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Comparative Study of the Effect of Chemical Fertilizers and Organic Fertilizers on *Eisenia foetida*

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Abstract: Today fertilizer has become essential to modern agriculture to feed the growing population. Chemical fertilizers are used extensively in modern agriculture, in order to improve crop yield. Urea is the most popular and widely used dry N fertilizer. The objective of the present study is to characterize the effect of fertilizers on the earthworm. The effects of soil fertilization with inorganic and organic fertilizers on earthworm rearing (populations, biomass, number of cocoons, juveniles etc.) were studied under different doses of the fertilizers for 60 days. When compared, marked changes were observed in the activity of *Eisenia foetida* in both type of fertilizers introduced. The present work indicates towards the deleterious effect of inorganic fertilizers on the survival of earthworm community in soil.

Keywords: Earthworms, organic fertilizers, chemical fertilizers, cocoons, biomass.

I. INTRODUCTION

Increased crop production largely relies on the type of fertilizers used to supplement essential nutrients for plants. Fertilizer application is required to replace crop land nutrients that have been consumed by previous plant growth with the ultimate goal of maximizing productivity and economic returns. Now a day, there is increased emphasis on the impact on soil environment due to continuous use of chemical fertilizers. The impact of chemical fertilizer application on agricultural land is seen not only in terms of the soil quality but also on the survival of soil organisms dwelling there in. Earthworms are major component of soil fauna in a wide variety of soils and climates and are involved directly or indirectly in biodegradation, stabilization through humus formation and various soil processes ([1] and [2]). Earthworms represent the greater fraction of biomass of invertebrate in the soil as soil macro fauna and play a vital role in structuring and enhancing plant nutrients and hence they can be successfully used as bio indicators for the evaluation of toxic risks of xenobiotic in terrestrial ecosystems [3]. Earthworm populations are influenced by various factors (soil, temperature, moisture, and pH) and the availability of organic matter for food, which may come from plant residues and animal or human waste applied to the land [4]. The abundance of earthworms in soils represents the health of soil ecosystems and the level of environmental safety ([5], [6] and [7]).

In literature, some researchers have concluded the chemical fertilizers to be harmful for soil organisms but on the contradictory they have been supported too to be beneficial as far as their food supply is concern. The acute toxicity of urea on *E. foetida* by using a simple paper contact method was studied, where the relative toxicity grade of urea was categorized as “very toxic” to *E. foetida* [8]. According to reference [9], the inorganic fertilizers may also contribute indirectly to an increase in earthworm populations by increasing the quantity of crop residues returned to the soils, although the long-term use of inorganic nitrogen fertilizers may sometimes cause a decrease in earthworm abundance and biomass, particularly if it is ammonia-based [10]. Other study which measured earthworm activity in mineral fertilizer by considering casting frequency of the worm found higher levels of casting activity in plots with inorganic

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fertilizers alone and with combination with organic matter than the control plots [11]. It is widely believed that organic fertilizers support higher earthworm populations by providing a nutrient rich substrate for earthworm populations, whether they feed directly upon the organic matter or upon the microorganisms which colonize the organic materials. Some researchers have reported in their studies that manure amendments supported higher earthworm densities and biomass than inorganic fertilizers after 5 years of soybean-corn-legume rotations [12]. However, the application of mineral fertilizer on clay soils had been reported to have no significant effect on earthworm populations in another work [13]. In long-term continuous cereal production, earthworm abundance and biomass was seen greatest in plots receiving a combination of manure and inorganic fertilizer ([14] and [9]). Earthworm biomass in plowed fallow plots of a former pineapple orchard was found to be three times greater in plots receiving manure than in inorganically fertilized plots, while a combination of manure and inorganic fertilizer supported the greatest earthworm biomass ([15] and [9]). A study on effect of domestic and industrial effluent on earthworm morpholgy has been carried out by reference [16].

The general recommendation for urea is 120kg/hectare in agricultural lands as per the Indian soil testing manual released in 2011 by the Department of Agriculture, Ministry of Agriculture, India. But Indian farmers overuse urea to achieve more productivity ignoring the negative effects on soil organisms particularly the earthworms. Our study was a short term investigation aimed to find out whether there is some difference in the effect of inorganic and organic fertilizers on earthworms, which are counted among the vital soil organisms favorable for maintaining fertility of soil. Urea was selected as the inorganic fertilizer and an organic fertilizer namely 'Kala Sona' in the local market was used for this purpose.

II. MATERIAL & METHODS

Experimental Model: Earthworms (*E. foetida*) were procured from the vermicomposting unit of Rajasthan College of Agriculture, Udaipur. They were maintained in the laboratory conditions and acclimatized for 15 days. The worms used in the experiment were approximately same body weight and body length.

CHEMICALS USED:

1) **UREA (46% N):** The inorganic fertilizer used in the experiment was Urea which was purchased from the local market. Once applied to the soil, urea is converted to ammonia, which reacts with water to form ammonium ions within two to three days (faster under warm conditions).
2) **KALA SONA (Humic Acid 95%):** Kala Sona is a unique soil conditioner, a naturally occurring organic substance consisting primarily of humic acid and minor levels of minerals, gypsum and clays. It eases organic material incorporation to the soil, accelerating its decomposition and nutrient utilization and eventually increases the carbon content of the soil.

Preparations of soil beds: The experiment was conducted as per method given in reference [11]. Plastic tubs were used for preparations of soil beds. Dried soil (from nearby farmland) was crushed and filtered through a fine mesh sieve. One kg of fine soil was then poured in each plastic tub and then water was added to moistened the soil then 250gm dried powdered (3 week old) cow dung was also added to each plastic tub to avoid starvation.

Addition of Urea: The Urea dose being practically applied in the local agricultural lands for the *Kharif* crop was found to be 174 kg/ hectare of land area. Here, in our experimental set up the soil bed contained 1 kg of soil and cow dung mixture made in the ratio of 1:1. Therefore, the calculated value of Urea for the soil bed was 3.48gm/ kg of soil. In addition to the dose being practiced by the farmers i.e. 3.48gm/ kg, three more doses of Urea were set viz. 0.75gm/ kg, 1.5gm/ kg, and 2.25gm/ kg.

Addition of Kala Sona: The dose of Kala Sona being used by the farmers was 4.5 kg/ hectare and so for our experimental set up the calculated dose of this organic fertilizer was 0.45gm/ kg of soil. One more dose of Kala Sona 0.9gm/ kg was set as the experimental dose.

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Experimental set-up: 20 mature earthworms (same age group) were added to each plastic tub. The tubs were covered with wet muslin cloth so that the moisture level needed by the worms is maintained and also it will prevent them to crawl out of the tub. Thus one control set and five experimental set were prepared. 3 replicates were used for each set. To maintain up-to 70 percent moisture level water was supplied regularly. After 15, 30, 45 and 60 days the changes were observed in activity, morphology, growth of earthworms as well as the number of cocoons and juveniles were also counted.

III. OBSERVATION

The chemical fertilizer urea was found to be fatal for the earthworm population when the dose reached more than 1.5gm/kg soil. A parallel control experiment set was also set to compare the changes in the behavior and morphology. The morphological change observed in the different sets of our experiment has been discussed below. The initial number of earthworms in all the set up along with the control set was 20. At the end of 60^{th} day, all the 20 earthworms were alive in the control set up and in both the organic fertilizer soil bed. In addition, under the dose of 0.75gm/kg urea, the earthworms were also safe. But, as the dose increased from 0.75gm/kg to 1.5gm/kg and 2.25gm/kg, mortality among the test animal was seen.

Days	Parameters	Control set	0.75gm/kg Urea	1.5gm/kg Urea	2.25gm/kg Urea	3.48gm/kg Urea	0.45gm/ kg Kala Sona	0.9gm/ kg Kala Sona
On 1st day	Number	20	20	20	20	20	20	20
	Biomass of alive worms (gm)	3.96	4.44	4.21	4.07	4.19	3.88	4.31
	Biomass/ individual (gm)	0.19	0.22	0.21	0.20	0.20	0.19	0.21
On 15th day	Number	20	20	20	17	0	20	20
	Biomass (gm)	6.41	6.64	6.53	6.74	NA	6.48	6.72
	Biomass/ individual (gm)	0.32	0.33	0.32	0.39	NA	0.32	0.33
	Cocoons	8	10	7	8	NA	6	7
On 30th day	Number	20	20	17	14	0	20	20
	Biomass (gm)	7.74	7.66	6.61	4.95	NA	7.72	7.80
	Biomass/ individual (gm)	0.38	0.38	0.39	0.35	NA	0.38	0.39
	Cocoons	62	51	36	43	NA	41	50
	Juveniles	7	5	6	2	NA	4	2
On 45th day	Number	20	20	17	14	0	20	20
	Biomass (gm)	8.56	8.33	6.12	4.87	NA	8.67	8.71
	Biomass/ individual (gm)	0.42	0.41	0.36	0.34	NA	0.43	0.44
	Cocoons	116	109	110	60	NA	120	106
	Juveniles	29	21	12	9	NA	39	31
On 60th day	Number	20	20	17	13	0	20	20
	Biomass	9.31	8.18	6.45	4.55	NA	9.63	9.20
	Biomass/ individual	0.46	0.40	0.37	0.35	NA	0.48	0.46
	Cocoons	129	115	91	83	NA	131	119
	Juveniles	57	32	21	14	NA	69	62

Table-1: Variation in number of adult worms, biomass, cocoons and juveniles under different sets

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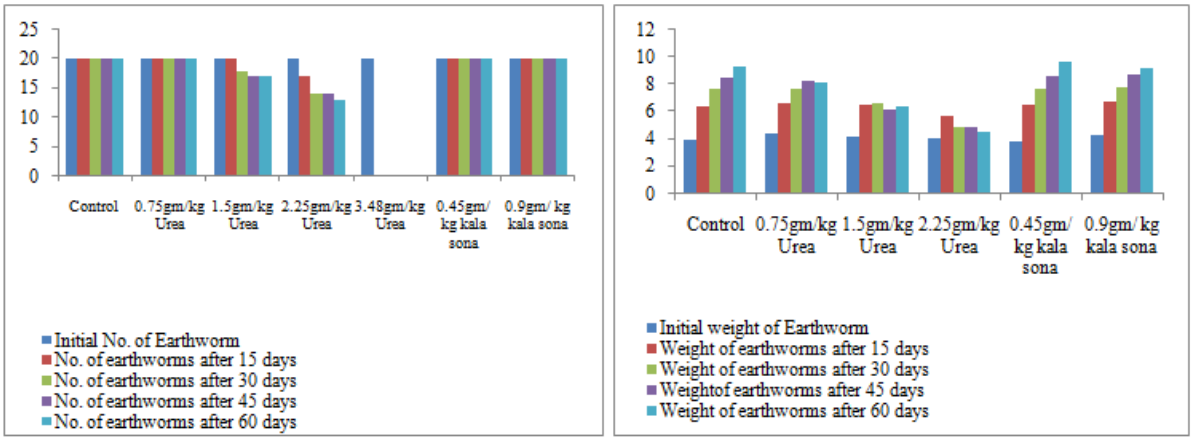
Apart from the observed mortality among the test animal, the changes in weight was noticed in the worms which were able to survive throughout the study period under the higher doses of urea than 0.75gm/kg. The weight of the earthworms was found to be increasing in the starting days of the experiment but after one month a steady pattern of weight gain was observed in urea dose of 2.25gm/kg and also the earthworms in this set was seen weakened in the later days. The initial increased weight of earthworms in this set from rest of the sets can be due to swelling of earthworm's body. On the other hand, there was found appreciable weight gain of the worms under both the organic fertilizer 'Kala Sona' set during the whole study than the control set.



(a) (b)

Fig- 1: (a) Graphical representation of variation in the number of earthworms under the controlled and experimental set up during 60 days.

(b) Graphical representation of variation in the weight of adult worms under the controlled and experimental set up during 60 days.

When the weight gain by earthworm on the 60th day was taken into consideration, highest weight was noted at the end of experiment in the organic fertilizer set of dose 0.45gm/kg and least in 2.25gm/kg urea set. The variation in the weight change was then analyzed on the per individual basis which is shown in table-1. The number of cocoons was highest in the control set and least in urea dose of 2.25gm/kg. Next to the control set the cocoons were found greater in the Kala Sona organic fertilizer dose of 0.45gm/kg. The control set had the highest number of juveniles compared to the rest of experimental set up. In the Urea dose of 2.25gm/kg the numbers of juveniles were only 14 which was the least among all the set up this can be attributed to the least number of cocoons in this set of urea dose.

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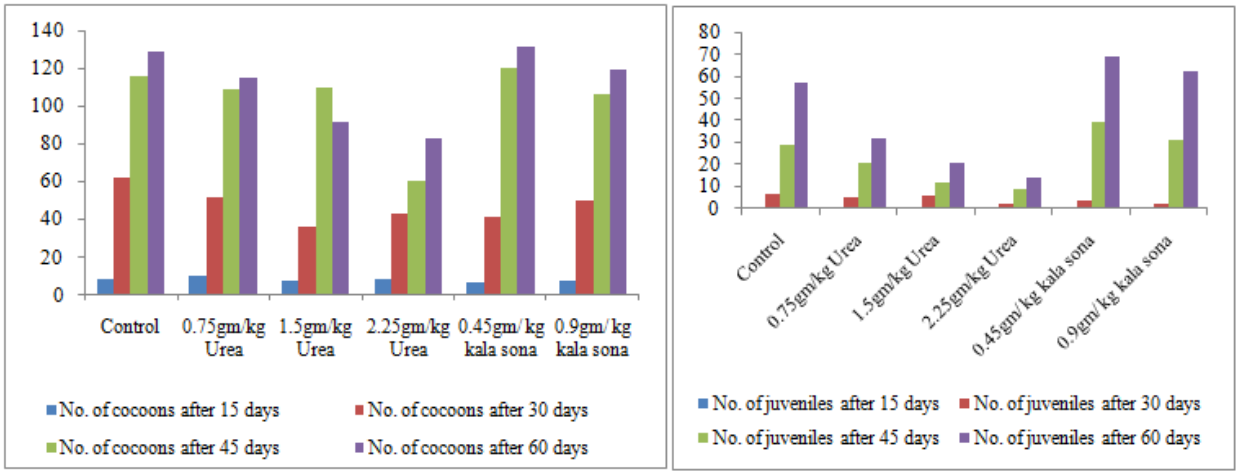

(a) (b)

Fig- 2: (a) Graphical representation of variation in the number of cocoons under the controlled and experimental set up during 60 days. (b) Graphical representation of variation in the number of juveniles under the controlled and experimental set up during 60 days.

At the urea dose of 3.48gm/kg soil, the entire worms were found dead within 24hrs which is shown in the photograph. Shrinking of earthworm body and rupturing of the epidermis and cuticle with the secretion of yellowish fluid was observed in this dose of urea. Least number of earthworms i.e. 13 were left in the soil bed treated with urea dose of 2.25gm/kg at the end of experiment. Although, these number of worms were alive in this experimental set up but the worm's body was found weakened with less body weight. The worms in this set dose were found trying to escape out from the tub; this has also been in fig.-3(c).

(a) (b) (c) (d)

Fig- 3 (a) Earthworms grouping and coiling closely in exposure to Urea (b) Fragmented body of dead *Eisenia foetida* under 3.48gm/kg dose of Urea within 24 hours. (All earthworms were dead) (c) Earthworms crawling out of the tub under Urea fertilizer (d) Lesions in earthworm skin under urea fertilizer.

At the end of our experiment, the healthiest earthworms were seen in the experimental set up with the organic fertilizer 'Kala Sona' and the weakened were the chemical fertilizer urea treated worms. Healthy numbers of cocoon and juveniles were counted in the organic fertilizer treated sets.

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(a) (b) (c) (d)

Fig- 4 (a) Earthworms in control set (b) Weakened earthworms in soil with urea fertilizer (c) Healthy earthworms with well-developed clitellum in soil with organic fertilizer. (d) Earthworm juveniles under organic fertilizer treatment

IV. RESULTS AND DISCUSSION

Urea is the most commonly used nitrogen fertilizer worldwide. The overused urea in agricultural fields may affect the soil organisms especially, the earthworms which are known well for their role in soil fertility [17].The experiment conducted during this investigation revealed many interesting facts. The chemical fertilizer Urea was found to be quite toxic to the earthworms. Different doses of Urea was administered to the soil and simultaneously one organic fertilizer 'Kala Sona' was also used at two doses to conduct a perfect comparison of the two types fertilizer on the earthworm activity. A control set up was run parallel to the experimental set up.There were significant changes in the mortality and weight of tested earthworms after exposure to Urea. There was a positive correlation between earthworm mortality and the concentration of Urea added to soil. The mortality reached 100% when the dose of Urea reached 3.48gm/kg which is the actual dose being practiced by the farmers in the agricultural land. The weight of earthworms exposed to Urea decreased steadily with the increase in the dose of Urea. The loss in body weight changed with increased exposure time. The sharp decrease in weight of earthworms revealed that the high concentration of urea was very toxic to the worms or it could be lethal for the total population. However, at the low concentration of urea there was no significant change in morphology except reduction in body weight.

The major effects on the earthworms could be seen in terms of the number of adult worms, their biomass and cocoon production which clearly indicates the general health of earthworms. The counting of the number of cocoons and juveniles was also done to estimate the harmful effects on their reproductive activity in the two types of fertilizers. The Juvenile and immature worms were also found to be influenced by urea application. Other studies recorded a drastic decrease in earthworm populations and biomass in grassland soils treated onlywith nitrogenous fertilizers [18]. Healthy earthworms in the organic fertilizer set up can be attributed to the fact that the organic fertilizers probably provide food directly for the earthworms and this might be the reason for the higher earthworm populations in the pots treated with organic matter [19]. Other researchers found similar or different results on this topic. Studies showed that the applications of fertilizers with nitrogen and phosphorous caused significant increases in earthworm number and biomass in an oxisoil from India [20]. Similar results were obtained by reference ([21], [22] and [23]). On the contrary, some studies found a significant reduction of earthworm population in certain conditions; it was reported that organic N had a greater effect on earthworm populations than inorganic N ([24], [25] and [26]). In reference [27], a negative impact with ammonium nitrate on grasslands has been reported. On the other hand, study in reference [28] found that urea had a beneficial effect on earthworm activity. Studies indicate, however, that the form and amount of mineral fertilizer can have negative effects on earthworm populations. For example, ammonium sulfate and sulfur coated urea, which at high doses can lead to soil acidification which decreases earthworm populations. Fertilizers with nitrogen create acidic conditions in soil, which is fatal for earthworm ([29], [30] and [7])

In our experiment, mortality of all the 20 earthworms were seen in the dose of urea which is practically been applied in the agricultural land by the farmers i.e. 3.48gm/kg soil. The deleterious effects of urea on earthworm were found under this dose within 24hrs in the form of all dead worms with lesions and separation of the posterior body parts. Urea had a strong toxic effect on the earthworm *Eisenia foetida*, this can be as it exerted its toxic action by way of skin infiltration.

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In rest of the doses variation in number, biomass of worms and the number of cocoons and juveniles were observed which indicates that the inorganic fertilizer had a sound effect on the reproductive potential of the earthworms. On the other hand, the organic fertilizer 'Kala Sona' was found to have positive effect on all the parameters studied of the worms.

V. CONCLUSION

This work is thus to examine the effects of mineral fertilizer urea and organic fertilizer 'Kala Sona' on earthworm *Eisenia foetida*. The application of environmentally realistic doses of urea revealed the possible harmful effects on earthworms when applied in the laboratory. The results of the present investigation clearly demonstrate that treatment with inorganic fertilizer urea is very harmful for *Eisenia foetida*. Whereas, the organic fertilizer Kala Sona was found to have a favorable effect all over. This study may be useful to evaluate ecological risk from agricultural activities such as the application of agrochemicals, and to avoid ecological damage from inappropriate application of chemical fertilizers. Therefore, it is advised that the use of nitrogenous fertilizer like urea should be within ecologically safe limits.

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