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Growth and dry matter yield of taro (*Colocasia esculenta* (L.) Schott) as influenced by organic nutrient management

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Abstract
An experiment was undertaken at College of Agriculture, Vellayani, Thiruvananthapuram, Kerala to study the effect of organic nutrition on growth and dry matter yield of taro over two seasons during June 2019 to January 2020 and June 2020 to January 2021. The experiment was laid out in randomized block design with three replications. The treatments comprised of six levels of organic sources (s_1- FYM + wood ash; s_2- FYM + wood ash +PGPR- I; s_3- FYM + wood ash + PGPR- I + vermiwash; s_4- Poultry manure + wood ash; s_5- Poultry manure + wood ash + PGPR- I; s_6- Poultry manure + wood ash + PGPR- I + vermiwash) and two levels of *in situ* green manuring (g_1- *in situ* green manuring with cowpea; g_2- *in situ* green manuring with daincha) with three control (c_1- Nutrient management through chemical fertilizers as per KAU POP (80 : 25: 100 kg ha^{-1}); c_2 - Nutrient management as per KAU organic POP (Adhoc); c_3 - Absolute control). During both the years, the highest leaf area was recorded with application of poultry manure along with wood ash, PGPR mix I and vermiwash (s_6). Dry matter production was also the highest for the organic source s_6 during both the years. *In situ* green manuring with daincha (g_2) was found superior to cow pea in producing higher leaf area per plant and total dry matter production during both the years. The treatment s_6g_2 was found equally effective as chemical nutrient management and superior to existing Adhoc organic management of KAU and absolute control in case of both growth parameter and dry matter production. Based on the results of the study it can be concluded that the organic nutrition involving application of poultry manure, wood ash along with PGPR mix I, vermiwash and *in situ* green manuring with diancha can be adopted for organic cultivation of taro.

Keywords: Colocasia, organic nutrition, vermiwash, leaf area, dry matter production

Introduction

Taro (*Colocasia esculenta*) is an underexploited crop, grown throughout the tropics especially in the warmer regions for its edible cormels, leaves and petioles. It is a staple food in many countries like Pacific, Caribbean and Asia and a supplement to potatoes in the southern United States. In India, taro is mostly cultivated in northern and eastern states. Taro is adapted to a wide variety of soil and climatic conditions and is an integral component of different farming systems adopted in the State of Kerala. The crop is manly used as vegetable in the State and have good keeping quality compared to other vegetables. It is also exported in raw tuber form mainly to Gulf countries. Growing concerns regarding food safety, environmental degradation and human health have generated interest in alternative agricultural systems like organic farming. The demand for organic food is steadily increasing both in developed and developing countries. There is scope for increasing the export of organically produced cocoyams (taro and tannia) fetching higher price in the market. Taro is highly responsive to organic manures and have fewer pest and disease problems as compared to other vegetables. One of the researchable issue in organic production of tuber crops is the scientific use of available organic sources of plant nutrients and adoption of organic nutrition to enhance crop productivity while maintaining the soil health. However the current knowledge of effect of organic nutrition on performance of the taro crop limited.

Materials and Methods

The experiment was conducted in a Farmer's field, Peringamala, Thiruvanathapuram, near by the College of Agriculture, Vellayani during June 2019 to January 2020 and June 2020 to January 2021. The taro variety Muktakeshi used in this study were sourced from Central Tuber Crops Research Institute, Sreekaryam. The experiment was a two factorial arrangement in a randomized block design and replicated three times. The treatments comprised six levels of organic sources (s_1- FYM + wood ash; s_2- FYM + wood ash +PGPR- I; s_3- FYM + wood ash + PGPR- I + vermi wash; s_4- Poultry manure + wood ash; s_5- Poultry manure + wood ash + PGPR- I; s_6- Poultry manure + wood ash + PGPR- I + vermi wash) and two levels of *in situ* green manuring (g_1- in situ green manuring with cowpea; g_2- in situ green manuring with daincha) with three control (c_1- Nutrient management through chemical fertilizers as per KAU POP (80 : 25: 100 kg ha^{-1}); c_2 - Nutrient management as per KAU organic POP (Adhoc); c_3 - Absolute control). The site was double-ploughed, and marked out into three blocks, which represent the replicates. Each block was divided into fifteen experimental plots (Plot size: 4. 8 m x 4.5 m), thus a total of forty five plots were used. A uniform dose of farm yard manure @ 12 t ha^{-1} were applied at the time of land preparation. One cormel weighing about 25-35g was planted at a spacing of 60 cmx 45 cm. The recommended dose of NPK for colocasia @ 80: 25: 100 kg ha^{-1} supplied through organic sources on N equivalent basis as per the treatments as basal dose except wood ash (applied while incorporating green manure). Corm treatment with 5 per cent suspension of PGPR mix I followed by soil application of PGPR enriched cow dung @ 10 g pit^{-1} (mixture of dry cow dung and PGPR mix I in 50:1 proportion) were done at planting and 2 MAP (Months After Planting) in treatments s_2, s_3, s_5 and s_6. Vermiwash (10 per cent dilution) sprayed at 2nd, 3rd and 4th month after planting in respective treatments. Green manure crops were raised (seed rate – 30 kg ha^{-1}) as per the treatments in the interspaces and incorporated in basins at 50 per cent flowering stage by uprooting. All plots were kept weed free by manual weeding. All other crop management practices were followed as per Kerala Agricultural University Package of Practices. Four cocoyam plants were randomly selected from each of the net plots, tagged and then used for the determination of leaf area (cm) at bi monthly interval. The length and breadth of each leaf was measured. The length taken from the apex of the leaf to the sinus region, while the breadth was measured across the point of petiole attachment. The leaf area (cm^2) was estimated according to the formula put forth by Biradar *et al.* (1978) [2].

Leaf area = 0.917 x L x B

(Where, L and B are the length and breadth of the leaf respectively)

The total leaf area was worked out by adding the leaf area of all the fully opened leaves at the time of observation. From each plot, uprooted plants containing both above and below ground portions were cleaned and plant parts were first shade dried and then kept at about 70 ±5^0 C in a hot air oven till constant weights were obtained. The dry weight was noted and total dry matter production at harvest was calculated in kg ha^{-1}.

KAU organic POP (Adhoc) for taro: Cattle manure or compost @ 12 t/ha as basal dressing. Green manuring (cow pea /sunhemp) @ 30 kg/ha. 10 kg P_2O_5 as rock phosphate has to be applied for the green manure crop at sowing time. At flowering (40-45 DAS) incorporate the plants along with 4t FYM /2t PM/ 2 t vermi compost/ 2 t coir pith compost and 1500 kg wood ash.

Table 1: Nutrient content and quantity of green manure crops (on dry weight basis) added

Green manure crop	Nutrient content, %			Quantity, t ha^{-1}
	N	P	K	
Cowpea	1.18	0.12	0.83	1.57
Daincha	1.34	0.26	0.53	4.55

Results and Discussions

Leaf area

Leaf area per plant increased from 2 MAP to 4 MAP and after that it showed a declining trend upto harvest irrespective of treatments during both the years (Table 2a). This clearly indicated the three growth stages of taro as explained by Sivan (1982) [12] - a period of establishment up to 6-8 weeks (phase I), grand growth period up to 20 weeks (Phase II) and a growth declining period but corm growth continues (Phase III). Organic sources significantly influenced the leaf area at all stages of crop growth with the highest number being recorded by s_6 in which poultry manure along with wood ash, PGPR mix I and vermiwash were applied, at all stages except 2 MAP during I year. During II year, leaf area per plant was significantly influenced by organic sources and the highest values were recorded with s_6 at 2 MAP, 4 MAP and 6 MAP and the effect was not significant at harvest stage. Regarding *in situ* green manuring at I year, significantly higher leaf area was recorded by *in situ* green manuring with daincha (g_2) at all stages of observation except 2 MAP wherein the effect was non significant. During II year, *in situ* green manuring had significant effect only at 4 MAP and 6 MAP and higher value was recorded by green manuring with daincha. SxG interaction significantly influenced the leaf area only at 4 MAP and 6 MAP during I year wherein the treatment combination s_6g_2 recorded significantly the highest value (2837.12 and 1525.67 cm^2 at 4 and 6 MAP respectively) and was followed by s_6g_1 (2752.99 and 1477.93 cm^2 at 4 and 6 MAP respectively). During II year, SxG interaction significantly influenced leaf area only at 4 MAP and the highest value was recorded by s_6g_2 (3155.43 cm^2) followed by s_6g_1 (2971.49 cm^2) which in turn was on par with s_5g_1, s_5g_2 and s_3g_2.

The superiority of the organic source s_6 (application of poultry manure along with wood ash, PGPR mix I and vermiwash) in leaf area per plant may be due to the combined effect of poultry manure, PGPR mix I and vermiwash. The mineralization pattern of poultry manure has indicated that nearly 60 per cent of nitrogen in this manure is present as uric acid which quickly changes to ammoniacal form that can be easily utilized by crop (Smith, 1950) [13]. The PGPR mix I is a microbial consortium for supplementing all the major nutrients which contains components cultures, *viz.*, *Azospirillum lipoferum*, *Azotobacter chroococcum*, *Bacillus megaterium* and *Bacillus sporothermoduransas* as reported by Gopi *et al.* (2020) [3]. Vacheron *et al.* (2013) [17] pointed out that PGPR can produce phytohormones and promote enzymatic activities which in turn may improve the root growth, uptake of minerals and water, and growth of the whole plant. Suja *et al.* (2017) [16] and Soubeih Kh and Mahmoud (2019) [14] also reported the enhanced plant height in taro by the application of biofertilizers. Vermiwash is very good liquid manure which favourably affect the growth and productivity of crop when applied as foliar spray (Subasashri, 2003) [15]. Ansari *et al*. (2015) [1] also reported the excelled shoot growth and number of leaves of colocasia plants with vermiwash hydroponic solution. The initial immobilization of nutrients on applying large quantity of FYM compared to continuous availability of nutrients from poultry manure may be the reason for higher growth parameters recorded with poultry manure containing treatments. Poultry manure is a bulky organic manure having higher content of mineralizable nitrogen due to its narrow C: N ratio. Singh *et al*. (1973) [11] also attributed the higher efficiency of poultry manure to its narrow C: N ratio and comparatively higher content of mineralizable nitrogen.

The superiority of diancha over cow pea in producing higher leaf area per plant may be due to the higher biomass production and higher content nitrogen and phosphorus of daincha compared to cowpea (Table 1). This may resulted in higher available soil nutrients and uptake of nutrients by crops in turn resulted in higher growth parameters. (Irin, *et al.*, 2019) [4] also reported the higher biomass production of daincha than cow pea. Singh and Shivay (2014) [10] stated that the increased of biomass accumulation of sesbania might be due to its fast and determinate growth habit leading to enhanced biomass incorporation/addition and nutrient availability in soil. Khind *et al.* (1987) [5] opined that, *Sesbania aculeata* could produce 21.1 t ha^{-1} of green biomass and accumulate about 133 kg N ha^{-1}. Sanjay *et al*. (2015) [9] reported that among the summer green manuring crops, daincha recorded significantly higher total fresh and dry matter accumulation compared with cowpea in their two consecutive researches.

Regarding treatments *vs.* control effect (Table 2b) on leaf area per plant, the organic treatments showed significant difference from C_1 (nutrient management through chemical fertilizers as per KAU POP) at all stages of crop growth during I year. All organic nutrition treatments were on par with C_1, except s_1g_2, s_4g_1 and s_4g_2 at 2 MAP; s_1g_1, s_1g_2, s_2g_1, s_2g_2, s_4g_1, s_4g_2 and s_5g_1 at 4 MAP; s_1g_1, s_1g_2, s_2g_1, s_2g_2, s_4g_1, s_4g_2 and s_5g_1 at 6 MAP and s_1g_1, s_1g_2, s_2g_2 and s_4g_1 at harvest which recorded significantly lower values of leaf area per plant than C_1. During II year, significant difference between treatments and C_1 were observed only at 4 MAP and the treatments s_6g_2, s_6g_1, s_5g_2, s_5g_1 and s_3g_2 which produced the leaf area per plant values 3155.43, 2971.49, 2865.50, 2816.95 and 2858.32 cm^2 respectively were on par with C_1 while all other treatment combinations produced significantly lower leaf area per plant. The on par effect of treatments especially s_3g_2, s_5g_1, s_5g_2, s_6g_1 and s_6g_2 with the C_1 indicates the efficiency of organic treatments as that of chemical nutrient management in the growth of taro. While comparing C_2 (nutrient management as per KAU organic Adhoc POP) with treatments, significant difference was observed in case of leaf area per plant only at 4 MAP and 6 MAP during I year and the treatments s_6g_1 and s_6g_2 at 4 MAP and s_2g_2, s_3g_1, s_3g_2, s_5g_2, s_6g_1 and s_6g_2 at 6 MAP were found to be significantly superior to C_2. During II year significant difference was observed only at 4 MAP and s_5g_1, s_5g_2, s_6g_1, s_6g_2, s_2g_2, s_3g_1 and s_3g_2 recorded higher leaf area than C_2, while the treatments s_1g_1 and s_4g_1 recorded significantly lower leaf area per plant compared to C_2. The superiority of organic treatments in leaf area compared to KAU organic POP indicates the higher growth promoting effect of treatments especially s_5g_1, s_5g_2, s_6g_1, s_6g_2, s_3g_2 and s_3g_1 compared to the existing organic management practice. This may be due to the effect additional organic sources like PGPR mix I and vermiwash. In the case of s_5g_1, s_5g_2, s_6g_1 and s_6g_2 quick nutrient release of poultry manure compared to FYM (used in KAU Adhoc organic POP) also might have enhanced the plant growth. The absolute control (C_3) had significant variation from all organic treatments at all stages of observation during both the years. During I year, the treatments s_3g_2 and s_6g_2 at 2 MAP; all treatments except s_1g_1 at 4 MAP; all treatments except s_1g_1, s_1g_2 and s_4g_1 at 6 MAP and the treatments s_2g_2, s_3g_1, s_3g_2, s_5g_2, s_6g_1 and s_6g_2 at harvest were found significantly superior to C_3. During II year, s_5g_2 and s_6g_2 at 2 MAP; all treatments at 4 MAP; s_2g_2, s_3g_1, s_3g_2, s_5g_1, s_5g_2, s_6g_1 and s_6g_2 at 6 MAP and s_6g_2, s_5g_2 and s_6g_1 at harvest recorded higher leaf area per plant than absolute control. The effect of organic sources and *in situ* green manuring reflected in the superiority of organic treatments in growth parameters compared to absolute control

Dry matter production at harvest

Among the organic sources, poultry manure application along with wood ash, PGPR mix I and vermiwash (s_6) recorded the highest dry matter production at harvest during both the years (Table 3a). During first year, s_6 (8.08 t ha^{-1}) was on par with s_5 (7.75 t ha^{-1}) in which poultry manure application along with wood ash and PGPR mix I were done, while during second year s_6 (6.12 t ha^{-1}) was on par with s_3 (5.95 t ha^{-1}) in which FYM application along with wood ash, PGPR mix I and vermiwash were done. *In situ* green manuring with daincha registered significantly higher dry matter production at harvest (7.43 t ha^{-1} during first year and 5.67 t ha^{-1} during second year) than *in situ* green manuring with cow pea during both the years. The interaction had significant effect on dry matter production at harvest during both the years. During first year, treatment combination s_6g_2 (application of poultry manure along with wood ash, PGPR mix I and vermiwash + *in situ* green manuring with daincha) recorded significantly the highest dry matter production at harvest (8.37 t ha^{-1}) followed by s_5g_2 (application of poultry manure along with wood ash and PGPR mix I + *in situ* green manuring with daincha) with 7.90 t ha^{-1} of dry matter production. During second year, s_3g_2 (application of FYM along with wood ash, PGPR mix I and vermiwash + *in situ* green manuring with daincha) recorded the highest dry matter production (6.55 t ha^{-1}) at harvest and was on par with s_6g_2 (6.42 t ha^{-1}). Improvement in growth character of taro by s_6g_2 (application of poultry manure along with wood ash, PGPR mix I and vermiwash + *in situ* green manuring with daincha) culminated in the improvement in dry matter production. The quick release of nitrogen from the poultry manure coupled with direct availability of nutrients through vermiwash application and increased nutrient availability consequent to the PGPR application would have resulted in higher dry matter production by s_6g_2. As explained earlier, the higher biomass production of daincha compared to cowpea resulted in the higher soil nutrient availability and it might have resulted in higher growth and production. The green manure applied to soil undergoes a series of chemical changes wherein the carbon compounds are converted to carbon dioxide and water, the nitrogenous compounds like protein are finally converted to nitrate and mineral constituents like phosphorus, potassium, calcium, magnesium etc present in the organic form or to some extent in the inorganic form are converted to more soluble forms and they become readily available to the succeeding cop (Palaniappan and Annadurai, 1999) [7].

As shown in Table 3b, significant difference was observed between organic treatments and C_1 (Nutrient management through chemical fertilizers as per KAU POP - 80: 25: 100 kg NPK ha^{-1}) during both the years. During first year, the treatments s_2g_2 (7.74 t ha^{-1}), s_3g_1 (7.16 t ha^{-1}), s_3g_2 (7.64 t ha^{-1}), s_5g_1 (7.60 t ha^{-1}), s_5g_2 (7.90 t ha^{-1}), s_6g_1 (7.79 t ha^{-1}) and s_6g_2 (8.37 t ha^{-1}) were at par with C_1 (7.85 t ha^{-1}). During second year, the treatments s_2g_2 (5.77 t ha^{-1}), s_3g_2 (6.55 t ha^{-1}), s_5g_1 (5.47 t ha^{-1}), s_5g_2 (5.59 t ha^{-1}), s_6g_1 (5.81 t ha^{-1}) and s_6g_2 (6.42 t ha^{-1}) were at par with nutrient management through chemical fertilizers (6.18 t ha^{-1}). As in the case of growth character some of the treatments were found as effective as nutrient management through chemical fertilizers in case of dry matter production.

Regarding treatments *vs.* nutrient management as per KAU organic POP- Adhoc (C_2), there was significant difference only during first year. Except s_1g_1, s_1g_2 and s_4g_2, all other treatments showed significantly higher value of dry matter production compared to C_2 (5.99 t ha^{-1}). Even though not significant, s_1g_2, s_2g_2, s_3g_1, s_3g_2, s_5g_1, s_5g_2, s_6g_1 and s_6g_2 recorded higher values of dry matter production than C_2 during second year. The enhancement of growth parameter by the treatments s_2g_2, s_3g_2, s_5g_1, s_5g_2, s_6g_1 and s_6g_2 over Adhoc organic KAU POP reflected in the dry matter production also. All organic treatments were significantly superior to absolute control (4.69 t ha^{-1} during first year and 3.50 t ha^{-1} during second year) during both the years. As observed in the case of leaf area, the higher dry matter production of organic treatments over absolute control is undoubtedly the effect of applied organic sources and *in situ* green manuring which enhanced soil nutrient status and direct feeding of nutrients through vermiwash spraying.

Table 2a: Effect of organic sources and *in si tu* green manuring on leaf area per plant, cm^2

Treatments	Leaf area per plant							
	I year				II year			
	2 MAP	4 MAP	6 MAP	Harvest	2 MAP	4 MAP	6 MAP	Harvest
Organic sources (S)								
s_1- FYM + wood ash	1348.75	2357.31	1274.04	694.07	1246.20	1925.42	974.48	622.23
s_2- FYM + wood ash +PGPR mix I	1695.12	2531.40	1361.98	810.28	1049.02	2634.94	1244.54	785.27
s_3- FYM + wood ash + PGPR mix I + vermiwash	1955.86	2658.37	1417.37	847.33	1359.07	2751.17	1362.58	884.28
s_4- PM+ wood ash	1109.67	2486.86	1284.70	735.23	849.01	2121.96	1158.08	774.97
s_5- PM+ wood ash + PGPR mix I	1664.15	2585.38	1397.51	808.61	1618.86	2866.23	1270.50	859.05
s_6- PM+ wood ash + PGPR mix I + vermiwash	1820.65	2795.05	1501.80	872.40	1668.40	3063.46	1399.86	969.65
S.Em(±)	111.00	10.127	6.724	29.468	158.410	42.465	62.19	76.458
CD (0.05)	325.551	29.703	19.72	86.427	464.601	124.546	182.397	NS
***In situ* green manuring (G)**								
g_1- Cowpea	1535.39	2517.29	1353.35	764.27	1242.73	2458.26	1176.92	774.04
g_2- Daincha	1662.67	2620.83	1392.45	825.04	1354.12	2662.80	1293.09	857.78
S.Em(±)	64.086	5.847	3.882	17.013	91.458	24.517	35.905	44.143
CD (0.05)	NS	17.149	11.385	49.899	NS	71.907	105.307	NS

Table 2b: Effect of S x G interaction and treatment *vs.* control effect on leaf area per plant, cm^2

Treatments	Leaf area per plant							
	I year				II year			
S x G interaction	**2 MAP**	**4 MAP**	**6 MAP**	**Harvest**	**2 MAP**	**4 MAP**	**6 MAP**	**Harvest**
s_1g_1	1492.83	2319.39[1]	1270.70[1]	661.24[1]	1155.25	1853.00[1,2,3]	921.16	554.58
s_1g_2	1204.67[1]	2395.22[1,3]	1277.37[1]	726.90[1]	1337.14	1997.85[1,3]	1027.80	689.88
s_2g_1	1782.15	2453.02[1,3]	1356.88[1,3]	774.95	1011.54	2530.49[1,3]	1166.22	749.84
s_2g_2	1608.09	2609.77[1,3]	1367.07[1,2,3]	845.61[3]	1086.50	2739.39[1,2,3]	1322.85[3]	820.69
s_3g_1	1617.89	2633.89[3]	1420.17[2,3]	822.12[3]	1408.35	2644.02[1,2,3]	1323.57[3]	885.22
s_3g_2	2293.83[3]	2682.86[3]	1414.57[2,3]	872.53[3]	1309.78	2858.32[2,3]	1401.59[3]	883.33
s_4g_1	1094.58[1]	2417.88[1,3]	1240.78[1]	703.36[1]	922.59	1883.60[1,2,3]	1126.92	774.59
s_4g_2	1124.75[1]	2555.83[1,3]	1328.63[1,3]	767.10	775.42	2360.32[1,3]	1189.24	775.36
s_5g_1	1584.01	2526.58[1,3]	1353.66[1,3]	799.50	1342.07	2866.95[2,3]	1213.83[3]	766.52
s_5g_2	1744.28	2644.17[3]	1441.37[2,3]	817.73[3]	1895.65[3]	2865.50[2,3]	1327.17[3]	951.57[3]
s_6g_1	1640.90	2752.99[2,3]	1477.93[2,3]	824.43[3]	1616.54	2971.49[2,3]	1309.84[3]	913.49[3]
s_6g_2	2000.39[3]	2837.12[2,3]	1525.67[2,3]	920.37[3]	1720.26[3]	3155.43[2,3]	1489.88[3]	1025.81[3]
S.Em(±)	156.977	14.322	9.509	41.674	224.026	60.055	87.95	108.128
CD (0.05)	NS	42.006	27.888	NS	NS	176.135	NS	NS
C_1- KAU PoP	2062.98	2750.10	1520.92	951.29	1684.00	3083.91	1411.15	1012.79
Treatment *vs.* C_1	S	S	S	S	NS	S	NS	NS
C_2-KAU organic PoP	1651.38	2397.71	1281.13	801.30	1337.60	2256.33	1174.69	832.07
Treatment *vs.* C_2	NS	S	S	NS	NS	S	NS	NS
C_3-Absolute control	1153.36	2125.54	1201.00	644.40	735.44	1473.04	839.49	459.30
Treatment *vs.* C_3	S	S	S	S	S	S	S	S

[1] significantly different from C_1; [2] significantly different from C_2; [3] significantly different from C_3

Table 3a: Effect of organic sources and in situ green manuring on dry matter production at harvest

Treatments	Dry matter production (t ha^{-1})	
	I year	II year
Organic sources (S)		
s_1- FYM + wood ash	6.25	4.72
s_2- FYM + wood ash +PGPR mix I	7.20	5.16
s_3- FYM + wood ash + PGPR mix I + vermiwash	7.40	5.95
s_4- PM+ wood ash	6.57	4.65
s_5- PM+ wood ash + PGPR mix I	7.75	5.53
s_6- PM+ wood ash + PGPR mix I + vermiwash	8.08	6.12
SEm(±)	0.112	0.132
CD (0.05)	0.328	0.388
***In situ* green manuring (G)**		
g_1- Cowpea	6.99	5.04
g_2- Daincha	7.43	5.67
SEm(±)	0.065	0.076
CD (0.05)	0.189	0.224

Table 3b: Interaction effect of organic sources and *in situ* green manuring and treatment *vs.* control effect on dry matter production at harvest

Treatments	Dry matter production (t ha^{-1})	
S x G interaction	**I year**	**II year**
s_1g_1	5.99[13]	4.30[13]
s_1g_2	6.52[13]	5.13[13]
s_2g_1	6.67[123]	4.55[13]
s_2g_2	7.74[23]	5.77[3]
s_3g_1	7.16[23]	5.36[13]
s_3g_2	7.64[23]	6.55[3]
s_4g_1	6.71[123]	4.74[13]
s_4g_2	6.43[13]	4.57[13]
s_5g_1	7.60[23]	5.47[3]
s_5g_2	7.90[23]	5.59[3]
s_6g_1	7.79[23]	5.81[3]
s_6g_2	8.37[23]	6.42[3]
S.Em(±)	0.158	0.187
CD (0.05)	0.464	0.549
C_1- KAU PoP	7.85	6.18
Treatments *vs.* C_1	S	S
C_2- KAU organic PoP	5.99	4.86
Treatments *vs.* C_2	S	NS
C_3- Absolute control	4.69	3.50
Treatments *vs.* C_3	S	S

[1] significantly different from C_1; [2] significantly different from C_2; [3] significantly different from C_3

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