weeding (20 and 40 DAS) + recommended dose of N, P, K and Zn, followed by T5 treatment (5.17 t/ha), wherein line sowing of sprouted seed and improved practices (herbicide application followed by one hand weeding, N, P, K + Zn at recommended dose) were adopted. Similar results were reported by Rachel Sophia Alexander and James Martin (1995) at Coimbatore in clay loam soil condition. Averaged over management practices, varieties ADT 36 (6.09 t/ha) and ASD 16 (5.84 t/ha) recorded higher grain yields indicating the positive response of these varieties to improved management practices (T5) such as wet seeding and herbicide application.

From the two years of study, it could be concluded that direct seeding under puddled condition is as good as transplanting. Varieties ADT 36, ASD 16 and IET 9978 responded positively for direct seeding and improved management practices *viz.*, direct seeding of sprouted seeds by broadcasting, butachlor application at 1.25 kg/ha 6 days after rice emergence followed by one hand weeding maximum tillering stage and application recommended dose of N, P and K (125:50:5 kg/ha) and $ZnSO_4$ (25 kg/ha); 1/3 N, full P and Z and 75% K as basal; 1/3 N at tillering and 1/3 with 25% K at P.I.stage.

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POPULATION DENSITY OF EARTHWORMS UNDER DIFFERENT CROP ECOSYSTEMS

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ABSTRACT

The population density of earthworms under four different crop ecosystems *viz.*, rice, cotton, sugarcane and pulse was assessed in six districts of Tamil Nadu. Among the four crop ecosystems studied, rice supported maximum earthworm population followed by sugarcane, cotton and pulses in that order. Among the different soils in the study area, organic matter rich soils supported more earthworm.

KEY WORDS : Earthworms, population density, crop ecosystems, soil types.

E..thworms are nocturnal invertebrates of agro ecosyste... This wonderful creature beneath our feet silently does the job of decomposition and humification by injesting soil and organic matter remains and make them undergo complex biochemical changes in it's intestine, excretes and mixes it well with the soil (N..vak and Rath, 1996). Thus, they enable the formation of nutrient rich humus that improves soil physical and chemical characters, which inturn will improve crop growth. It is clear that a good population of earthworms helps in improving soil properties and boost crop yield. But modern agricultural practices drastically affect the population of earthworms. So, the present study was undertaken to estimate the population density of earthworms in six districts of Tamil Nadu with varying soil types.

MATERIALS AND METHODS

The quantitative study of earthworm populations requires their extraction and enumeration in some portion of soil using any of the standard sampling methods. In this study, earthworm population was estimated by the handsorting method (Bretscher, 1896) in the rice, sugarcane, cotton and pulse cropped soils of the six districts selected (Table 1). Soil samples from an area of $1m^2$ were dug out from ten places from each crop ecosystem and earthworms were sorted out from them by hand. Sampling was done by digging with a spade first cutting around the edge of the sample. The samples were sorted against a pale coloured background to increase the probability of detecting earthworms for which white trays were used. After handsorting, the population of very small species and immature worms which were most commonly missed out in hand sorting was estimated by the soil washing method (Raw, 1960). The handsorted samples were washed away of soil in a 2 mm sieve within another 0.5 mm mesh sieve standing in a bowl of water. The sieves were then immersed in magnesium sulphate solution and the worms that floated to the surface were collected. Species wise population of worms was not attempted for want of expertise in the identification of earthworms.

RESULTS AND DISCUSSION

Significant differences were observed in the population density of earthworms between different crop ecosystems. Of the four crop ecosystems sampled, rice ecosystem harboured more

Table 1. List of Places of sample collection

District	Place	Soil type	Crop
*Kanyakumari	Killiyoor	Clay loam	Rice
	Marthandam	Clay loam	Pulse
Tirunelveli	Panakudi	Sandy loam	Rice
Kattabomman	Vasudevanallur	Clay loam	Cotton
	Vasudevanallur	Clay	Sugarcane
	Vasudevanallur	Sandy Clay	Pulse
V.O.Chidambaranar	Killikulam	Red soil	Rice
	Killikulam	Red soil	Cotton
	Killikulam	Red soil	Sugarcane
	Killikulam	Red soil	Pulse
Madurai	Othakadai	Sandy clay	Rice
	Othakadai	clay	Cotton
	Usilampatti	clay	Sugarcane
	Vilankudi	Sandy clay	Pulse
Kamarajar	Muthuramalingapuram	Black soil	Rice
	Muthuramalingapuram	Black soil	cotton
	Narikudi	Black soil	Sugarcane
	Narikudi	Black soil	Pulse
Ramanathapuram	Mandalamanickam	Black soil	Rice
	Kamudhi	Black soil	Cotton
	Mandalamanickam	Black soil	Sugarcane
	Valaiyapoongulam	Clay	Pulses
Coimbatore	Paddy Breeding Station	Clay soil	Rice
	Eastern block	Clay soil	Cotton
	Eastern Block, TNAU	Clay soil	Sugarcane
	University farm, TNAU	Red soil	Pulses

* No cultivation of sugarcane and cotton

Table 2. Population density of earthworms in individual crop ecosystems

Crop ecosystem	Mean population (m^{-2})
Rice	62.23
Cotton	21.33
Sugarcane	45.17
Pulses	16.92
SE	1.59
CD (0.05)	3.33
CD (0.01)	4.54

population of earthworms with an average population density of 62.23 m^{-2} than sugarcane (45.17 m^{-2}), cotton (21.3 m^{-2}) and pulse crop ecosystems (16.92 m^{-2}) (Table 2). The highest population density was observed in the rice fields of Tirunelveli Kattabomman district with an average of 111 m^{-2} and lowest population of earthworms (2.7 m^{-2}) was observed in cotton fields in the eastern block of the Tamil Nadu Agricultural University campus, Coimbatore (Table 3).

The differences in earthworm population among different crop ecosystem may be due to the fact that the number of species supported by agricultural soils depend mainly upon the kind and extent of the plant cover and it's permanence (Edwards and Lofty, 1978). Population density of earthworms recorded in the present study is far below than that recorded by Lavelle (1987) in tropical Nigeria (1000-3000 individuals m^{-2}). It may be due to paucity of abundant organic matter or leaf litter, continuous moisture and less or no disturbance of soil, but the population estimated in this investigation comes nearer to the estimate of Khalaf-El- Duweini and Ghabbour (1965) in Egypt ; Lal (1974) in maize fields of Nigeria (100 m^{-2}) ; Dash and Patra (1977) in grassland sites of Orissa and by Kaushal and Bisht (1994) in Himalayan pasture soil (138.8 m^{-2}).

With respect to individual ecosystems, the higher population density encountered in rice fields might be due to the continuous availability of moisture and shade from the rice canopy. Shade might also have influenced the population of earthworms in sugarcane fields (Westernacher and Graff, 1987). Besides soil moisture, mulch cover might have also favoured the earthworm population in the sugarcane ecosystem. Low population of earthworms in cotton fields can be attributed to intense application of pesticides, frequent tillage of

Table 3. Population density of earthworms in different crop ecosystems in different districts

District (D)	Crop ecosystem (C)			
	Rice	Cotton	Sugarcane	Pulses
Tirunelveli Kattabomman	111.00	17.32	49.70	14.20
V.O.Chidambaranar	54.80	24.20	35.30	27.30
Kamarajar	37.80	28.50	31.80	14.90
Madurai	57.40	24.60	52.20	17.41
Ramanathapuram	37.30	30.70	34.42	15.76
Coimbatore	75.10	2.70	67.70	12.00
	SE	CD (0.05)		CD (0.01)
D at C	4.31	8.99		12.26
C at D	3.91	8.15		11.12

soil, absence of ground cover and lack of adequa moisture in the soil surface. Frequent tillage of s often leads to a reduction in earthworm activi because it increases the soil temperature a decreases the soil moisture reserves (Lal *et a* 1978 ; Edwards and Lofty, 1982) apart fr causing physical injury. As for the low earthw density in the pulse cropped soil, it might be du the fallow effect (Simpson *et al.*, 1993).

Though modern agricultural practices can held responsible for the low earthworm populati in agricultural fields and those methods cultivation that retain organic matter in the so without intense pesticide application are known encourage earthworm activity (Zisci, 1969).Studi on the earthworm population in other cro ecosystems is also to be carried out to evolve strategy to increase their population in Tamil Nad soils.

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RESEARCH NOTES

NITROGEN FIXATION AND NODULATION OF CASUARINA IN RELATION TO IRON AND ZINC

Nitrogen fixation is carried out by a wide ariety of symbiotic and free living organisms in ifferent soil conditions and moisture status. *asuarina equisetifolia* is an actinorhizal plant odulated by Frankia. Phosphorus availability can e increased in the soil through increased olubilisation and mineralisation by inoculating the oil with Vesicular-arbuscular mycorrhizae (VAM). ron and zinc application to nodulating tree crops as been found beneficial. Boardman and Mc Guire 1990) explained the role of zinc in forestry specially in nodule formation. Iron is mainly esponsible for binding and reduction of dinitrogen Richards, 1990).

Nursery experiment was conducted during May '93 to September '93 in polythene bags containing potmixture (3:1 ratio soil : FYM) at the Forest College and Research Institute, Mettupalayam with one month old seedlings of *C. equisetifolia*. Major nutrients, *Frankia* and VAM inoculation were included as main treatments and micronutrient application as subtreatments. The experiment was laid out in factorial completely randomised design with four replications. After 120 days, the seedlings were carefully uprooted for measuring biometric characters and analysed for Zn and Fe contents. N fixation was estimated by total N difference method.

Table 1. Number of nodules per seedling

Treatments	Sandy					Sandy Loam				
	Control	Fe	Zn	Fe+Zn	Mean	Control	Fe	Zn	Fe+Zn	Mean
Control	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Frankia	1.99	2.34	2.64	2.92	2.47	2.99	2.24	3.39	3.74	3.32
VAM	0.71	0.71	1.73	1.99	1.28	0.71	0.71	0.71	0.71	0.71
Frankia+VAM	2.54	2.73	3.16	3.46	2.97	2.54	2.73	2.99	3.32	2.90
Fertilizer (NPK)	0.71	1.55	1.85	2.23	1.58	0.71	0.71	0.71	0.71	0.71
Fertilizers+Frankia	1.29	1.53	0.71	2.34	1.46	0.71	2.64	2.99	2.99	2.30
Fertilizers + VAM	0.71	0.71	1.53	2.21	1.29	0.71	2.64	0.71	0.71	1.19
Fertilizers+Frankia+VAM	2.91	3.46	3.74	3.67	3.45	3.16	3.32	3.46	3.74	3.44
Soil(-FYM)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
Mean	1.36	1.60	1.86	2.25	1.77	1.44	1.93	1.82	1.93	1.78

C.D. (P=0.05) T-0.36 M-0.24 TxM - 0.27 C.D. (P=0.05) T-0.12 M-0.08 TxM - 0.13

S x SL NS