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Effect of incorporation of various green manures on green foliage yield and economics of stem amaranthus (*Amaranthus viridis* L.)

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Abstract
A field experiment was conducted at Agricultural College and Research Institute, Kudumiyanmalai, Pudukkottai district was conducted during the year of 2023 in order to investigate the effect of various green manure on growth and yield of stem amaranthus (*Amaranthus viridis* L.). To test their effect, 8 green manures (Sunnhemp, daincha, cowpea, cluster bean, horse gram, Kolingi, moth bean and *Calopogonium*) against control on amaranthus were studied. These green manures were incorporated at 35 DAS and allowed to decompose for 15 days. The green manure growth parameters *viz*., Plant height, number of branches/plants, green bio mass and dry bio mass were recorded. Apart from growth parameters, microbial population was also counted. The results showed that bacterial (252×10^{6}/g of soil) and fungal population (20×10^{36}/g of soil) were also observed in Sunnhemp incorporated treatment. Stem Amaranthus (*Amaranthus viridis)* was sown as per the treatment schedule 15 days after the incorporation of green manures *in-situ*. Growth characters of *Amaranthus viridis* were recorded at 15 days after sowing and at harvest stage. All the growth characters *viz*., Plant height, no. of leaves, LAI and leaf stem ratio were higher in the sunnhemp as a green manure incorporated treatment followed by cowpea as a green manure incorporated treatment. Lowest growth attributed were recorded in the control plot. With respect to green foliage, highest foliage yield was observed in the sunnhemp (16,923 kg/ha) as a green manure incorporated treatment and the lowest green foliage yield is observed in control plot (2489 kg/ha). The highest net profit (Rs.1,35,680/ha) was also realized in the sunnhemp as a green manure incorporated treatment followed by cowpea as a green manure incorporated treatment.

Keywords: Amaranthus, green foliage yield, green manure, incorporation sunnhemp, cowpea, daincha, moth bean, horse gram, cluster bean, Calpogonium

Introduction
Leafy vegetables feeding those over populated and under nourished areas. Amaranthus (*Amaranthus sp*.) occupies a prominent position among tropical leafy vegetables all over the world. Amaranthus is one of the important and popular leafy vegetables of India. Though majority of Indian population are vegetarian, the per capita intake of vegetables is estimated to be only about 135g as against the requirement of about 285 g, among which leafy vegetables constitute 80 g for a balanced diet. Due to their nutritional superiority, amaranthus have been suggested as alternative source of rich protein. Apart from exceptionally superior nutritive value, vegetable amaranthus is a potential crop for exploitation due to its fast growth, hardy nature, high biomass productivity and suitability for cultivation both in kitchen garden and commercial garden Dhangrah *et al*., (2015) [4].

Now a days, the chemical fertilizers are very costly besides excessive use of chemical fertilizers creates a multiple nutrients deficiency, deteriorating soil structure. The excess amount of nitrogen (N) fertilizer increases nitrite accumulation in plant leaves and this could result negative impact on human health. In recent years, organic farming, which requires utilization of various organic sources, has gained popularity to eliminate the negative effects of mineral fertilizers for human health. Of the several organic manuring practices, green manuring was found to be an effective one for sustainable nutrient management suiting intensive agriculture. However, information on the use green manures for amaranthus is scanty in India. Therefore, an attempt was made to study the productivity of stem amaranth on various green manure against farmers practice of without any application of any fertilizers and green manures.

Materials and Methods

The trial was conducted at Agricultural College and Research Institute, Kudumiyanmalai, Pudukkottai district of Tamil Nadu. The agricultural college is located in southern zone of agro-climtatic zone of Tamil Nadu. It is located at 10°38' North and 78 °82' east. The average altitude of this college is 119m msl. The mean annual precipitation is 960 mm with most of the rain falling between October and December. The average maximum temperature is 38.1 °C and minimum temperature is about 20.2 °C. The soils are red lateritic soils. There were nine treatments which were replicated three times. Experiment was laid out in Randomized Block Design (RBD).

The treatments consist of T_1-Control, T_2-Sunnhemp incorporated at 35 days after sowing, T_3-Daincha incorporated at 35 days after sowing, T_4-Cowpea incorporated at 35 days after sowing, T_5-Horse gram incorporated at 35 days after sowing, T_6-Moth bean incorporated at 35 days after sowing, T_7- Cluster bean incorporated at 35 days after sowing, T8-Kolinji (*Tephrosia purpurea*) incorporated at 35 days after sowing, T_9 – *Calopogonium* (*Calopogonium mucunoides***)** incorporated at 35 days after sowing. The date of sowing was done on green manure at 13.4.2023. Green manures were incorporated manually on 18.5.2023. The Amaranthus was sown on 2.6.23. The stem amaranthus variety is CO 2. Initial soil sample was taken, all the growth parameters were recorded like plant height, number of leaves, no. of branches, no. of nodules, fresh weight, nutrient content of all the green manures and dry matter production were taken. The amaranthus was harvested on 7.7.23.

The growth parameters of amaranthus *viz*., Plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), leaf area index, leaf stem ratio, total foliage yield, total chlorophyll content and microbial count (bacteria and fungi) were recorded at harvest stage. Leaf: stem ratio (fresh and dry) were obtained by di vidi ng the leaf weight (fresh and dry) by stem weight (fresh and dry) and recorded in a ratio at 15DAS and harvest stage. Statistical analysis variance was done using the Agres statistical software (1994, Pascal International Software Solutions) and conclusions were drawn from the results obtained from the package.

Results and Discussion

Growth characters of green manures at the time of incorporation

The results showed that the higher plant height was recorded in the sunnhemp green manure (83 cm) which was on par with daincha (75 cm). The lowest plant height was recorded in the green manure *Calopogonium* (9.7 cm). Significantly highest number of branches/plant was recorded in the sunnhemp (27.9) which is followed by daincha (15.0). The lowest number of branches/plant was recorded in the *Calopogonium* (3.4). More number of nodules/plant was recorded under sunnhemp (14.5) which was significantly higher. This was followed by cowpea with 12.8 number of nodules produced per plant. The lowest number of nodules/plant was produced by *Calopogonium* (2.9) (Table 1). The greater number of nodules accommodated in sunhemp at indicated the crops' quick growth and development of adequate carbon sources that have met the nutrient needs of bacteria residing in nodules resulting in a higher nodule count This was followed by next best crop with a higher nodule count was cowpea. The least no. of nodules was found in the *Calopogonium* with poor growth. The least energy produced by the nodules utilised for the early vegetative growth and development of the slow growing green manure crops *viz*., *Calopogonium*, horse gram and moth bean. With regard to green biomass the highest biomass was recorded in the daincha (21,296 kg/ha) which was on par with sunnhemp (21,182 kg/ha). The lowest green biomass was recorded in *Calopogonium* with green biomass yield of 3571 kg/ha. The highest dry matter production was recorded in the sunnhemp (16, 923 kg/ha) which was followed by daincha (14, 859 kg/ha) indicating that the sunnnhemp was effective in utilization soil resources. Hence, the increased biomass production through more photosynthates production. The lowest dry matter production was produced by the *Calopogonium* (2489 kg/ha) (Table 1). Similar result was reported by Naidu *et al*., (2021) [3] and Venkatalakshmi *et al*., 2009 [18]. The presence of nodules in the unfertilized plants suggested that there were native soil rhizobia that were able to infect the roots of the host but not enough to produce a significant improvement in the growth (Mweetwa *et al*., 2016) [12].

Effect of green manures on growth attributes of amaranthus at 15 days after sowing

The results of the experiment showed that the higher plant height of amaranthus on 15 DAS was recorded in sunnhemp green manure incorporated treatment (9.6 cm) which is on par with cowpea green manure (9.5 cm) incorporated treatment. The lowest plant height (8.6 cm) of amaranthus was recorded in the control plot (Table 2). The number of leaves/plant at 15 DAS was recorded highest on the sunnhemp green manure (16.5) incorporated treatment which is significantly superior than the cowpea green manure (15.4) incorporated treatment. The lowest number of leaves/plant (10.1) was recorded in the control plot. The highest leaf area index (LAI) of amaranthus was recorded at 15 DAS in the sunnhemp green manure incorporated treatment (0.180) which is on par with the cowpea green manure incorporated treatment (0.176). The lowest LAI (0.131) was recorded in the control plot. With respect to leaf stem ratio of amaranthus at 15 DAS the highest leaf stem ratio was recorded in the sunnhemp incorporated treatment (1.678) which is on par with cowpea incorporated treatment (1.630). The lowest leaf stem ratio (1.385) was at 15 DAS in the control plot (Table 2).

Effect of green manures on growth attributes of amaranthus at harvest stage

The highest plant height of amaranthus at harvest stage was recorded at 30 days after sowing in sunnhemp green manure incorporated (62.8 cm) treatment which was significantly superior than the cowpea green manure incorporated (57.2 cm) treatment. The lowest plant height (18.1 cm) was recorded in the control plot. The highest number of leaves/plant (46.4) was recorded in the sunnhemp treatment which is significantly superior than the cowpea green manure incorporated (42.1) treatment. The lowest number of leaves/plants was recorded (19.7) in the control plot (Table 3). The highest leaf area index (3.25) of amaranthus at harvest stage was recorded in the sunnhemp green manure incorporated treatment which is significantly superior than the cowpea green manure incorporated treatment (3.20). The lowest LAI (2.87) was registered in the control plot. At harvest stage the highest leaf stem ratio was recorded in the

sunnhemp green manure (3.96) which is significantly superior than that of cowpea green manure (3.88). The lowest leaf stem ratio (3.31) was recorded in the control plot. The highest leaf chlorophyll was recorded in the sunnhemp green manure treatment (350.1) followed by the cowpea green manure treatment (338.9). The lowest chlorophyll content (293.3) was recorded in control plot (Table 3). This may be due to N fixation by the sunnhemp and subsequently which was utilized by the amaranthus (Table 3). Green manure sunnhemp fixed higher N their by Cholorphyll content was higher was reported by Shah *et al*., (2011) [17].

Effect of green manures on green foliage yield of Amaranthus

Highest green foliage yield of 16,923 kg/ha was recorded in the sunnhemp green manure incorporated treatment followed by cowpea green manure treatment registered with the green foliage yield of 14859 kg/ha. The lowest green foliage yield (2489 kg/ha) was recorded in the control plot (Table 3). Bouldin (1988) [2] found that that green manure decomposes rapidly and releases nitrogen quickly in soil and incorporation of green manure is an excellent source of nitrogen for the succeeding crop. The results revealed that the incorporation daincha biomass also significantly influenced the yield and yield contributing characters of subsequent transplant Aman rice as compared to the control. Amaranthus yield was enhanced significantly with Oloyin green manure was reported by Adewale and Etooluwa (2020) [1] (Table 3). Similar findings were reported by Wagger, (1989) [19], Delogua *et al*., (1998) [5], Kumar and Goh, (2002) [9], Herencia *et al*., (2007) [7], Salmeron *et al*., (2011) [16], Mandal *et al*., (2003) [10] in various crops.

Effect of green manures on Microbial population

Microbial population was recorded 15 days after green manure incorporation. The highest bacterial population ($252x10^6$) was recorded under sunnhemp green manure incorporated treatment. This was on par with cowpea green manure incorporated ($230x10^{-6}$) treatment. The lowest bacterial population was recorded in the control plot ($180x10^6$) (Table 3). Higher soil fungal population was registered in the sunnhemp green manure ($20x10^{-3}$). This was on par with cowpea green manure ($19x10^{-3}$). The lowest fungal population was recorded in the control plot ($7x10^{-3}$). Mineralization of N by daincha green manure in soil and greater multiplication of soil microbes, which could convert organically bond N to inorganic form (Rahman *et al*. 2013) [11]. Ehsan *et al*. (2014) [6] also reported similar results for *S. aculeata* green manure in rice-based cropping system. This might be due to incorporation of green manuring crop in soil activate the microbial population in soil which start the decomposition of organic matter rapidly. Green manure is good source of carbon, which is food for microbes, which helps to multiplies bacteria, fungi and actinomycetes populations in soil. These results are in agreement with those reported by Raut *et al*., (2022) [15].

Effect of various green manure incorporation on Chlorophyll content of Amaranthus-mg/m^2)

Many of the references quoted that SPAD value directly correlated to the chlorophyll content of the leaves. The findings of the experiment showed that the highest SPAD value (350.1) in sunnhemp green manure incorporated treatment which is followed by the cowpea green manure incorporated (338.9) treatment. The lowest SPAD value (293.3) was recorded in the control plot. Research by Peyvast *et al*., (2007) [14] shows that the level of chlorophyll in plants increases rapidly following application of organic fertilizer.

Effect of various green manure incorporation on green foliage yield of Amaranthus

Highest green foliage yield of 16,923 kg/ha was recorded in the sunnhemp green manure incorporated treatment followed by cowpea green manure treatment registered with the green foliage yield of 14859 kg/ha. The lowest green foliage yield (2489 kg/ha) was recorded in the control plot (Table 3). Bouldin, (1988) [2] opinioned that green manure decomposes rapidly and releases nitrogen quickly in soil and incorporation of organic matter is an excellent source of nitrogen for the first crop sequence. The results revealed that the incorporation daincha biomass also significantly influenced the yield and yield contributing characters of subsequent transplant Aman rice as compared to the control. Amaranthus yield was enhanced significantly with Oloyin green manure was reported by Adewale and Etooluwa, 2020.

Effect of various green manure incorporation on Economics: The highest net return (Rs.1,35,680/ha) was recorded in the sunnhemp green manure incorporated treatment followed by cowpea green manure treatment (Rs.1,15,090 /ha). The lowest net income (Rs.6990/ha) was obtained in the control plot. The highest B:C ratio (5.0) was recorded in the sunnhemp green manure incorporated treatment followed by cowpea green manure treatment (4.4). The lowest B:C ratio (1.4) was recorded in thein the control plot. Hiremath and Patel (1995) [8] and Nooli (2001) [13] also reported higher monetary advantages in terms of net returns and B: C ratio due to incorporation of green manures.

Table 1: Growth and green bio mass and dry matter production of various green manures at the time of 35 days after sowing.

Particulars	Plant height (cm)	No. of branches /Plant	Green bio mass (kg/ha)	Dry matter production (kg/ha)	No. of nodules /Plant
T1- Sunnhemp	83	27.9	21182	16923	14.5
T2- Daincha	75	15.0	21296	14859	10.3
T3- Cowpea	57	8.5	15054	10966	12.8
T4- Horse gram	26	5.3	6375	4465	4.7
T5- Moth bean	30	5.7	16583	11620	10.2
T6- Cluster bean	48	5.9	13738	9694	12.4
T7- Kolingi	32	7.8	8488	5989	4.7
T8- *Calopogonium*	9.7	3.4	3571	2489	2.9
SEd	3.0	0.6	497	382	0.3
CD (=0.05)	10.0	1.9	1491	1122	1.0

Table 2: Effect of various green manure incorporation on Growth attributes of amaranthus at 15 DAS

Particulars	Plant height (cm)	No. of leaves/plant	LAI	Leaf stem ratio
T1-Control	8.6	10.1	0.131	1.385
T2- Sunnhemp	9.6	16.5	0.180	1.678
T3- Daincha	8.7	11.7	0.046	1.402
T4- Cowpea	9.5	15.4	0.176	1.630
T5- Horse gram	8.9	12.2	0.157	1.446
T6- Moth bean	9.1	12.9	0.162	1.478
T7- Cluster bean	9.3	14.3	0.172	1.575
T8- Kolingi	9.2	13.4	0.157	1.532
T9- *Calopogonium*	8.8	11.2	0.152	1.425
S.Ed	0.0	0.2	0.02	0.02
CD (=0.05)	0.1	0.6	0.07	0.07

Table 3: Effect of various green manure incorporation on Growth attributes (at Harvest stage), green foliage yield and economics of amaranthus

Particulars	Plant height (cm)	No. of leaves /plant	LAI	Leaf stem ratio	Green foliage yield (kg/ha)	Net income (Rs./ha)	B:C
T1-Control	18.1	19.7	2.87	3.31	2489	6990	1.4
T2- Sunnhemp	62.8	46.4	3.25	3.96	16923	1,35,680	5.0
T3- Daincha	41.9	34.7	2.93	3.09	4465	11,200	1.3
T4- Cowpea	57.2	42.1	3.20	3.88	14859	1,15,090	4.4
T5- Horse gram	49.9	39.9	2.99	3.47	9694	63,190	2.9
T6- Moth bean	49.9	40.5	3.05	3.55	10966	76,160	3.3
T7- Cluster bean	52.9	41.9	3.15	3.68	14859	1,14,990	4.4
T8- Kolingi	52.7	40.7	3.09	3.79	11620	82,700	3.5
T9- *Calopogonium*	46.2	39.4	2.99	3.39	5989	26,190	1.8
S.Ed	1.3	1.0	0.01	0.02	382	-	-
CD (=0.05)	3.9	3.0	0.04	0.07	1122	-	-

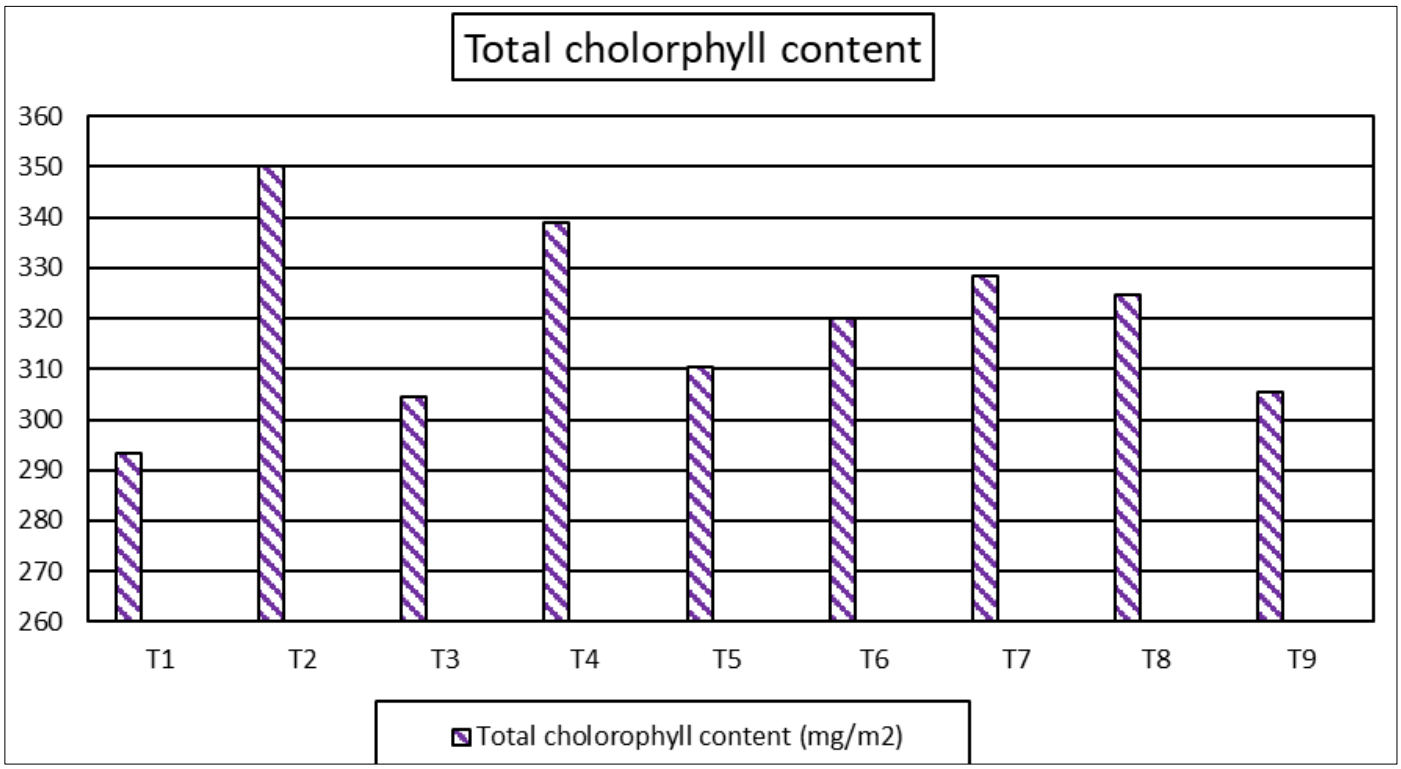

Fig 1: Effect of various green manure incorporation on Total chlorophyll content of amaranthus

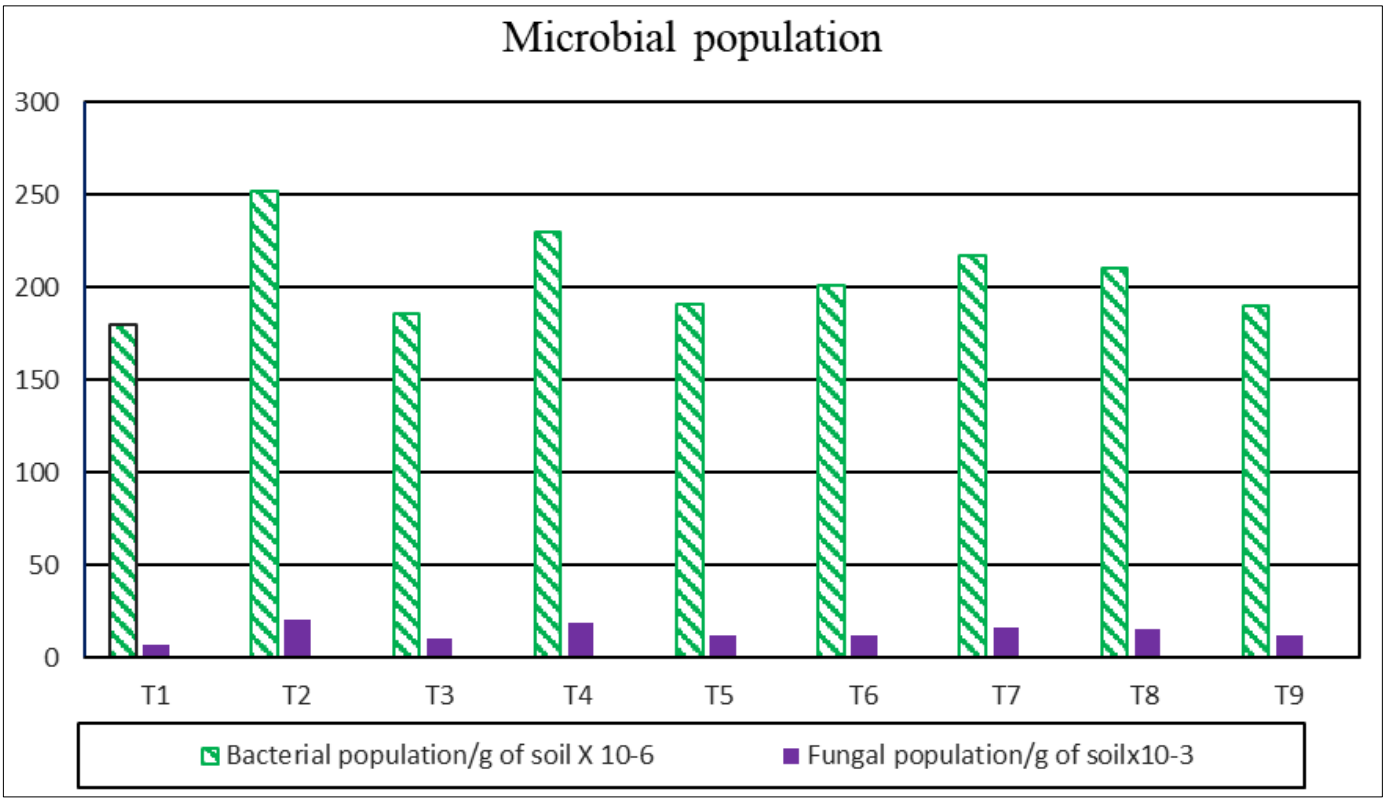

Fig 2: Effect of various green manure incorporation on microbial population of soil

Conclusion

Based on the results obtained it can be concluded that among the various green manures, sunnhemp incorporation exhibit significant effect in growth and green foliage yield of amaranthus. Hence, sunnhemp green manure incorporation at 35 days after sowing can be recommended for the vegetable organic growers.

Conflict of Interest

There is no conflict of interest of any kind among the authors

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