Suthamathy Nadarajah[1] and Thayamini H. Seran[2]

Influence of effective microorganisms on root-shoot ratio and harvest index of groundnut *(Arachis hypogaea L.)*

(1)Department of Crop Science, Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka.
(email: nsuthamathy@yahoo.com)
(2)Department of Crop Science, Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka.

Abstract: Effective microorganisms (EM) solution was used in combination with different rates of cattle manure to study feasibility of EM in groundnut cultivation. This study determined the fraction of biomass partitioned to root vs. shoot in groundnut response to cattle manure and EM application. Significant reduction in root- shoot ratio was noted with manure application. Further, it was observed that EM application significantly improved harvest index (HI) of the crop. It suggests that cattle manure at the rate of 15 t/ha with EM would give better plant performance of groundnut.

Keywords: Cattle manure, Effective microorganism, groundnut, R-S ratio, harvest index

Introduction

The relative growth rates of root and shoot are important parameters of dry matter production (Cannell and Willett, 1976). The root-shoot ratio (R-S) is given as the ratio of dry weight of the roots to the dry weight of the top of a plant (Harris, 1992). R-S ratio correlates with inherent factors such as plant species, age and region (Mokany *et al*., 2006). For most crop plants, except tuber crops R-S ratio is high early in the growing season and decrease with crop maturity. R-S ratio of root and tuber crop (where root is sink) increases with maturity of crop and favorable conditions for tuberization also increase the R-S ratio in tuber crops (Rogers *et al.*, 1996). R- S ratios of adult plants in Mediterranean ecosystems to be higher than temperate ecosystems, possibly as an adaptation to dry season (Hilbert and Canadell 1995).

The R-S ratio is one of the growth parameter to assess the performance of crops and overall health of plants. R-S ratio depends upon the partitioning of photosynthate which may be influenced by the external factors. There are studies shows that R-S of crops influenced by nutrients, water deficient, carbon dioxide concentration (Lindquist *et al*., 2005; Cakmak *et al*., 1994; Gutschick, 1993; Rogers *et al.*, 1996). Cattle manure is commonly used organic manure and use of effective microorganism is also expanding in many countries. Studies showed that EM has positive effect on crop performance in organic farming system (Sangakkara and Higa, 1992; Sangakkara, 1994; Sangakkara, 1996). Groundnut (*Arachis hypogaea* L.) is commonly grown leguminous crop in Sri Lanka and it showed positive yield response to organic manure (Chandrasekaran *et al*., 2000).The aim of this experiment was to determine the response of R-S ratio and HI to EM in groundnut (*Arachis hypogaea* L.) when applied with cattle manure.

Material and Methods

The experiment was conducted in 2010 at the Agronomy farm of Eastern University of Sri Lanka. The experimental site comes under the agro ecological zone of low country dry zone [7° 43'N, 81° 42'E]. The soil is sandy regosol. Treatments included presence (T_1) and absence (T_2) of the recommended dose of

inorganic fertilizer and different levels (5, 10, 15 and 20 tha^{-1}) of cattle manure with or without EM soil application (T_3-T_{10}) as indicated in Tab 1. All treatments were replicated four times in Randomized Complete Block Design. Cattle manure (CM) was applied in different rates to plots (T_3-T_{10}) two weeks before sowing. Planting space of groundnut was 45 cm between rows and 15 cm within a row with one seed per hole and each plot measured 2.2 x 2.0 m. EM solution was prepared two hours before spraying by diluting EM stock solution with molasses and water (1:1:1000) as recommended in EM application manual (Anon., 1995). The EM solution was sprayed in two weeks interval from 4^{th} week onwards upto 10^{th} week of planting groundnut at the rate of 10L/ha.

All other agronomic practices except fertilizer management were followed according to the recommendation. Observations were made on plant height, number of branches and dry weight of stem, root and pods in each treatment at the time of harvesting. Plant parts i.e stem, pods and root in each treatment were oven dried at 105°C over night to determine the dry weights and R-S ratios were calculated. In a physiological perspective, R-S ratios have been interpreted as reflecting the differential investment of photosynthates between the aboveground and belowground organs (Titlyanova *et al.,* 1999). Additionally, Harvest index was also calculated. Harvest index was calculated by using weights of pods and total dry matter per plant. Collected data were statistically analyzed, significant difference between the treatments were determined using analysis of variance (ANOVA) using SAS software and the mean separation were done using Tukey's studentized range test at 5% level.

Table 1:
Treatment of study

Treatments	Code
With fertilizer (control)	T_1
No fertilizer + no CM	T_2
5 t/ha CM	T_3
5 t/ha CM + EM	T_4
10 t/ha CM	T_5
10 t/ha CM + EM	T_6
15 t/ha CM	T_7
15 t/ha CM + EM	T_8
20 t/ha CM	T_9
20 t/ha CM + EM	T_{10}

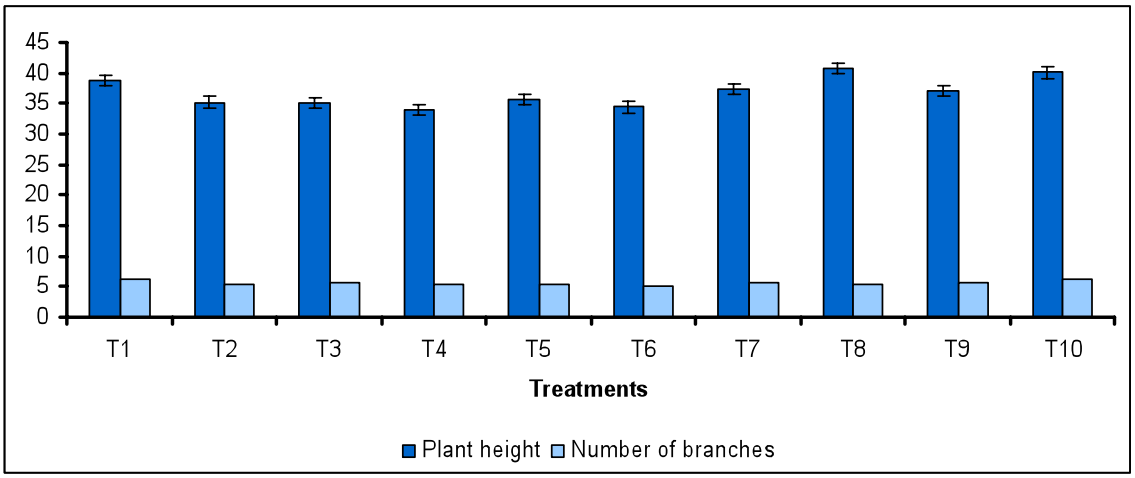

Figure 1: Plant height (cm) and number of branches per plant in each treatment at harvest

Results and Discussion

Plant height

There was significant difference (P<0.01) in plant height among the treatments (Fig 1). The difference in plant height among the treatments might be due to the variation in rate of manure application and EM combination. The average plant height ranges from 33.92 to 40.75cm. Maximum number of branches was observed in T_1. EM enhances the microbial diversity in soil (Higa and Parr, 1994) and thus improves soil health (Xu, 2000). The adequate absorption of essential nutrients requires for biochemical and physiological processes of plants (Ihejirika, 2007). Yousaf *et al* (2000) reported that EM inoculation improves the plant height in groundnut. Even though, number of branches per plant were not significantly differ (P>0.05) among the treatments. Branching habit is one heritable trait of crop.

Shoot-root ratio

Shoot dry weight showed significant differences (P<0.01) among treatments (Tab2). Increasing trend in dry weight of shoot was observed with increasing rate of CM application. Addition of CM may improve in soil health thus leading to high uptake of major nutrients resulted in better performance. CM contains considerable amount of nitrogen (N) and phosphorus (P) (0.35% N, 0.12% P_2O_5). N and P are primarily stimulating shoot and root growth respectively (Harris, 1992). Photosynthetic microorganisms are one constituent of EM which enhances photosynthesis (Wang *et al.*, 2000) and it may lead to high dry matter accumulation in plant parts. It was reported that increase in cattle manure rate increase the total dry matter yield per plant in okra (Dada and Fayinminnu, 2010).

Results shown in Tab 2 revealed that R-S ratio of crop was altered either by manure application or EM. The mean R-S ratio ranges from 0.061 to 0.112.Comparatively higher R-S ratios were obtained in T_2 and T_3 than other treatments and the values are significantly differed (p<0.01) from all others treatments. The nutrients content in T_2 and T_3 were low. It was clear that increase in nutrient content of soil either by chemical fertilizer or optimum amount (>10 t/ha) of organic manure leads reduction in R-S ratio of crops. Further it was noticed that R-S ratio in T_3 was significantly (p<0.05) differed from T_4 which implied that EM application has indirect influence on R-S ratio. A reduction in R-S ratio is in response to more favourable growing condition (Harris, 1992; Rogers *et al.*, 1996). However, gradual increase in manure rate had no significant (p>0.05) influence on R-S ratio of groundnut. It is probably because of the ability of plants to adapt to changing conditions when the changes are not too drastic or rapid (Harris 1992).

Table 2: The R-S ratios of groundnut in each treatment

Treat ments	Dry weight of shoot / plant (g)	Dry weight of root /plant (g)	R- S ratio
T_1	40.37 ± 2.26 abc	2.66 ± 0.35	0.066 b
T_2	24.86 ± 1.04 e	2.74 ± 0.16	0.110 a
T_3	26.98 ± 0.96 de	3.04 ± 0.45	0.112 a
T_4	31.50 ± 1.20 cde	2.34 ± 0.17	0.073 b
T_5	32.04 ± 1.18 cde	2.14 ± 0.04	0.067 b
T_6	36.44 ± 2.03 bcd	2.22 ± 0.10	0.061 b
T_7	39.16 ± 2.92 abc	2.57 ± 0.16	0.066 b
T_8	44.84 ± 1.78 ab	2.79 ± 0.13	0.062 b
T_9	42.27 ± 1.16 ab	2.68 ± 0.18	0.063 b
T_{10}	47.59 ± 3.22 a	2.99 ± 0.39	0.062 b
F value	**	ns	**
CV%	10.97	21.91	16.7

Table 3: The influence of cattle manure with EM on plant dry matter and harvest index of groundnut

Treat ments	Crop residue /plant (g)	Dry weight of pods /plant (g)	Harvest index
T1	19.52 ± 1.55 ab	23.52 ± 1.32 ab	0.54 ± 0.02 a
T2	15.89 ± 0.25 b	11.70 ± 0.88 d	0.42 ± 0.01 c
T3	16.58 ± 1.11 ab	13.44 ± 0.82 d	0.45 ± 0.02 bc
T4	16.49 ± 0.76 ab	17.34 ± 0.73 c	0.52 ± 0.01 ab
T5	15.95 ± 0.50 bc	18.22 ± 0.92 c	0.53 ± 0.01 a
T6	17.16 ± 0.59 b	21.50 ± 1.65 bc	0.56 ± 0.02 a
T7	19.22 ± 1.58 ab	22.50 ± 1.55 b	0.54 ± 0.01 a
T8	22.51 ± 1.68 a	26.63 ± 1.22 a	0.53 ± 0.01 ab
T9	20.60 ± 0.92 ab	23.85 ± 0.91 ab	0.54 ± 0.01 a
T10	22.36 ± 2.45 a	26.22 ± 1.60 a	0.56 ± 0.02 a
F value	*	**	**
CV%	**14.1**	**12.3**	**6.6**

Value represents mean ± standard error of four replicates. F test: - **: P< 0.01.ns: not significant. Means followed by the same letter are not significantly different according to Tukey's studentized range test Duncan's Multiple Range Test at 5% level

Pod yield and Harvest index

EM application showed significant influence (P<0.01) on crop residue and pod yield of groundnut fertilized with cattle manure (Tab 3). Crop residue is the sum of dry matter accumulated in plant parts except economic parts. The average dry matter (oven dry weight) of crop residue and pods per plant ranged from 15.89 g to 22.51 g and 11.70 g to 26.63 g respectively. Pods are the sink for dry matter accumulation in groundnut therefore highly significant variation (P<0.01) exhibited in pod dry matter at harvest among the treatments. The highest dry matter (both crop residue and pods) was obtained in T_8 (15 t/ha CM with EM) and it was statistically similar with the pod yield of chemical fertilizer (T_1). Javaid and Mahmood (2010) stated that EM application significantly enhanced shoot and pod biomass of soybean with farmyard manure application.

Result showed that there was significant (P<0.01) effect on harvest index (HI) due to the manure application (Table 3). It was revealed that to achieve high HI (more than 0.5), the plant required to fertilize with optimum level of manure. The average value of HI ranged from 0.42 (T_2) to 0.56 (T_8). Harvest index indicates the partitioning of photosynthate between economic plant part and crop residue (vegetative plant parts) of groundnut. HI values for peanuts ranged from 20% to 47% (Fageria *et al.,* 2006).

Conclusion

In this study, the results indicated that combination of EM with cattle manure had significant improvement in plant growth. Manure application had significant reduction in R-S ratios of groundnut. Further, it was noticed that EM significantly improved harvest index of crop. Cattle manure (15 t/ha) with EM would give better plant performance on sandy regosol.

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