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Research Article

AMELIORATION OF SOIL PROPERTIES BY BIOINOCULATION ON THE GROWTH OF *SORGHUM VULGARE* (NTJ1).

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ABSTRACT

The present study was planned to assess the amelioration effect on rhizosphere soil with the use of bioinoculants like nitrogen fixing bacteria (NFB) *Azotobacter chlorocooccum* and phosphate solubilizing bacteria *Pseudomonas striata* (PSB) and vermicompost as individual and in combination on growth of NTJ1variety of *Sorghum vulgare.* The Physico-chemical properties *viz.,* Soil pH, organic carbon content, essential Nutrients (N, P, K), growth promoting elements (Fe, Mn, Zn and Cu) of soil were evaluated with pot culture experiments in 30^{th}, 60^{th} and 90^{th} day with different treatments (T_1-T_7). The results of the study showed that the application of bioinoculants (NFB & PSB) and vermicompost as biofertilizer can be one of the management practices that can help to maintain or increase the content of organic matter and improve soil fertility. The result also indicated that our formulation is found desirable to improve the soil physical and chemical properties apart from increasing the grain yield and green stalk yield of *Sorghum vulgare* variety NTJ1.

Keywords: *Bioinoculants, Pot Culture, Azotobacter Chlorocooccum, Pseudomonas Striata*

INTRODUCTION

Plant growth depends upon soil fertility and the inherent ability of soils to supply essential nutrient elements to plants. Soil fertility is related to the amount of available nutrients which is measured by crop yield capacity and still others look it to be a major function of organic matter or even soil texture. The pH and Organic carbon content affects all chemical, physical and biological soil properties (Brady and Weil, 2002 & Nigam *et al*., 2014). Organic matter to agricultural soils improves the physical, chemical and biological soil properties, as well as supply plants with nutrients (Aranda *et al*., 2015). The mineralization time is variable and depends mainly on the organic matter’s chemical composition, as well as on the soil’s physicochemical characteristics, moisture and temperature (Tejada *et al*., 2014). Macronutrients (N, P and K) and Micronutrients (Fe, Mn, Zn, and Cu) are important soil elements that control soil fertility (Nigam *et al*., 2014). Vermicompost, Phosphate Solubilizing Bacteria (PSB) and free living Nitrogen fixing bacteria (NFB) are the most widely used biofertilizers significantly contributing N, P and K to plants and also providing resistance to drought. These are inexpensive and abundant resources available in most parts of the globe.

Soil test-based fertility management is an effective tool for increasing productivity of agricultural soils that have high degree of spatial variability resulting from the combined effects of physical, chemical or biological processes (Goovaerts,1998). Recently, Barragan - Ocana and Carmen del-Valle-Riveraa (2016) studied and analysed about the effects of the use of biofertilizers in agriculture on rural development and environmental protection in under developed countries.

In our previous study, inoculation of Vermicompost, Nitrogen fixing bacteria (NFB) and Phosphate Solubilizing Bacteria (PSB) enhanced the number of leaves, shoot length, fresh and dry biomass of root and shoot, Protein and lipid contents in shoot and root compared to control plants. We found that the contents of chlorophyll, carbohydrates, were also found increased in treatment plants. The inoculation of vermicompost, NFB and PSB was found superior than single inoculum not only in promoting plant growth, but also in maintaining soil fertility (Girija and Vijaya, 2016 a & b).

In continuation of the experiment we have investigated the physico chemical properties of the rhizosphere soil in the presence of Nitrogen fixing bacteria and phosphate solubilizing bacteria in a sole application or in combination with vermicompost on *Sorghum vulgare* NTJ1 variety.

MATERIALS AND METHODS

The seeds of *Sorghum vulgare* variety (NTJ1) were procured from Sri Venkateswara Agriculture research institute, Tirupati, Andhra Pradesh.

Maintanance of culture,Vermicompost preparation and experimental design was followed according to Girija and Vijaya (2016). Culture of *Azotobacter chlorocooccum* and *Pseudomonas striata* was obtained from Regional Biofertizers Development Centre, Bangalore Division, India.

Experimental site

This study was implemented in Glasshouse at the Department of Botany, Sri Venkateswara University, Tirupati.

Vermicompost Preparation

Fresh leafy vegetation was collected from different sites of Sri Venkateswara University campus at 10 -20 % flowering stage and chopped into the small pieces (2-3 cm). Equal amount of weed vegetation was used for each treatment. The material was uniformly spread into the pits to a height of about 5 cm and sprinkled with 10 percent cow dung slurry (1 kg dung in 10 liter water) and soil. Secondly, plant material was added and finally, the pits were sealed with dung slurry and fine clay to prevent loss of heat or exchange of gases. After partial decomposition (15 days), first turning was given for uniform decomposition and sufficient amount of water was sprinkled for maintaining 50-60 percent moisture. Then the earthworms of the species *Eisenia foetida* and *Eudrilus eugeniae* (50-60 individuals per pit) were released.

The vermicomposting process was completed within 25 days and a completely decomposed fine, dark brown colored granular excreta was obtained for the field experiment.

Pot Experiment and Conditions

A pot experiment with soil was carried out in a greenhouse controlled at 30–35 °C. The weekly average temperatures ranged between 27.1^{o}C to 36.2^{o}C and 14.6^{o}C to 23.7^{o} C respectively during the experimental period (30th, 60th and 90th day).

Sorghum vulgare plants were grown in plastic pots containing a sterilized mixture of soil and sand (1/1 w/w). Eight experimental replicates were prepared for each treatment. Seeds of sorghum vulgare were surface sterilized with 0.005% sodium hypochloride and they were sown into a 5cm depth in pots in green house under natural photoperiods (23.5/18°C day/night, 6000/4000 lux light intensity) for three months. Inoculum of vermicompost (20gm/kg soil), 20 ml of N2 and PSB was laid around the seed. The experimented treatments are given in Table 1.

Table 1: Inoculation Conditions of Bioinoculants NFB & PSB with and without Vermicompost

S. No	Treatment	Conditions Adopted
1.	$\mathbf{T_1}$	Control (No inoculation),
2.	$\mathbf{T_2}$	Inoculation with vermicompost,
3.	$\mathbf{T_3}$	Inoculation with nitrogen fixing bacteria (*A. chrocooccum),*
4.	$\mathbf{T_4}$	Inoculation with phosphate solubilizing bacteria (*P.striata*),
5.	$\mathbf{T_5}$	Inoculation with vermicompost and *A. chrocooccum,*
6.	$\mathbf{T_6}$	Inoculation with vermicompost and *P. striata ,*
7.	$\mathbf{T_7}$	Inoculation with vermicompost, *A. chrocooccum* and *P.striata.*

Soil Physical and Chemical Analysis

The physical and chemical analysis of the soil from the pots was carried out on 30th, 60th and 90th day in all the treatments. Soil samples were collected at 10 cm depth from each pot separately. They were air dried under shade and grounded with wooden pestle to break the clumps. Dried samples were passed through 2 mm sieve. Samples were stored in polythene bags until use. Sieved soil samples were further sub sampled and ground to pass through 0.5 mm sieve for micronutrient analysis. Properties of the soil were done following Barreto *et al*., (2009). Soil pH was determined by using (Jackson, 1967). Organic carbon content of soil was estimated by following Walkely and Black's method (1934).

Soil Nutrients (Nitrogen, Phosphorous and Potassium)

Available nitrogen in the soil samples was determined with alkaline potassium permanganate method as proposed by Subbaiah and Asija (1956). Available nitrogen was calculated using the following formula.

$$\text{Available nitrogen (Kgs / Hectare)} = \frac{14 \text{ x TV x } 0.02 \text{ x } 2.24 \text{ x } 10^{6}}{\text{weight of soil x } 1000} \text{ ; TV= Titre value}$$

The available phosphorous in the soil samples was estimated by Olsen's method (Oslen and Sommers, 1982). The available potassium was extracted with neutral normal ammonium acetate solution and the potassium content was determined by using the flame photometer (Jackson, 1967).

The micronutrients iron, manganese, zinc and copper in the soil sample were analyzed by DTPA extract method (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

In this study the determination of various topographic parameters (Soil pH and Organic carbon) and characteristics of micro and macro nutrients of soil were done with the bioinoculation treatments with NFB,PSB and vermicomposst in pot culture with *Sorghum vulgare* seedlings at 30th, 60th and 90th day.

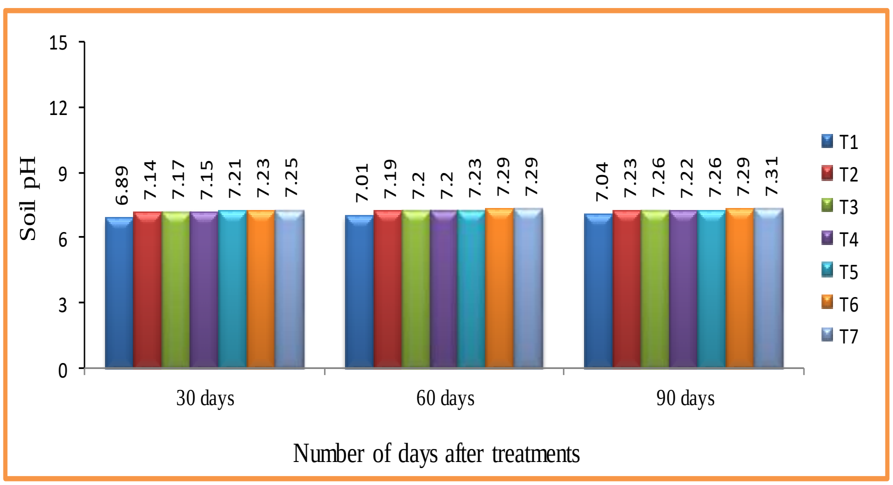
Physical Characteristics of Soil

Soil pH

There was a significant difference in soil pH at 0.01% level in different treatments. On 30th, 60th and 90th day, soil pH in the control (T_1) was ranged from 6.84 to 7.04 and in the T_2, $T_{3,}$ T_4, T_5, T_6 and T_7 treatments, it ranged from 7.14 to 7.31. (Figure 1a)

Soil Organic Carbon (OC) (%)

On 30th, 60th and 90th day, the highest percent of organic carbon was recorded in T_7 (0.82, 0.84, 0.89) followed by T_6 plants (0.77, 0.80, 0.83). The percent of organic carbon in T_5 plants was found almost similar to T_4 plants. The content of organic carbon in $T_{2,}$ $T_{3,}$ T_4 T_5 and $T_{6,}$ treatments was significantly (0.01%) high compared to T_1 plants. But there is no significant difference between the treatments and days at 1% level (Figure 1b).



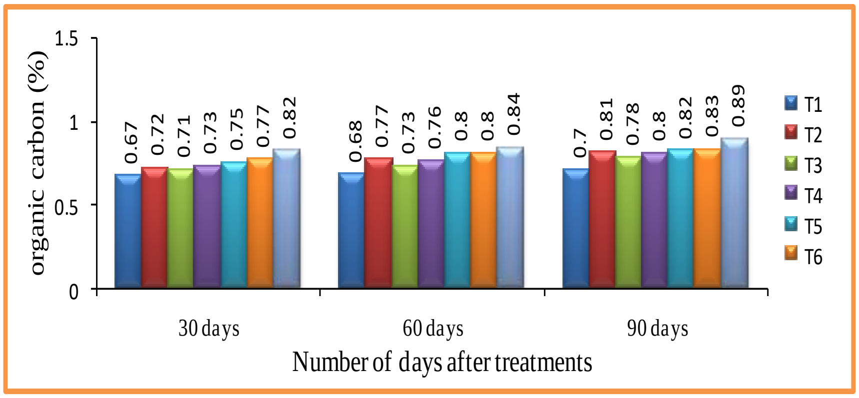


Figure 1 (a, b): Effect of Vermicompost, NFB and PSB on pH and Organic Carbon of Rhizosphere Soil

Chemical Characteristics of the Rhizosphere Soil

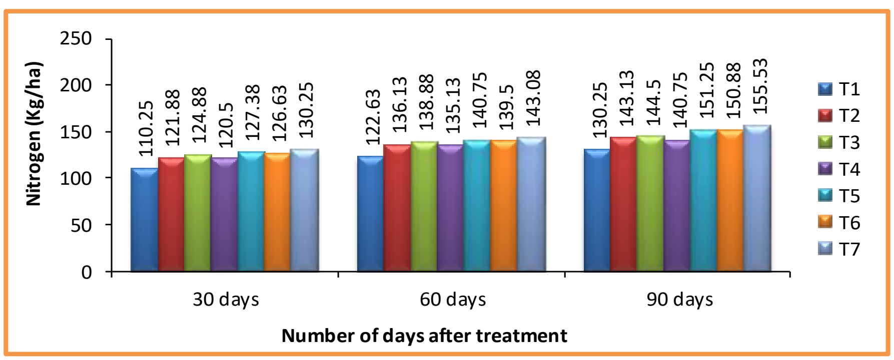
Soil nitrogen, phosphorous and potassium differed significantly at all the stages of the plant growth.

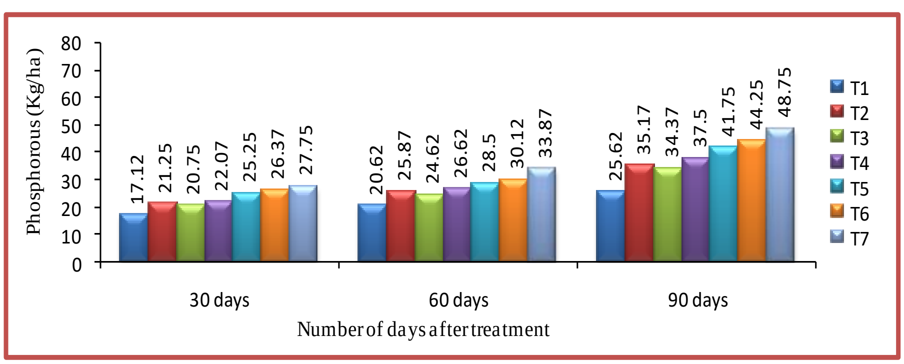
Soil Nitrogen

On 30th day, the control (T_1) showed 110.25 nitrogen content preceded by T_2 (122.63) and highest in T_7 (130.25). On 60th day, the T_1 showed (122.63) nitrogen content and in treatments it ranged from 122.63 to 130.25. On 90th day, T_7 plants showed highest nitrogen content (155.5), followed by T_6 (150.88), T_5 (151.25), T_4 (140.75), T_3 (144.5), T_2 (143.13) and control (T_1) 130.25 (Figure 2a).

Soil Phosphorous

On 30th day, the control (T_1) showed 17.12 phosphorous content preceded by T_2 (21.25) and highest in T_7 (27.75). On 60th day, the T_1 showed (20.62) phosphorous content and in treatments it ranged from 25.87 to 33.87. On 90th day, T_7 plants showed highest phosphorous content (48.75), followed by T_6 (44.25), T_5 (41.75), T_4 (37.5), T_3 (34.37), T_2 (35.37) and control (T_1) 25.62 (Figure 2b).





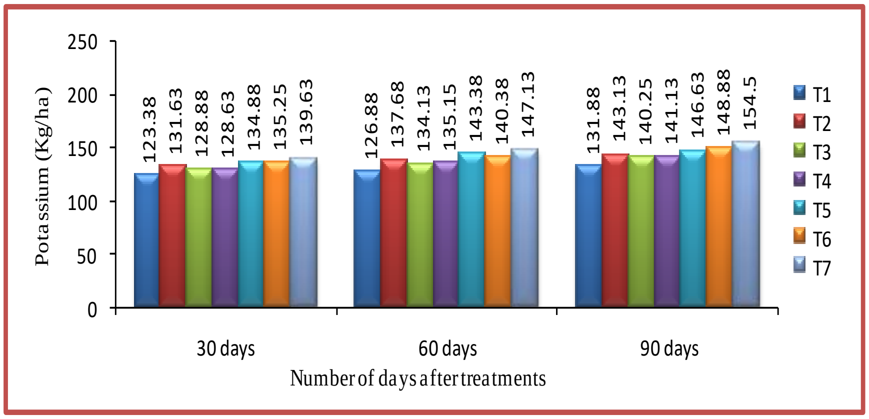


Figure 2 (a, b, c): Effect of Vermicompost, NFB and PSB on Nitrogen, Phosphorous and Potassium Content of the Soil

Soil potassium

On 30th day, the control (T_1) showed 123.8 potassium content preceded by T_2 (121.88) and highest in T_7 (139.63). On 60th day, the T_1 showed (126.88) potassium content and in treatments it ranged from 136.13 to 143.88. On 90th day, T_7 plants showed highest potassium content (155.53), followed by T_6 (148.88), T_5 (146.63), T_4 (141.13), T_3 (140.25), T_2 (143.13) and control (T_1) 131.88. **(Fig: 2c)**

There was a significant difference in soil Nitrogen, Phospohorus and Potassium content among different days of a given treatment at 1 % level, and also significant difference between interaction of treatment and days

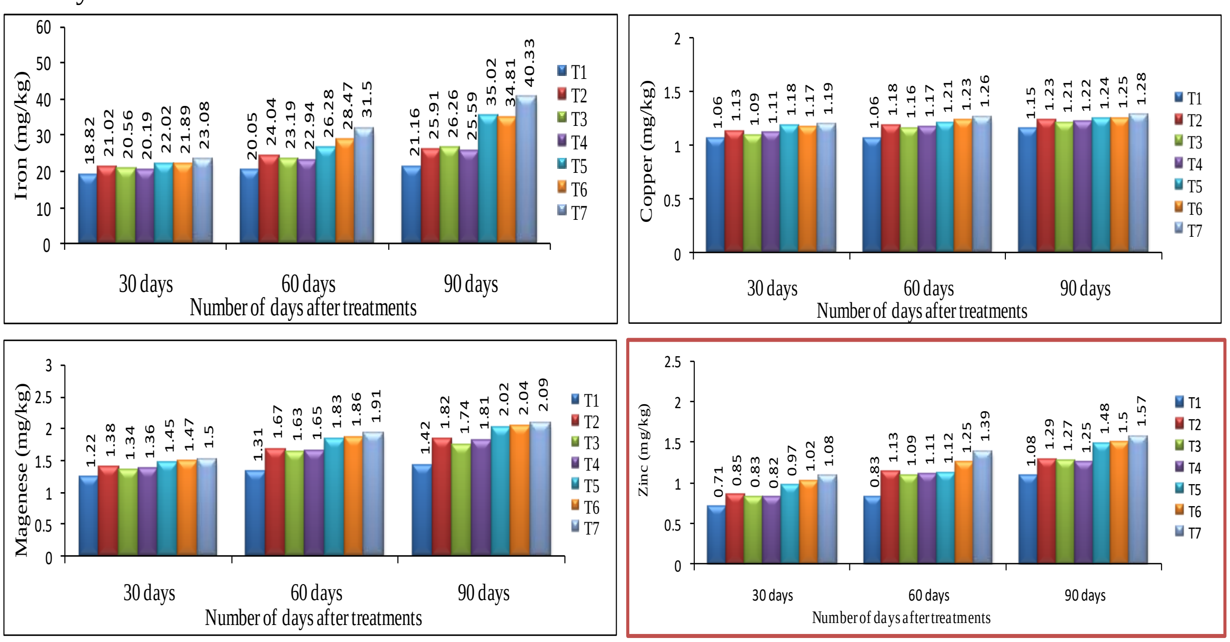


Figure 3 (a, b, c, d): Effect of NFB PSB and Vermicompost on Iron, Copper, Manganese and Zinc Content of Rhizosphere Soil at 30th, 60th and 90th Day

Soil zinc (mg/Kg)

On 30th day, the zinc content was maximum in T_7 soil samples (1.08) and minimum in control T_1 (0.71). In rest of the treatments, the zinc content was more compared to control (T_1). On 60th day, the lowest amount of zinc was recorded in T_1 (0.83) and the highest in T_7 (1.39), T_6 (1.25), T_5 (1.12), T_3 (1.27), T_4 (1.25) and T_2 (1.13). On 90th day, the zinc content in T_7 was 1.57 followed by T_5 (1.48), T_6 (1.50) and in T_1 plants the content was 1.08. It was observed that there was a significant difference between the treatments and different days of a given treatment at 1 % level. (Table 2, fig: 3a)

Soil iron (mg/Kg)

Soil iron content differed at all the stages of plant growth in different treatments. On 30th day, the T_1 showed 18.82 and in the treatments the iron content ranged from 21.02 to 23.08. On 60th day, the T_1 showed 20.05 and in the treatments the iron content ranged from 24.04 to 31.50. On 90th day, when compared with control (T_1), the highest amount of iron was found in T_7 (40.33) sample followed by T_5 (35.02) which was statistically on par with T_6 (34.81). (Table 2, fig: 3b)

Soil copper (mg/Kg)

Soil copper content differed at all stages of the plant growth in all the treatments. The copper content increased significantly (1 % level) from 30th day to 90th day in all the treatments. In T_1 there was no increase from 30 days 60 days, but it increased from 1.06 to 1.15 from 60th day to 90th day. On 90th day, when compared with control (T_1), the highest amount of copper was found in T_7 (1.28) sample followed by T_5 (1.24) which was statistically on par with T_6 (1.25). (Table 2, fig: 3c)

Soil manganese (mg/Kg)

It was observed that there was a significant difference among the treatments and different days of a given treatment at 1 % level in manganese status of soil. All the treatments (T_2, T_3, T_4, T_5, T_6 and T_7) exhibited more manganese content than control T_1 (1.22, 1.31, 1.42) on 30th, 60th and 90th day. (Table 2, fig: 3d)

Conclusion

The rhizosphere soil from all the treatments (T_1, T_2, T_3, T_4, T_5, T_6 and T_7) was collected and analyzed for soil Physico-chemical characters on 30th, 60th and 90th day. The soil colour was found varying from T_1, to T_7 treatment. The high organic content in T_7 resulted in dark colour of the soil. The major and minor nutrients like nitrogen, phosphorus, potassium, zinc, iron, copper and manganese were also found in high in the rhizosphere soil in presence of vermicompost, NFB and PSB. This investigation showed ameliotation effect of rhizospere soil physicochemical properties from pot culture of *Sorghum vulgare* variety (NTJ1) can be a good alternate source in agriculture, horticulture and other land plants management systems. These findings show the potentials as of vermicompost, bioinoculants (NFB and PSB) develop a specific inoculum applicable to soils containing a single or in different proportion and can reduce cost and dependence on xenobiotic synthetic chemicals.

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Table 2: Effect of NFB, PSB and Vermicompost, on Zinc, Iron, Copper and Manganese Contents of Pot Cultured Soil

Treatments	Zinc(mg/kg)			Iron(mg/kg)			Copper(mg/kg)			Manganese(mg/kg)		
	Days after Treatment											
	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days	30 Days	60 Days	90 Days
T_1	0.71	0.83	1.08	18.82	20.05	21.16	1.06	1.06	1.15	1.22	1.31	1.42
	(0.05)	(0.07)	(0.04)	(0.76)	(0.54)	(0.60)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)
T_2	0.85	1.13	1.29	21.02	24.04	25.91	1.13	1.18	1.23	1.38	1.67	1.82
	(0.03)	(0.04)	(0.04)	(0.66)	(0.42)	(0.64)	(0.05)	(0.05)	(0.03)	(0.04)	(0.03)	(0.04)
T_3	0.83	1.09	1.27	20.56	23.19	26.26	1.09	1.16	1.20	1.34	1.63	1.74
	(0.05)	(0.04)	(0.03)	(0.46)	(0.89)	(0.70)	(0.04)	(0.05)	(0.02)	(0.02)	(0.02)	(0.04)
T_4	0.82	1.11	1.25	20.19	22.94	25.59	1.11	1.178	1.22	1.36	1.65	1.81
	(0.05)	(0.05)	(0.03)	(0.36)	(0.62)	(0.89)	(0.05)	(0.06)	(0.03)	(0.03)	(0.03)	(0.03)
T_5	0.97	1.12	1.48	22.02	26.28	35.02	1.18	1.21	1.24	1.45	1.83	2.02
	(0.06)	(0.05)	(0.04)	(0.52)	(0.66)	(0.84)	(0.05)	(0.03)	(0.04)	(0.03)	(0.02)	(0.06)
T_6	1.02	1.25	1.50	21.89	28.47	34.81	1.17	1.23	1.25	1.47	1.86	2.04
	(0.05)	(0.05)	(0.03)	(0.45)	(0.97)	(0.69)	(0.06)	(0.02)	(0.03)	(0.04)	(0.02)	(0.05)
T_7	1.08	1.39	1.57	23.08	31.50	40.33	1.19	1.26	1.28	1.50	1.91	2.09
	(0.05)	(0.04)	(0.05)	(0.69)	(1.02)	(1.03)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)	(0.03)
CD	0.049	0.068	0.092	0.288	0.182	0.182	0.062	0.058	0.072	0.091	0.084	0.088
SEM	0.014	0.032	0.038	0.018	0.062	0.064	0.014	0.042	0.033	0.022	0.038	0.033

Values within the brackets indicate standard deviation.

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