

IMPACT OF DIFFERENT ORGANIC FOOD SOURCES ON THE GROWTH AND REPRODUCTIVE PERFORMANCE OF COMPOSTING EARTHWORMS *EISENIA FETIDA* AND *PERIONYX SANSIBARICUS*

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ABSTRACT : The present assessment has been designed to study the effect of different organic waste material viz.; leaf litter and kitchen waste plus goat dung (1+1+2), fennel straw plus cow dung (1+1), groundnut straw plus cow dung (1+1) and castor straw plus cow dung (1+1) used as bedding mixture on growth and different life cycle stages of composting epigeic earthworm species (Oligochaeta) : *Eisenia fetida* and *Perionyx sansibaricus* under laboratory condition for 90 days. Evaluation of their life stages in a particular bedding mixture may be beneficial for large-scale earthworm production. Rapid maturity rate 29.34 ± 1.45 day and incubation period of cocoon 10.33 ± 0.34 day of *Eisenia fetida* was observed in groundnut straw plus cow dung bedding, while earlier maturity rate 41.00 ± 3.05 day and incubation period of cocoon 13.00 ± 0.55 day of *Perionyx sansibaricus* recorded in leaf litter and kitchen waste plus goat dung containing culture. High cocoon production rate was noted in *Eisenia fetida* (1.88 ± 0.02 worm/week) in the groundnut straw plus cow dung bedding and in *Perionyx sansibaricus* (1.21 ± 0.25 worm/week) in leaf litter and kitchen waste plus goat dung bedding. Maximum number of cocoon hatchling of *Eisenia fetida*, 3.69 ± 0.06 no/cocoon was observed in culture containing groundnut straw plus cow dung bedding and in *Perionyx sansibaricus* highest hatchling success rate was recorded 2.28 ± 0.08 no/cocoon in leaf litter and kitchen waste plus goat dung bedding. The biomass growth of *Eisenia fetida* and *Perionyx sansibaricus* also observed and it was higher in groundnut straw plus cow dung and leaf litter and kitchen waste plus goat dung bedding material respectively. Both the species performed poorly in bedding containing castor straw plus cow dung organic material. The present result concludes that the growth and reproductive strategy of worms shows suitability in a particular organic waste material.

Key words : Epigeic, Life cycle, Culture, Hatchling, Bedding material.

INTRODUCTION

Vermicomposting is an eco-biotechnology in which earthworms helps to transform complex organic material into stabilized humus-like product vermicompost. It refers to the use of earthworms on a large scale to produce eco-friendly compost from organic wastes and involves detailed planning to provide the optimum conditions for the growth and reproduction of earthworms (Hartenstein, 1981). All aspects of the earthworm biology such as growth and reproductive potential must be known in order to utilize the earthworms successfully in vermicomposting (Senapathi and Das, 1984). Suitable species of earthworms, the quality and type of raw materials, temperature, moisture, aeration and number of earthworms seem to influence the vermicomposting process (Jambhekar, 1992). Biology of earthworm species suitable for vermicomposting has been described by Dominguez and Edwards (2010). In any case, the high biomass, high production coupled with high instantaneous growth rate and higher turnover values are some of the positive attributes of the species for vermicomposting (Sinha *et al.*, 2002). The reproduction, biomass growth, vermicompost yield and quality have been suggested to be stimulated by quality and intake of feed by earthworms (Bohlen, 2002). Vermicomposting potential of *E.fetida* and *P.excavatus* by using a variety of waste materials such as cattle dung (Chaudhuri and Bhattacharjee, 2002), household waste, sewage sludge, industrial waste, etc. (Edwards, 2004 and Suthar, 2006) is being investigated. Bhat *et al.* (2018) re-

ported that earthworms were used as a organic managers and biofertilizer producer.

The end product, *i.e.* vermicompost is considered as an excellent product, since it is homogenous, has desirable aesthetics, has reduced levels of contaminants and tends to hold more nutrients over a longer period without impacting the environment. Rapid urbanization resulted in an ever-increasing accumulation of urban solid waste. In India, domestic waste is mostly of organic nature and contributes 70-80% to the total solid urban waste. However, it can be used as a potential resource for transformation from expensive disposal problem to stabilized vermicompost production for sustainable land restoration practices. The growth patterns *E.fetida* in number of different organic waste resources have been investigated by various authors in laboratory culture (Edwards, 1998; Kaplan *et al.*, 1980; Kaushik & Garg 2003 and Garg & Kaushik, 2005). The influence of different food sources on growth and reproduction performance of *P.sansibaricus* were studied by Suthar (2007). Gunadi *et al.* (2002) and Gunadi & Edwards (2003) have studied growth, reproduction, and mortality of *E.fetida* for over a year in solid manure, pig manure, and supermarket waste solids.

P.sansibaricus are considered as endemic species while *E.fetida* are to be considered as exotic earthworm species. But, little is known about the composting use of *P.sansibaricus*. Therefore, to establish the use of this species for vermicomposting operations, proper research work is still

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required. Since both species of earthworm have distinct morphological characteristics and also possibly waste degradation patterns their reproductive potential under different organic ambience warrants appropriate experimental confirmation. Besides, comparative studies on composting efficiencies on these species duly need richer literature. Understanding the growth and reproductive efficiency of vermicomposting worms in various substrates is highly essential for effective utilization of earthworms in sustainable waste management system (Appelhof *et al.*, 1996 and Jesikha & Lekeshmanswamy, 2013). Ali and Kashem (2018) has determined the cocoon production rate, hatching success, number of hatchling and growth of *Eisenia fetida* and *Eudrilus eugeniae* in the media containing cowdung.

The comparison of the composting efficiency can be performed by using a common substrate for both species such as fennel straw and groundnut straw. Since every species has specific patterns of utilization of nutrient provided by the bedding material, this protocol is also justifying as they may have not been previously tested as vermicomposting substrates. In this study, efforts have been made to compare the composting potential of *E. fetida* and *P.sansibaricus* by using a common culture material an agro waste that had not been explored extensively in previous studies.

MATERIAL AND METHODS

Preparation of bedding and earthworm culture : Four different types of bedding materials mix substrate were used for experimentation. These bedding materials not only served as bedding but also as a food source for earthworms. The substrates used were as follows : (a) Leaf litter and kitchen waste plus goat dung, (b) groundnut straw plus cow dung, (c) fennel straw plus cow dung and (d) castor straw plus cow dung. All these bedding materials were collected from household waste (kitchen waste), goashala (dung), university campus, Jodhpur (leaf litter) and agricultural land area (agricultural waste) of Sirohi. Life cycle experiments were carried out under laboratory condition with average moisture levels of 60-80%. During the process, moisture was maintained by watering the vermi beds regularly. The temperature of vermi beds was 27±3°C and was maintained by using jute cloths. In this experiment two earthworm species (*Eisenia fetida* and *Perionyx sansibaricus*) were designated in triplicate sets of vermi beds (each 3 kg) prepared in a ratio of 1:1 in plastic containers (30 cm diameter x 25 cm height) and moistened to stabilize within 48 hours. Employed earthworms *E. fetida* were obtained from

vermicompost unit of Kanhaiya goashala, Pal Balaji Road, Jodhpur, and other species *P.sansibaricus* was collected from field (Sirohi). In the experimental sets 25 worms of each species were inoculated separately. One set of control bedding material (without earthworm) was run simultaneously. The culturing plastic containers were perforated at 2-3 places to facilitate leaching of excess water. The vermiculture experiments were conducted for 90 days and maturation, cocoon production, incubation of cocoon and hatchling count were observed as the experimental layout described below.

Biomass, maturation period and cocoon production rate : Five hatchlings of earthworm species in good health condition were taken from the experimental containers for reproductive potential determination. The hatchlings were washed with distilled water to remove any dirt stick on, dried briefly on paper towel, weighed on electronic balance and finally introduced in each respective experimental container. Three replicates were established to monitor the growth and maturation progress daily, the biomass was measured in cluster of earthworm in each container and mature phases was observed. The substrate in treatment container was examined daily in order to determine the onset of cocoon production. Once the cocoons appeared, they were separated by hand sorting, washed lightly in distilled water and counted to determine total number of cocoon rate (no of cocoon/worm/week). No additional feed was added at the time of measurements. On the basis of the obtained data the gain in biomass of the worms (g/worms) were calculated.

Incubation period of cocoon and number of hatchlings : To determine the incubation period and number of hatching per cocoons, fifteen freshly laid cocoons from treatment were taken from the above containers and placed in containers which contained the same material in which their parents were reared. Three replicates were prepared. The bedding were observed daily for the emergence of hatchlings in order to determine the incubation period. As soon as the appearance of hatchling started, they were removed daily using a fine painting brush and counted by hand sorting in order to determine the total number of hatchlings that emerged from a cocoon. The number of un-hatched cocoons was also counted in order to find out the hatching success of cocoons.

RESULTS AND DISCUSSION

A. Life cycle of *Eisenia fetida* : Incubation period of *E. fetida* varied significantly ($P<0.05$) with respect to changes in bed-

Table. 1 Effect of different bedding materials on the life of cycle of *E. fetida*. Each datum is the mean±SEM of three replicates.

Bedding materials	No. of cocoon worm/week	Incubation period of cocoon (day)	No. of hatchling (No./cocoon)	Maturation period (day)	Biomass (g/worms)
Leaf litter and kitchen waste plus goat dung	1.60±0.047	16.67±1.202	2.12±0.065	37.00±1.528	0.49±0.012
Castor straw plus cow dung	1.34±0.031	18.67±0.667	1.71±0.085	50.67±1.763	0.42±0.021
Fennel straw plus cow dung	1.72±0.040	14.33±1.202	2.90±0.065	34.67±1.202	0.53±0.011
Ground nut straw plus cow dung	1.88±0.020	10.33±0.334	3.69±0.066	29.34±1.452	0.61±0.013
F-value	43.37	14.89	151.47	36.68	25.11
P-value	< 0.001	< 0.05	< 0.001	< 0.001	< 0.001

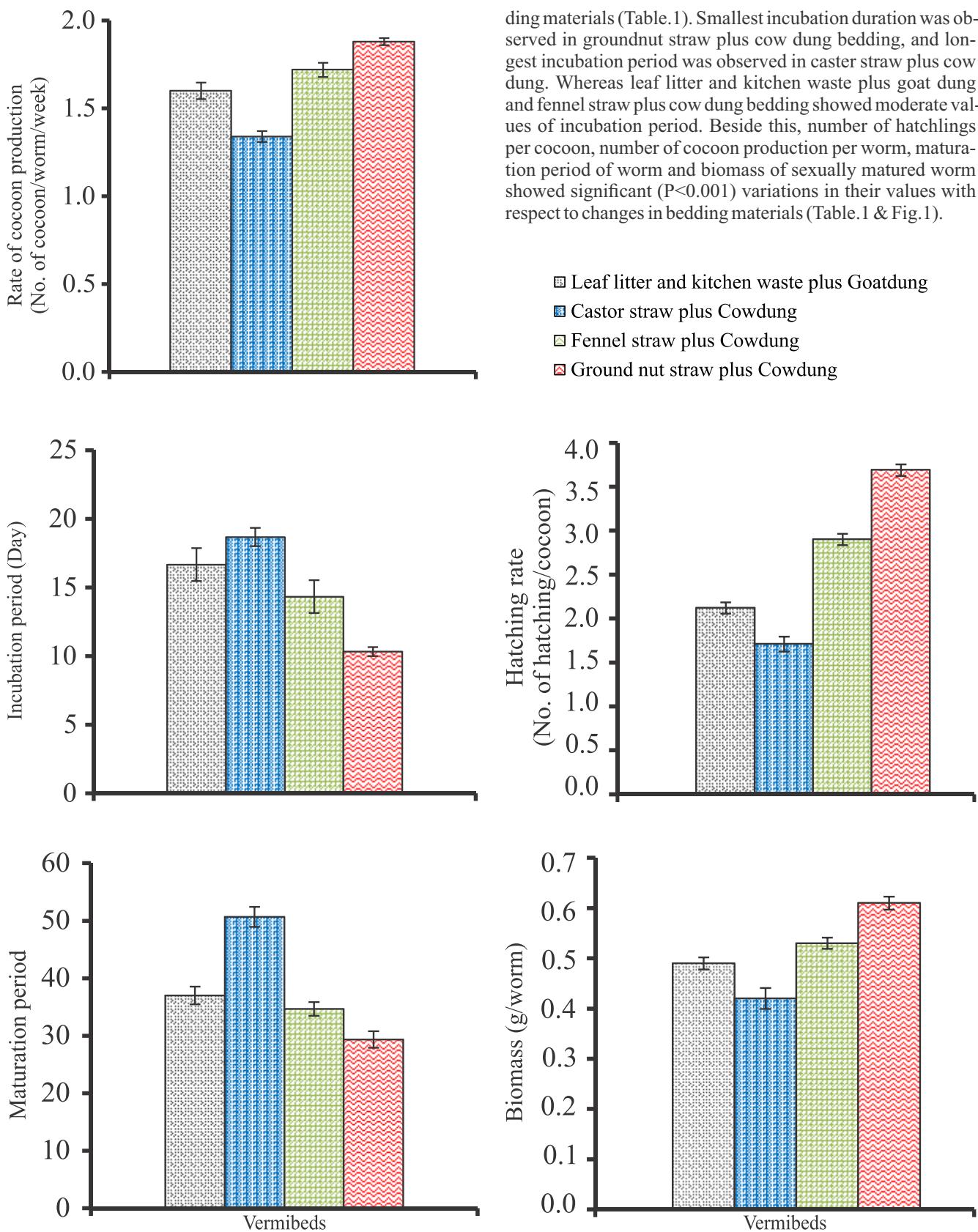


Fig. 1 Effect of different bedding materials on production of cocoon, incubation period, number of hatchlings per cocoon, maturation period and biomass of *Eisenia fetida*.

ding materials (Table.1). Smallest incubation duration was observed in groundnut straw plus cow dung bedding, and longest incubation period was observed in castor straw plus cow dung. Whereas leaf litter and kitchen waste plus goat dung and fennel straw plus cow dung bedding showed moderate values of incubation period. Beside this, number of hatchlings per cocoon, number of cocoon production per worm, maturation period of worm and biomass of sexually matured worm showed significant ($P<0.001$) variations in their values with respect to changes in bedding materials (Table.1 & Fig.1).

B. Life cycle of *Perionyx sansibaricus* : The value of incubation period, number of hatchling per cocoon, number of cocoon production per worm, maturation period of worm and biomass of sexually matured *P.sansibaricus* significantly ($P<0.001$) changed in relation to different bedding materials (Table.2). Maximum value of cocoon production per worm, hatchling per cocoon and wet biomass of earthworm were reported in leaf litter and kitchen waste plus goat dung bedding, while minimum was found in caster straw plus cow dung. The groundnut straw plus cow dung and fennel straw plus cow dung bedding showed moderate values of mentioned parameters. Therefore, lowest incubation and maturation period were recorded in leaf litter and kitchen waste plus goat dung bedding, while highest was found in caster straw plus cow dung. On the other hand, groundnut straw plus cow dung and fennel straw plus cow dung bedding exhibited moderate values (Table.2 & Fig.2).

Life cycle stages : Reproductive potential of *E.fetida* and *P.sansibaricus* were studied in different bedding substrates viz., leaf litter and kitchen waste plus goat dung, castor straw plus cow dung, fennel straw plus cow dung and groundnut straw plus cow dung (Tables.1&2). The values of cocoon/worm/week, incubation period, hatchling/cocoon, maturation period and biomass of *E.fetida* and *P.sansibaricus* varied significantly ($P<0.001-0.05$) with respect to different bedding materials.

The reproductive rate, number of cocoon production, number of hatchling per cocoon and biomass values of *E.fetida* and *P.sansibaricus* were significantly higher in groundnut straw plus cow dung and leaf litter and kitchen waste plus goat dung bedding respectively, while these were lowest in caster straw plus cow dung bedding for both (Tables.1&2 and Figs.1&2). It may be due to rapid decomposing nature, easy digestibility with good sustenance values of bedding substrates which facilitate the more rapid growth and more cocoon production. Neuhauser *et al.* (1980) reported that the rate of weight gain by *E.fetida* is dependent on population density and the type of food. During composting period microbial growth play an important role in earthworm nutrition and fast growth as well as cocoon production of earthworm species (Fayolle *et al.*, 1997).

In laboratory condition physio-chemical properties had a remarkable growth, metabolism and cocoon production in *E.fetida* than *P.sansibaricus* added bedding substrate. Loh *et al.* (2005) also described that biomass gain and cocoon production by *E.fetida* was more in cattle waste than goat waste.

Time of maturation of cocoons and cocoon production vary with species, population density, age structure and external factors specially soil temperature, moisture and energy content of the available food (Lee,1985; Julka,1988 and Edwards & Bohlen,1996).

In the present study shortest incubation and maturation period, maximum hatchling/cocoon and biomass of *E.fetida* were observed in ground straw plus cow dung bedding. Whereas, *P.sansibaricus* showed shortest incubation and maturation period, maximum hatchling/cocoon and biomass in leaf litter and kitchen waste plus goat dung bedding material. However, caster straw plus cow dung bedding substrate exhibited poor performance of cocoon production per week, incubation period, hatchling/cocoon, maturation period and biomass of both species. The palatability and nutritive superiority of feeding substrate may play an important role in reproductive potential of earthworms. When earthworms were cultured on different fed substrates they showed variation in their growth (Kale & Bano,1992; Viljoen & Reinecke,1994 and Dominguez *et al.*,2001). Ndegwa *et al.* (2000), Tripathi & Bhardwaj (2004), Gajalakshmi *et al.* (2005), Garg *et al.* (2005) and Parthasarathi (2007) also reported that the different substrates directly influence the growth, survival and reproductive potential of earthworms.

Incubation period of cocoon of both studied worms varies in between 10.33-22.33 day; it is supported by Reinecke *et al.* (1992) who reported that a mean incubation period is 15-17.8 days for cocoon of tropical earthworm. Bisht *et al.* (2007) observed that cocoon development time of a species also varied with the media for incubation. Number of hatchlings per cocoon is recorded as 1.71-3.69 for *E.fetida* in different bedding substrates. Edwards (1998) reported mean number of hatchlings per cocoon as 3.3 for *E.fetida*. Chaudhury and Bhattacharjee (2011) stated the shape, size, development time and hatching success of cocoons differed greatly among earthworm species in different wastes.

The reports of Bohlen (2002) also supported the present findings that the nutritive superiority of feed substrate stimulates the time of sexual maturity in earthworms. More or less similar results have been described by other workers showing different life phases and sexual maturity of *E.fetida* in different beddings (Neuhauser *et al.*,1979; Hartenstein & Hartenstein,1881; Edwards *et al.*,1985; Venter & Reinecke, 1988; Reinecke *et al.*,1992; Garg *et al.*,2005 and Khomami *et al.*,2016). Development of *E.fetida* was better in cow dung bedding substrate, whereas *P.sansibaricus* showed greater re-

Table. 2 Effect of different bedding materials on the life of cycle of *P.sansibaricus*. Each datum is the mean \pm SEM of three replicates.

Bedding materials	No. of cocoon worm/week	Incubation period of cocoon (day)	No. of hatchling (No./cocoon)	Maturation period (day)	Biomass (g/worms)
Leaf litter and kitchen waste plus goat dung	1.21 \pm 0.025	13.00 \pm 0.0557	2.28 \pm 0.084	41.00 \pm 3.055	0.45 \pm 0.006
Castor straw plus cow dung	0.70 \pm 0.018	22.33 \pm 0.667	1.55 \pm 0.030	73.67 \pm 1.856	0.33 \pm 0.012
Fennel straw plus cow dung	0.91 \pm 0.040	16.33 \pm 0.082	1.87 \pm 0.052	58.67 \pm 1.453	0.37 \pm 0.006
Ground nut straw plus cow dung	1.09 \pm 0.026	14.00 \pm 0.557	2.03 \pm 0.040	50.67 \pm 1.202	0.39 \pm 0.004
F-value	61.85	37.07	30.81	46.74	38.01
P-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

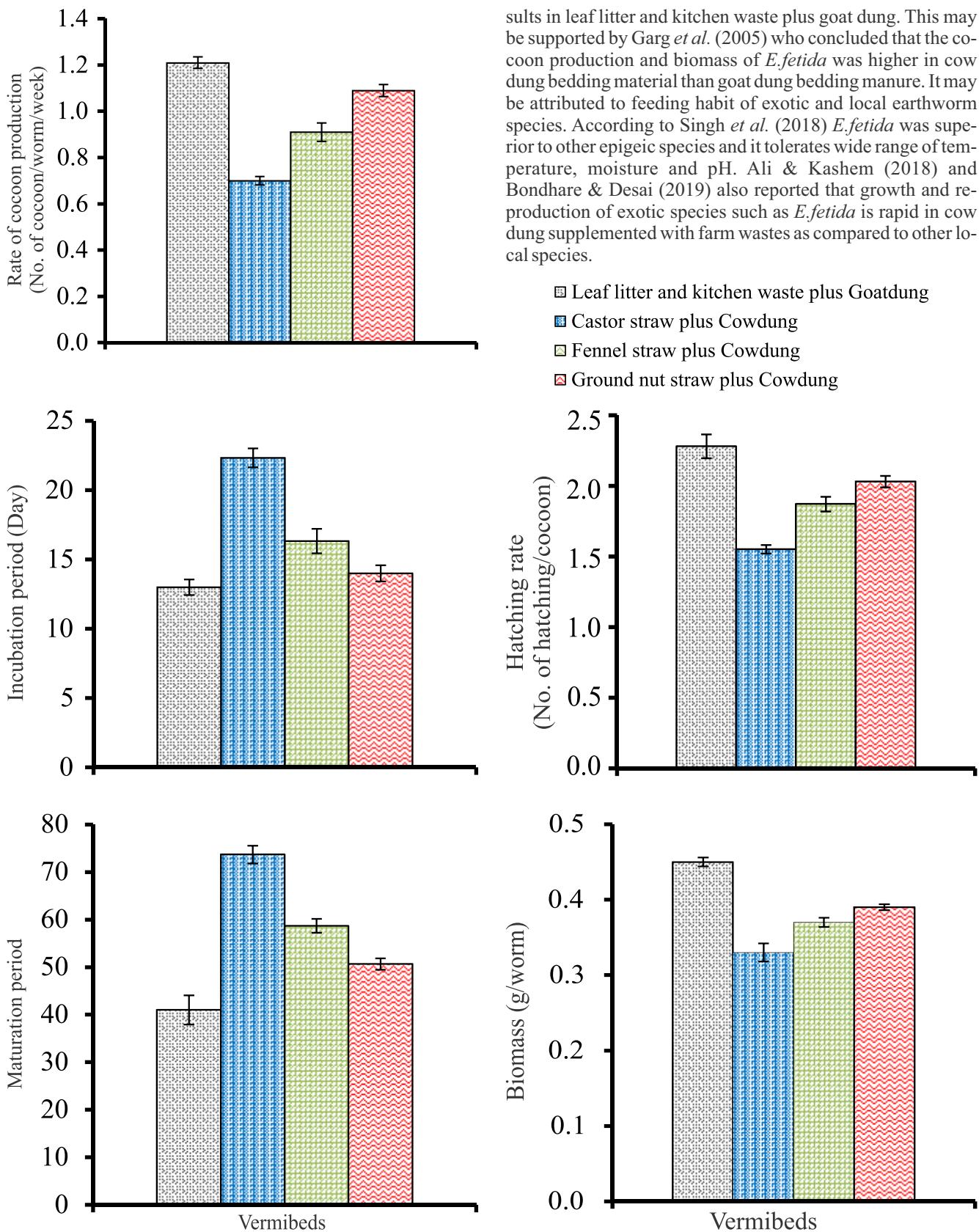


Fig. 2 Effect of different bedding materials on production of cocoon, incubation period, number of hatchlings per cocoon, maturation period and biomass of *Perionyx sansibaricus*.

The variation in the rates of cocoon production could be due to differences in biochemical quality of the feeding substrates. According to Edwards *et al.* (1998) growth rate is a good indicator for comparing the different wastes suitable for growth of earthworms and also find out the time taken to attained sexual maturity. In contrast Garg *et al.* (2005) observed that in some bedding materials the weight gain by earthworms was more but cocoon production was lower than other feeds tested.

On the other hand, the more continuous and high rate of cocoon production as well as higher hatching success in *E.fetida* and *P.sansibaricus* indicated their possible usefulness in vermiculture for waste degradation as well as for soil reclamation depending upon the species (Bhattacharjee & Chaudhuri, 2002 and Chaudhuri & Bhattacharjee, 2011). Further a detailed and systemic study is required to divulge the facts about cocoon productivity, incubation period, number of hatching/cocoon, maturation period and biomass dy-

namics in different animals manure and agro-wastes in Rajasthan.

The reproduction potential of *Eisenia fetida* is higher than *Perionyx sansibaricus*. However, to know about their reproductive strategies in different wastes as a decomposer, it is important that the different life stages of the worms on bedding material be studied thoroughly. *Eisenia fetida* is most suitable earthworm species for composting than any other local species.

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