage and reduced tillage mean oribatid mite population was higher than the conventional tillage system. It was recorded as (42.07 / 100 gm of rhizospheric soil) and (37.8 / 100 gm of rhizospheric soil) at 28 DAS both in zero tillage and reduced tillage during 2019 respectively. In the next year (2020) mean population was increased and it was recorded as (48.73 / 100 gm of rhizospheric soil) and (50.13 / 100 gm of rhizospheric soil) at the initial stage of crop sowing (28 DAS). It was reported that mean population of oribatid mite was also increased with the crop maturity period and it was estimated as (89.87 / 100 gm of rhizospheric soil) and (88.2 / 100 gm of rhizospheric soil) during 2019 and (95.13 / 100 gm of rhizospheric soil) and (94.07 / 100 gm of rhizospheric soil) during 2020 from both zero tillage and reduced tillage (**Fig. 2**), (**Fig. 3**) and (**Table. 2**).

In the present experiment, it was found that the mean oribatid mite population per 100 g of rhizospheric soil in conventional tillage was low than the zero tillage and reduced tillage. Conventional tillage practice alters the soil physical and chemical properties by destruction of soil organic matter content, soil organic carbon, soil moisture, soil fertility which leads to significant reduction of the soil oribatid mite population. The above experimental results are confirmatory with the findings of King and Hutchinson, 1976; Edwards and Lofty, 1969; Hulsmann and Wolters, 1998: Ayuke *et al*., 2009; Maribie *et al*., 2011; Kihara *et al*., 2015; Ayuke *et al*., 2019. They stated that, soil oribatid mites have been considered as most abundant mesofaunal group within the soil ecosystem and they are very much sensitive to changes of different soil physical and chemical parameters. In the present study, it was reported that the population strength of soil oribatid mite was increased in zero tillage and reduced tillage in the second year (2019-2020) than the first year (2018-2019) whereas reverse situation was taken place in conventional tillage. Implementation of zero tillage and reduced tillage with the retention of paddy straw residue with proper proportion create the conducive environment by increasing the soil moisture status, soil organic carbon status, soil water holding capacity, soil porosity, maintaining the optimum soil temperature regime, soil pH which allows the long term sustenance of the soil oribatid mite population throughout the crop duration period (Bhattacharya, 1979; Bhattacharya *et al*., 1985, Ghatak and Roy, 1991; Schrader, 2000; Bedano *et al*., 2005; Kamczyc, 2006; Singh and Ray, 2015; Mupangwa, 2016; Mhlanga and Thierfelder, 2021).

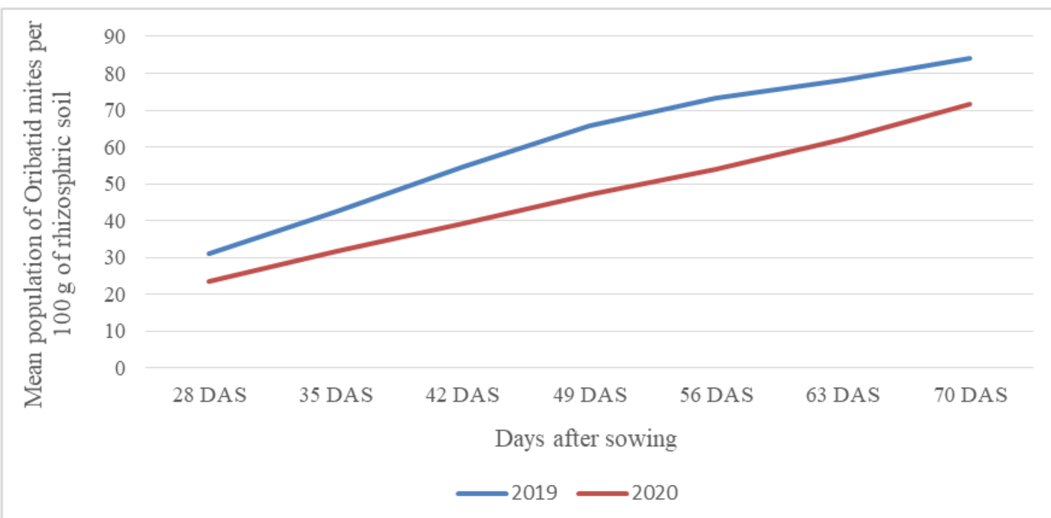

Fig. 1: Population dynamics of oribatid mite in Black gram crop in Conventional tillage

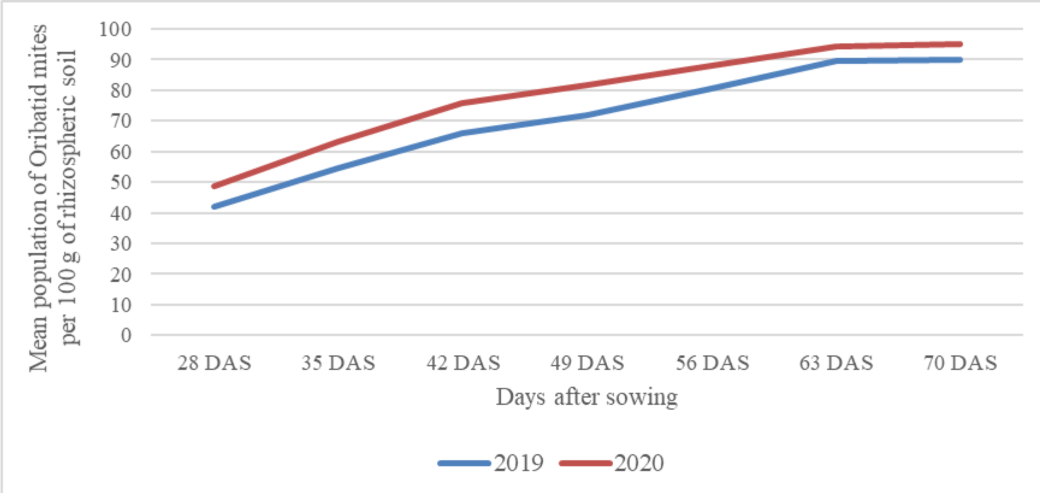

Fig. 2: Population dynamics of oribatid mite in Black gram crop in Zero tillage

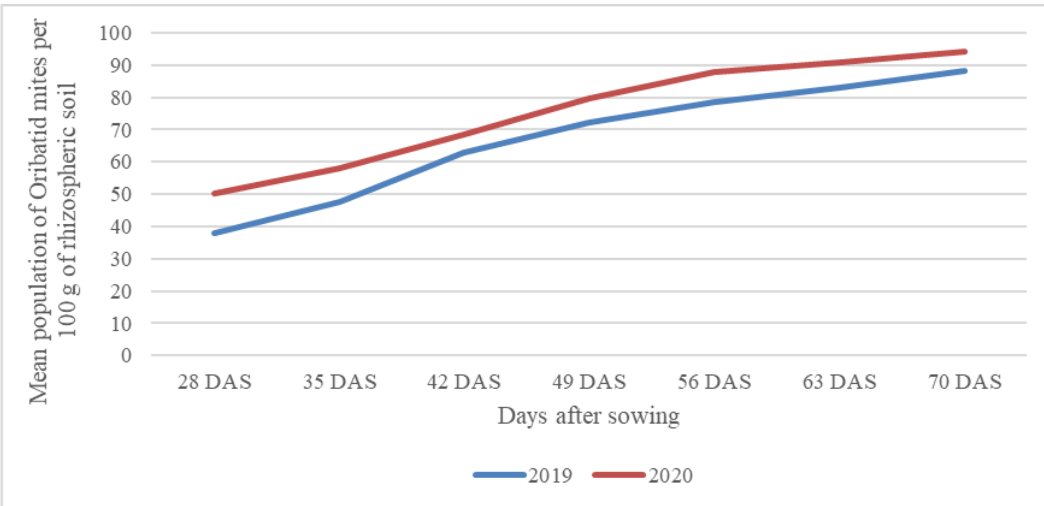

Fig. 3: Population dynamics of oribatid mite in Black gram crop in Reduced tillage

ROLE OF ORIBATID MITE IN CROP PRODUCTIVITY IN BLACK GRAM CROP

Impact of oribatid mite population in soil system on crop productivity is studied during the experiment. In Black gram, two major yield attributing parameters viz. number of pods per plant and number of grains per pod and yield were estimated from the three tillage systems (Conventional tillage, Zero tillage and Reduced tillage) during 2019 and 2020. Positive correlation value was obtained between yield, yield attributing parameters and oribatid mite population in the three tillage systems (Conventional tillage, Zero tillage and Reduced tillage) during 2019 and 2020 (**Table. 3**). The range of R^2 value (0.9967 - 0.998) was high in regression analysis in between crop yield and oribatid population (**Fig. 3 – Fig. 8**).

Table: 3. Correlation study between yield attributing parameters and yield of Black gram crop and oribatid mite population in Mustard – Black gram – Rice cropping sequence

Correlation between number of pods / plant of Black gram crop and oribatid mite population					
Year	Conventional tillage (CT)	Year	Zero tillage (ZT)	Year	Reduced tillage (RT)
2019	0.026	2019	0.194	2019	0.272
2020	0.270	2020	0.060	2020	0.195
Correlation between number of seeds / pods of Black gram crop and oribatid mite population					
Year	Conventional tillage (CT)	Year	Zero tillage (ZT)	Year	Reduced tillage (RT)
2019	0.279	2019	0.414	2019	0.532

2020	0.671	2020	0.374	2020	0.387
Correlation between yield of Black gram crop and oribatid mite population					
Year	Conventional tillage (CT)	Year	Zero tillage (ZT)	Year	Reduced tillage (RT)
2019	0.668	2019	0.674	2019	0.520
2020	0.212	2020	0.623	2020	0.679

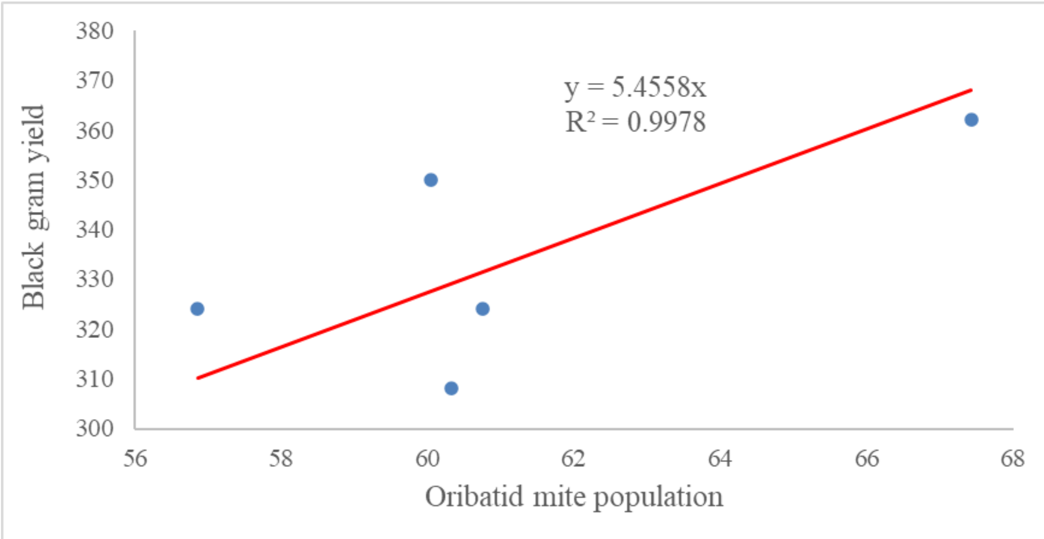

Fig. 4. Regression analysis between yield of Black gram crop and oribatid mite population during 2019 in Conventional tillage

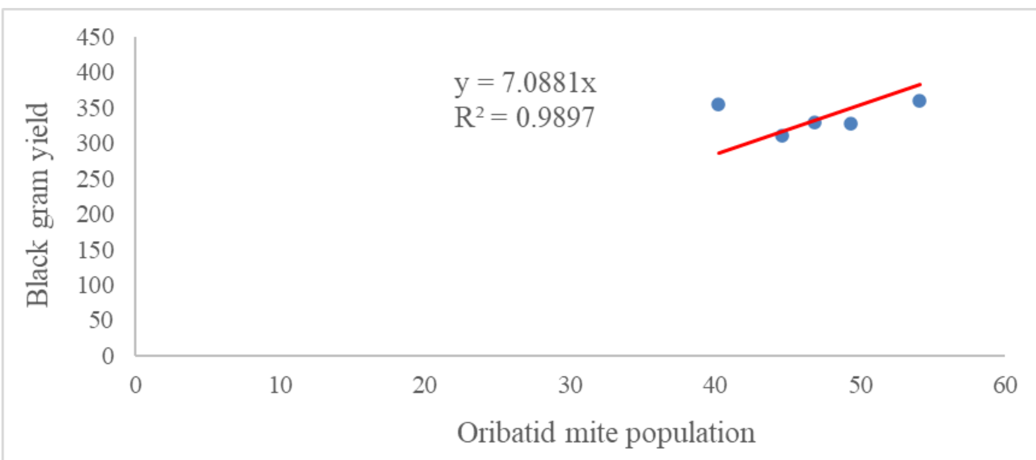

Fig. 5. Regression analysis between yield of Black gram crop and oribatid mite population during 2020 in Conventional tillage

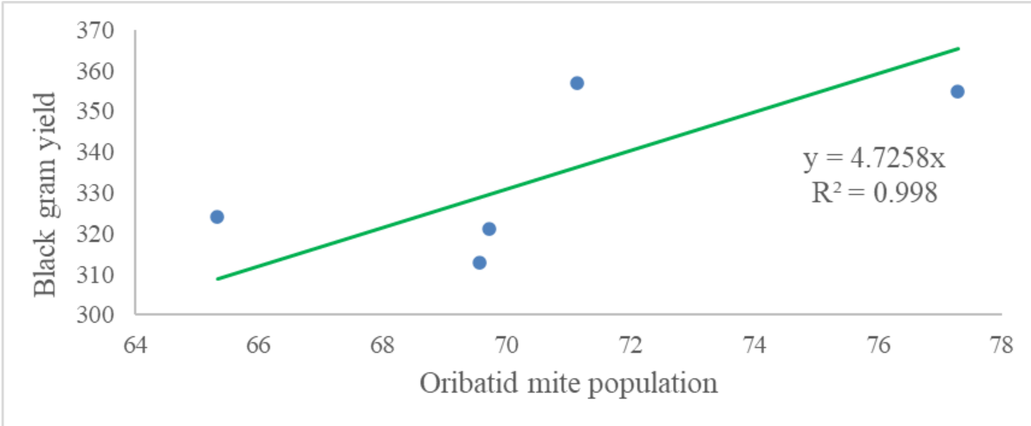

Fig. 6. Regression analysis between yield of Black gram crop and oribatid mite population during 2019 in Zero tillage

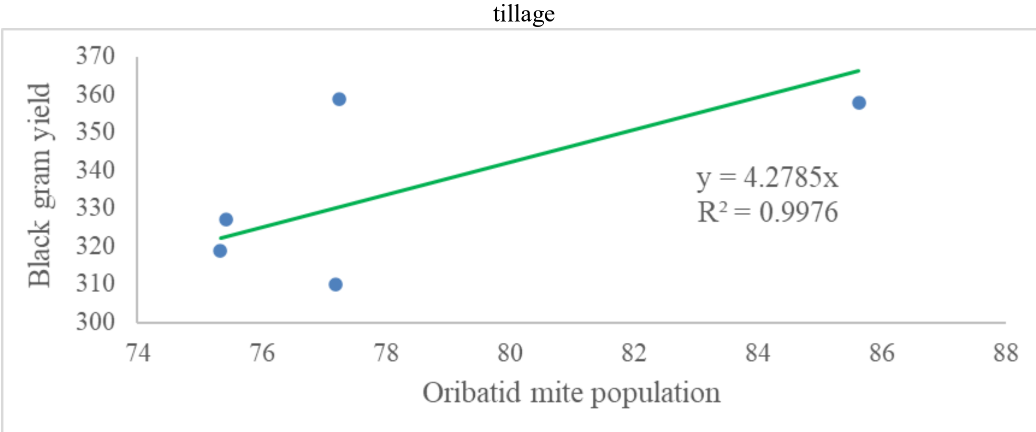

Fig. 7. Regression analysis between yield of Black gram crop and oribatid mite population during 2020 in Zero tillage

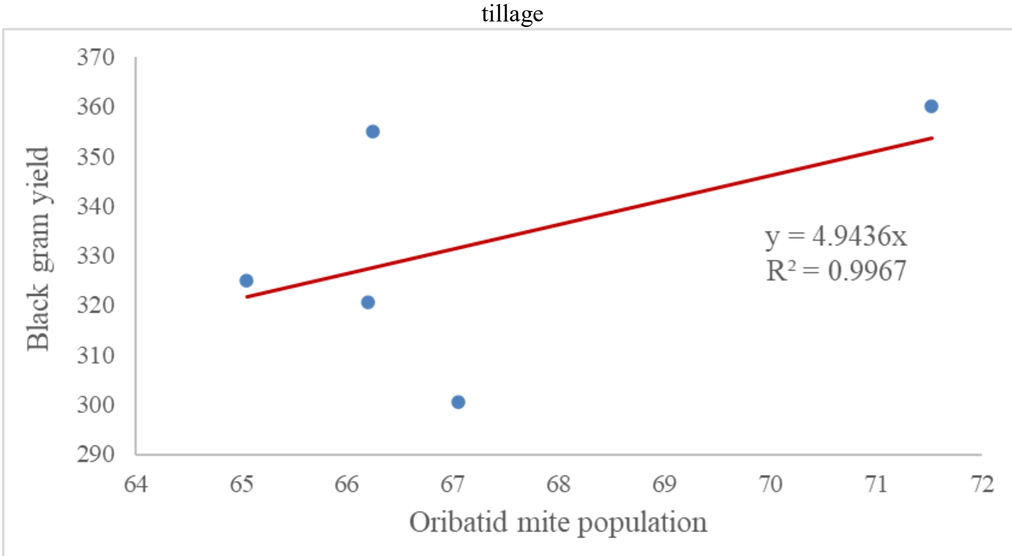

Fig. 8. Regression analysis between yield of Black gram crop and oribatid mite population during 2019 in Reduced tillage

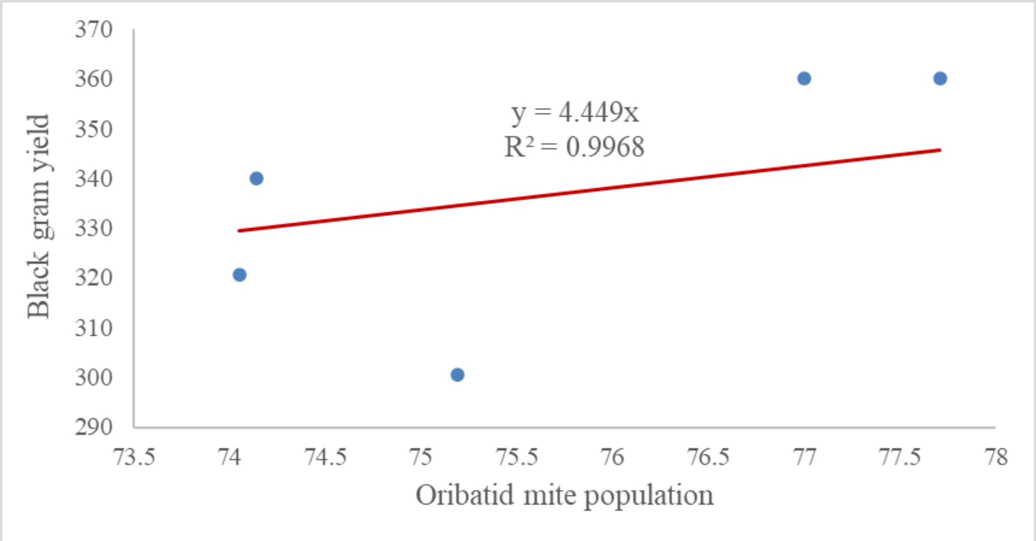

Fig. 9. Regression analysis between yield of Black gram crop and oribatid mite population during 2020 in Reduced tillage

From the present experiment, it was found that the correlation value was positive in between oribatid mite population and yield and yield attributing parameters of Black gram crop. The R^2 value was also high which indicate that, there is a significant relationship among the yield and yield attributing parameters (dependent variables) and oribatid mite population (independent variable). The present work is comparable with the outcomes of the trial conducted by Haq (2016, 2019). From his experimental study, it was confirmed that, oribatid mites provide the significant impact on the growth and development of the yield attributing characters (pod length, number of seeds per pod, number of pods per plant) of Okra crop and cowpea crop which ultimately leads to increase of the crop yield. In the present study, application of zero tillage and reduced tillage with the retention of paddy straw residue create the favourable environment within the soil ecosystem which boost up the growth and development of oribatid mites. On the other hands, conventional tillage causes drastic damage of the soil health and different soil chemical and physical properties which in turn to reduction the biodiversity of soil mesofauna and population of oribatid mites. The oribatid mites mainly feed on plant litters, fungi and algae and take part the crucial role in biodegradation process of organic matters and release many essential plant nutrients in the soil ecosystem which help in enhancement of crop yield (Baker *et al*., 1989; Haq, 1996, 2007; Wickings and Grandy, 2011; Behan-Pelletier and Norton, 2016).

CONCLUSION

From the present experimental data, it has been concluded that Oribatid mite has a positive role in enhancement of Black Gram productivity as well as cultivate the crop in Zero Tillage and Reduced tillage condition which will promote the growth of Oribatid mites.

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REFERENCES

Ayuke, F.O., Karanja, N. K., Muya, E. M., Musombi, B. K., Mungatu, J. and Nyamasyo, G.H.N. 2009. Macrofauna diversity and abundance across different land use systems in Embu, Kenya. *J. Trop. Subtrop. Agroecosyst*., **11**: 371–384.

Ayuke, F.O., Kihara, J., Ayaga, G. and Micheni, A.N. 2019. Conservation agriculture enhances soil fauna richness and abundance in low input systems: examples from Kenya. *Front. Environ. Sci*., 7: 1-17.

Baker, T. G., Will, G. M. and Oliver, G. R. 1989. Nutrient release from silvicultural slash: Leaching and decomposition of *Pinus radiata* needles. *Forest. Ecol. Man*., **27**: 53-60.

Bedano, J. C., Cantu, M. P. and Doucet, M. E. 2005. Abundance of soil mites (Arachnida: Acari) in a natural soil of Central Argentina. *Zool Stud*., **44**: 505–512.

Behan-Pelletier, V. M. and R.A. Norton. 2016. Sarcoptiformes: Oribatida. In: Thorp, J.H., Rogers, D.C. (eds.), Thorp and Covich's Freshwater Invertebrates (4th ed.), Vol. 2: Keys to Nearctic fauna. Elsevier, Boston, PP. 295-305.

Berthet, P. 1964. L'activité des oribatides (Acari: Oribatei) d'une chênaie. *Institut Royal des Sciences Naturelles de Belgique*., **152**: 1-152.

Bhattacharya, T. 1979. Climate, soil and soil inhabiting arthropods of Shantiniketan and adjoining areas. *J. Res*., **3**: 12-23.

Bhattacharya, T., Haldar, G. and Saha, R. K. 1985. Soil microarthropods of a rubber plantation and a natural forest. *Environ. Ecol*., **3**: 143-147.

Coleman, D. C. 2008. Frompeds to paradoxes: linkages between soil biota and their influences on ecological processes. *Soil Biol. Biochem*., **40**: 271–289.

Coleman, D. C., Crossley, D. A. and Hendrix, P.F. 2004. Fundamentals of soil ecology, Second Ed. Elsevier Academic Press, Burlington, PP. 386

Cornaby, B. W., Gist, C. S. and Crossley Jr. D.A. 1985. Mineral cycling in Southeastern ecosystems. In: Howell, F.G., Gentry, J.B. and Smith, M.H. (eds.), ERDA Symposium Series (CONF-740153). US, PP. 588-597.

Cortet, J., Joffre, R., Elmholt, S. and Krogh, P.H. 2003. Increasing species and trophic diversity of mesofauna affects fungal biomass, mesofauna community structure and organic matter decomposition processes. *Biol. Fertil. Soils*., **37**: 302–312.

Edwards, C. A. and Lofty J. R. 1969. The influence of agricultural practice on soil micro-arthropod populations. In: Sheals, J. G. (ed.), The soil ecosystem. Systematics Association Publication. Ecol. Bull. (Stockholm), **25**: 237-242.

Ekschmitt, K., Liu, M., Vetter, S., Fox, O. and Wolters V. 2008. Strategies used by soil biota to overcome soil organic matter stability: why is dead organic matter left over in the soil? *Geoderma*., **128**: 167–176.

Ghatak, T. K. and S. Roy. 1991. The role of soil moisture and organic matter on the distribution of acari fauna in the forest floor of Hooghly district, West Bengal. In: Mukherjee A.B., Som Choudhury, A.K. and Sarkar, P.K. (eds.), Contribution to Acarological Researches in India. Kalyani Publishers. New Delhi, India. PP. 143-158.

Ghilarov, M. S. 1971. Invertebrates which destroy the forest litter and ways to increase their activity. In: Duvigneaud, P. (ed.), Productivity of forest ecosystems. Unesco, Paris, France, PP. 433-442.

Gist, C. S. and Crossely Jr. D.A. 1975. The litter arthropod community in a southern Appalachian hardwood forest: numbers, biomass and mineral element content. *Am. Midl. Nat*., **93**: 107-122.

Hammer, M. 1972. Investigation on the oribatid fauna of Tahiti, and on some oribatids found on the atoll Rangiroa. *BioI. Skr. Dan. Vid. Selsk*., **19**: 1-65.

Haq, M. A. 2007. Biodegradation and productivity in tropical ecosystem by oribatid mites. In: Behan- Pelletier, V., Ueckermann, E.A., Perez, T.M., Estrada- Venegas, E.G. and Badii, M. (Eds.), Acarology XI: Proceedings of the International Congress. Instituto de Biologia and Facultad de Ciencias, Universidad Nacional Autónoma de México Sociedad Latinoamericana de Acarologia, México, 137-150.

Haq, M. A. and A. Xavier. 2005. Four new species of phthiracarid mites (Acari: Oribatei) from Malabar, Kerala. India. *Zoo's Print Journal*., **20**: 2062-2071.

Haq, M. A. 1982. Feeding habits of ten species of oribatid mites (Acari: Oribatei) from Malabar, South India. *Indian J. Acarol*., **6**: 39-50.

Haq, M. A. 1994. Role of oribatid mites in soil ecosystems. In: Bhandari, S. C. and Somani, L. L. (eds.), Ecology and biology of soil organisms. Agrotech Publishing Academy, Udaipur, pp. 143-177.

Haq, M. A. 1996. Nutritional diversity of oribatid mites in relation to soil fertility. *Journal of Karnataka University Science*., **40**: 76-91.

Haq, M. A. 2016. Oricultural farming practice: a novel approach to agricultural productivity. Proceedings of the International Congress. *J. Acarol. Soc. Japan*., **25**: 1-192.

Haq, M. A. 2019. Potential of oribatid mites in biodegradation and mineralization for enhancing plant productivity. *Acarol. Stud*., **1**: 101-102.

Haq, M. A. and Konikkara, I.D. 1988. Microbial association in Xylophagous oribatids. In: ChannaBasavanna, G.P., Virakthamath, C.A. (eds.), Progress in Acarology, Vol. 1. Oxford and IBM publishing co, Pvt. Ltd., New Delhi, PP. 483-489.

Hartenstein, R. 1962. Soil Oribatei. I. Feeding Specificity among Forest Soil Oribatei (Acarina). *Ann. Entomol. Soc. Am*., **55**: 202-206.

Hayes, A. J. 1963. Studies on the feeding preferences of some Phthiracarid mites. *Entomol. Exp. Appl*., **6**: 241-256.

Hulsmann, A. and Wolters, V. 1988. The effects of different tillage practices on soil mites, with particular reference to oribatida. *Appl. Soil. Ecol*., **9**: 327-332.

Kamczyc, J. 2006. Microhabitat preferences of *Veigaia mollis* Karg, 1971 in the mountain reserve “Szczeliniec Wielki”. *Biol. Lett*., **43**: 193–195.

Kihara, J., Martius, C. and Bationo, A. 2015. Crop residue disappearance and macrofauna activity in sub-humid western Kenya. *Nutr. Cycl. Agroecosyst*., **102**: 101–111.

King, L. K. and Hutchinson, K. J. 1976. The effects of sheep stocking intensity on the abundance and distribution of mesofauna in pastures. *J. Appl. Ecol*., **13**: 41-55.

Kowal, N. E. 1969. Ingestion rate of a pine-mor oribatid mite. *Am. Midl. Nat*., **81**: 595-598.

Kowal, N. E. and Crossley Jr., D.A. 1971. The ingestion rates of microarthropods in pine mor, estimated with radioactive calcium. *Ecology*., **52**: 444-452.

Luxton, M. 1966. Laboratory studies on salt marsh Acarina, with notes on their behaviour. *Acarologia*., **8**: 163-175.

Maribie, C. W., Nyamasyo, G. H. N., Ndegwa, P. N., Mungatu, J. K., Lagerlof, J. and Gikungu, M. 2011. Abundance and diversity of soil mites (Acari) along a gradient of land use types in Taita Taveta, Kenya. *Trop. Subtrop. Agroecosystems*., **13**: 11-26

Mhlanga, B. and Thierfelder, C. 2021. Long-term conservation agriculture improves water properties and crop productivity in a Lixisol. *Geoderma*., **398**: 115107.

Mupangwa, W., Mutenje, M., Thierfelder, C. and I. Nyagumbo: 2016. Are conservation agriculture (CA) systems productive and profitable options for smallholder farmers in different agro-ecoregions of Zimbabwe? Renew. *Agric. Food Syst*., **23**: 1–17.

Norton, R. A. 1985. Aspects of the biology of soil arachnids, particularly saprophagous and mycophagous mites. *Quaestiones Entomolgicae*., **21**: 523-541.

Rogers, W. S: Root studies VIII. 1939. Apple root growth in relation to rootstock, seasonal and climatic factors. *J. Pomol. Hortic. Sci*., **17**: 99- 130.

Schrader, S. and Bayer, B. 2000. Abundances of mites (Gamasina and Oribatida) and biotic activity in arable soil affected by tillage and wheeling. *Braunschweiger Naturkundliche Schriften*., **6**: 165-181.

Singh, L. A. and Ray, D.C. 2015. Effect of no-tillage and tillage on the ecology of mite, Acarina (Oribatida) in two different farming systems of paddy field in Cachar district of Assam. *J. Environ. Biol*., **36**: 319-323.

Tadros, M. S. 1976. The role of soil fauna in the decomposition of organic matter. *Annal. Zool*., **196**: 347-356.

Walters, V. 2000. Invertebrate control of soil organic matter stability. *Biol. Fert. Soil*., **31**: 1–19.

Werner, M. P. and Dindal, D.L. 1987. Nutritional ecology of soil arthropods. In: Slansky Jr., F. and Rodriguez, J.G. (eds.), Nutritional ecology of insects, mites, spiders and related invertebrates. Wiley Interscience Publications, New York, PP. 815-836.

Wickings, K. and Grandy, A.S. 2011. The oribatid mites, *Scheloribates moestus* (Acari: Oribatida) alters litter chemistry and nutrient cycling during decomposition. *Soil. Biol. Biochem*., **43**: 351-358.

Table. 1: Mean value of oribatid mite per 100 gm of rhizospheric soil under different treatments of conservation agriculture of Black gram crop in Mustard – Black gram – Rice cropping sequence during 2019

Treatments	Mean value of oribatid mite per 100 gm of rhizospheric soil of Black gram crop in different dates of sowing during 2019						
	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS	70 DAS
CN1	28.00 (5.34)	40.33 (6.39)	51.00 (7.18)	66.00 (8.15)	73.00 (8.57)	75.67 (8.73)	86.33 (9.32)
CN2	29.67 (5.49)	36.67 (6.10)	56.33 (7.54)	64.33 (8.05)	74.33 (8.65)	80.00 (8.97)	81.00 (9.03)
CN3	37.67 (6.18)	50.67 (7.15)	62.33 (7.93)	71.00 (8.46)	78.67 (8.90)	84.33 (9.21)	87.33 (9.37)
CN4	30.67 (5.58)	43.33 (6.62)	51.00 (7.18)	64.67 (8.07)	75.67 (8.73)	80.00 (8.97)	80.00 (8.97)
CN5	29.67 (5.49)	41.00 (6.44)	52.33 (7.27)	62.00 (7.91)	64.33 (8.05)	71.33 (8.48)	77.33 (8.82)
ZN1	42.33 (6.54)	52.00 (7.25)	64.33 (8.05)	73.33 (8.59)	84.00 (9.19)	93.33 (9.69)	88.67 (9.44)
ZN2	40.67 (6.42)	49.00 (7.04)	67.67 (8.26)	70.33 (8.42)	77.67 (8.84)	94.00 (9.72)	87.67 (9.39)
ZN3	53.00 (7.31)	69.67 (8.38)	75.00 (8.69)	77.67 (8.84)	84.67 (9.23)	88.67 (9.44)	92.33 (9.64)
ZN4	44.00 (6.67)	49.33 (7.06)	59.67 (7.76)	70.00 (8.40)	82.67 (9.12)	89.33 (9.48)	93.00 (9.67)
ZN5	30.33 (5.55)	52.33 (7.27)	62.33 (7.93)	68.00 (8.28)	74.00 (8.63)	82.67 (9.12)	87.67 (9.39)
RN1	38.00 (6.20)	48.67 (7.01)	60.33 (7.80)	73.67 (8.61)	79.33 (8.93)	81.00 (9.03)	82.67 (9.12)
RN2	36.00 (6.04)	46.00 (6.82)	60.67 (7.82)	66.33 (8.18)	78.33 (8.88)	90.33 (9.53)	91.67 (9.60)
RN3	41.33 (6.47)	52.00 (7.25)	70.33 (8.42)	78.67 (8.90)	82.33 (9.10)	84.33 (9.21)	91.67 (9.60)
RN4	38.67 (6.26)	47.33 (6.92)	62.33 (7.93)	69.00 (8.34)	72.67 (8.55)	79.33 (8.93)	86.00 (9.30)
RN5	35.00 (5.96)	43.33 (6.62)	61.67 (7.88)	73.67 (8.61)	79.67 (8.95)	81.00 (9.03)	89.00 (9.46)
CD for Factor (A)	N/A	N/A	0.600	N/A	N/A	N/A	0.317
CD for Factor (B)	N/A	0.572	N/A	N/A	N/A	N/A	N/A
CD for Factor (B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

at the same level of (A)							
CD for Factor (A) at the same level of (B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SE (d) for Factor (A)	0.257	0.274	0.210	0.121	0.228	0.223	0.111
SE (d) for Factor (B)	0.406	0.276	0.349	0.252	0.253	0.310	0.271
SE (d) for Factor (B) at the same level of (A)	0.704	0.478	0.604	0.437	0.438	0.538	0.469
SE (d) for Factor (A) at the same level of (B)	0.680	0.508	0.580	0.409	0.453	0.530	0.434
SE (m) for Factor (A)	0.182	0.194	0.149	0.085	0.161	0.158	0.079
SE (m) for Factor (B)	0.287	0.195	0.247	0.178	0.179	0.219	0.191
SE (m) for Factor (B) at the same level of (A)	0.407	0.434	0.333	0.191	0.360	0.353	0.176
SE (m) for Factor (A) at the same level of (B)	0.481	0.359	0.410	0.289	0.320	0.375	0.307

Value in Parenthesis is the square root transformation of the original value

Table. 2: Mean value of oribatid mite per 100 gm of rhizospheric soil under different treatments of conservation agriculture of Black gram crop in Mustard – Black gram – Rice cropping sequence during 2020

Treatments	Mean value of oribatid mite per 100 gm of rhizospheric soil of Black gram crop in different dates of sowing during 2020						
	28 DAS	35 DAS	42 DAS	49 DAS	56 DAS	63 DAS	70 DAS
CN1	22.67 (4.81)	30.33 (5.55)	37.67 (6.18)	39.33 (6.31)	43.00 (6.60)	49.00 (7.04)	59.67 (7.76)
CN2	23.00 (4.85)	30.00 (5.52)	39.67 (6.34)	44.33 (6.70)	47.67 (6.94)	56.67 (7.56)	71.00 (8.46)
CN3	27.67	34.00	42.33	51.00	65.33	74.33	84.00

	(5.31)	(5.87)	(6.54)	(7.18)	(8.11)	(8.65)	(9.19)
CN4	24.00 (4.95)	33.33 (5.82)	41.00 (6.44)	51.33 (7.20)	55.67 (7.49)	66.67 (8.20)	73.33 (8.59)
CN5	19.67 (4.49)	31.00 (5.61)	35.67 (6.01)	48.67 (7.01)	57.67 (7.63)	64.67 (8.07)	70.67 (8.44)
ZN1	49.00 (7.04)	58.67 (7.69)	71.00 (8.46)	80.00 (8.97)	88.67 (9.44)	96.33 (9.84)	97.00 (9.87)
ZN2	47.33 (6.92)	65.67 (8.13)	74.33 (8.65)	77.00 (8.80)	84.33 (9.21)	95.33 (9.79)	96.33 (9.84)
ZN3	59.67 (7.76)	79.67 (8.95)	85.00 (9.25)	91.00 (9.57)	94.33 (9.74)	94.67 (9.76)	95.00 (9.77)
ZN4	50.67 (7.15)	52.67 (7.29)	73.00 (8.57)	80.00 (8.97)	86.00 (9.30)	92.67 (9.65)	93.00 (9.67)
ZN5	37.00 (6.12)	59.00 (7.71)	75.67 (8.73)	81.33 (9.05)	87.33 (9.37)	92.67 (9.65)	94.33 (9.74)
RN1	46.33 (6.84)	55.33 (7.47)	77.00 (8.80)	83.67 (9.17)	86.00 (9.30)	94.33 (9.74)	96.33 (9.84)
RN2	52.67 (7.29)	62.67 (7.95)	67.33 (8.24)	73.00 (8.57)	85.00 (9.25)	90.33 (9.53)	95.33 (9.79)
RN3	54.67 (7.43)	62.00 (7.91)	70.33 (8.42)	82.00 (9.08)	89.00 (9.46)	91.00 (9.57)	95.00 (9.77)
RN4	48.67 (7.01)	57.33 (7.60)	64.67 (8.07)	79.00 (8.92)	89.33 (9.48)	89.33 (9.48)	90.67 (9.55)
RN5	48.33 (6.99)	53.33 (7.34)	63.67 (8.01)	80.33 (8.99)	89.67 (9.50)	90.00 (9.51)	93.00 (9.67)
CD for Factor (A)	0.443	0.861	0.685	0.586	1.030	0.597	0.996
CD for Factor (B)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CD for Factor (B) at the same level of (A)	N/A	N/A	N/A	N/A	N/A	0.810	N/A
CD for Factor (A) at the same level of (B)	N/A	N/A	N/A	N/A	N/A	0.872	N/A
SE (d) for Factor (A)	0.156	0.302	0.240	0.206	0.361	0.210	0.349
SE (d) for Factor (B)	0.403	0.569	0.455	0.344	0.262	0.202	0.334
SE (d) for Factor	0.698	0.986	0.789	0.596	0.454	0.350	0.579

(B) at the same level of (A)							
SE (d) for Factor (A) at the same level of (B)	0.643	0.932	0.745	0.571	0.543	0.376	0.625
SE (m) for Factor (A)	0.110	0.213	0.170	0.145	0.255	0.148	0.247
SE (m) for Factor (B)	0.285	0.403	0.322	0.243	0.185	0.143	0.236
SE (m) for Factor (B) at the same level of (A)	0.246	0.477	0.380	0.325	0.571	0.331	0.552
SE (m) for Factor (A) at the same level of (B)	0.455	0.659	0.527	0.404	0.384	0.266	0.442

Value in Parenthesis is the square root transformation of the original value