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Influence of Various Organic Nutrient Sources on Dry matter Partitioning and Physiological parameters of Vegetable Cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.)

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ABSTRACT: Organic farming is one of the best alternate crop production systems to safe guard human health and other life in agricultural ecosystem from toxic chemicals used in agriculture. Cluster bean is leguminous industrial crop, with huge demand for various sectors like food consumer markets, pharmaceuticals, medicine etc. Indiscriminate use of chemical inputs in cluster bean cultivation affects human health system and environment. So, the research on influence of different organic nutrient sources compared to conventional recommended dose of fertilizers (RDF) on dry-matter partitioning and physiological parameters on vegetable cluster bean was explored. The experiment was carried out using randomized complete block design (RCBD) with twelve treatments and three replications at irrigated condition ta Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore between June to September, 2018. The dry weight of root, stem, leaf and total plant dry weight, LAI, CGR, AGR and RGR of cluster bean were measured and had shown significant difference with application of recommended dose of fertilizer (50:50:25 – NPK) along with a foliar spray application of TNAU pulse wonder (T_{11}). However, it was statistically on par with organic farmers' practice (T_1) and FYM @ 25 t/hain addition to foliar spray of 3% *Panchagavya* (T_2). Considering the need for chemical free environment at food production sites, the farmer's practice of applying FYM @ 10 t/ha + *Jeevamruth* @ 500 l/ha through irrigation + foliar spray application of *Panchagavya* @ 3% is found to beneficial for vegetable clusterbean growth and yield.

Keywords: Organic manures, Vegetable Cluster bean, Dry-matter partitioning, Physiological parameters and recommended dose of fertilizers (RDF).

INTRODUCTION

India holds second position in vegetable production following China, with a land area of 10.2 million hectares (175 million tonnes). However, in comparison to global production, we continue to lag behind in the production of a variety of vegetables (Nath *et al.*, 2015). As a result, there is a compelling need to increase vegetable productivity in ecological safe and sustainable way. Today, the globe is also dealing with issues related to indiscriminate use of synthetic chemicals in food production and their impact on human and environmental health (Chávez-Dulanto *et al.*, 2021). Organic farming is one of the finest food production solutions for a healthier and more sustainable existence, as it supports and improves agro-ecosystem health by adhering to principles of health, ecology, fairness, and caring for everyone, including soil (Timsina, 2018).

Organic vegetable farming is becoming increasingly popular in India, however scientifically verified information about organic methods of cultivation has yet to be produced to meet the needs of today's Farmers in many vegetable crops. In the developing world, the average yield ratio (organic: nonorganic) was more than one (Badgley *et al.*, 2007). Since the last two decades, organic agriculture has been one of the most dynamic and quickly increasing sectors of agriculture (Timsina, 2018).

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]is a leguminous crop that is native to the Indian subcontinent (Vavilov, 1951). It is popularly known as '*Guar*', and it has captured a prominent position because of high export potential and multiple benefits from the crop. It is also valued for its high yield and drought tolerance. Green tender pods are rich in protein (3.2 g), vitamin C (49 mg), vitamin A (65.31 IU), energy (16 k Cal), iron (4.5 mg), calcium (57 mg), fat (1.4 g), carbohydrate

(10.8 g) and moisture (8.1 g) per 100 g edible piece (Longvah *et al.*, 2017). It also heals stomach ulcers, high blood pressure, obesity, plague, arthritis, inflammation, sprains and liver enlargement, among other problems (Pathak, 2015).

The vegetable cluster bean requires abundant supply of nutrients for its good growth and development. Organic manures like vermicompost, farm yard manure, *Panchagavya* and humic acid can be used as substitute for inorganic fertilizers in cluster bean to maintain soil productivity and environment quality. Organic manures not only increase soil chemical characteristics by supplying macro and micro nutrients, but they also reduce crop failure by supplying growth promoting chemicals and improve soil physical qualities such as structure and moisture retention capacity (Kumar, 2016). In this paper we discussed the impact of organic manures on dry-matter portioning and physiological growth rate of vegetable cluster bean compared to inorganic fertilizers.

MATERIAL AND METHODS

A field trial in *kharif* was conducted from July to October, 2018 at wetland farms of Tamil Nadu Agricultural University, Coimbatore to evaluate the influence of organic manures dry matter partitioning and physiological parameters. The experimental field was organically maintained from past 10 years. The field has alkaline pH(8.27) with clay loamy soils in texture, less salinity (0.25 dS/m), medium organic carbon (0.45%), less available nitrogen, medium phosphorus and high potassium (218, 18.2 and 402 kg/ha, respectively). The field trail was laidoutin randomized complete block design with twelve treatments and three replications.

The following are the treatments:

T_1: Organic farmer's practice (farm yard manure (FYM) @ 10 tonnes per hectare + *Jeevamruth* @ 500 litres per hectare on 3rd days after sowing (DAS), 30 DAS and 60 DAS along with irrigation + *Panchagavya* @ 3% as foliar spray (FS) application on 30, 45 and 60 days after sowing (DAS).

T_2: FYM @ 25 tonnes per hectare + *Panchagavya* @ 3% as foliar spray on 30, 45 and 60 DAS.

T_3: FYM @ 12.5 tonnes per hectare + *Panchagavya* @ 3% as foliar spray on 30, 45 and 60 DAS.

T_4: FYM @ 12.5 tonnes per hectare + banana pseudostem sap @ 2% as foliar spray on 30, 45 and 60 DAS.

T_5: Vermicompost @ 5 tonnes per hectare + *Panchagavya* @ 3% as foliar spray on 30, 45 and 60 DAS.

T_6: Vermicompost @ 5 tonnes per hectare + banana pseudostem sap @ 2% as foliar spray on 30, 45 and 60 DAS.

T_7: *Ganajeevamruth* @ 500 kg per hectare + *Panchagavya* @ 3% as foliar spray on 30, 45 and 60 DAS.

T_8: *Ganajeevamruth* @ 500 kg per hectare + banana pseudostem sap @ 2% as foliar spray on 30, 45 and 60 DAS.

T_9: Humic acid @ 6 litres per hectare + *Panchagavya* @ 3% as foliar spray on 30, 45 and 60 DAS.

T_{10}: Humic acid @ 6 litres per hectare + banana pseudostem sap @ 2% as foliar spray on 30, 45 and 60 DAS.

T_{11}: Recommended dose of fertilizer (NPK = 50:50:25 kg/ha) + TNAU pulse wonder @ 1% as foliar spray

T_{12}: Absolute control.

The farm yard manure (FYM), *Ganajeevamruth*, vermicompost and humic acid were applied as basal before sowing, whereas *Panchagavya*, banana pseudostem sap were applied as foliar spray on 30, 45, and 60 days after sowing (DAS). *Jeevamruth* was applied to experimental plot along with irrigation water on 3rd day after sowing (DAS), 30th and 60th DAS. The banana pseudostem sap was extracted from banana standing plant (8-year-old tree), by making sharp incision on stem with a sharp knife. The collected sap was applied as foliar spray by diluting 2 ml of sap in one liter of water.

To achieve excellent tilth, the cultivator was used for two times followed by one time with rotovator. Using a bullock drawn ridge former, 45 cm width ridges were created. The dimension of the plots was 6.75 m × 3.15m. Prior to sowing, organic manures were put to the soil and the field was irrigated. Seeds of Cluster bean variety MDU 1 were treated with *Rhizobium* culture @ 80 g/kg. Sowing was taken up on one side of the ridge at 15 cm distance followed by a first irrigation was provided on the same day. Later, the second on the third DAS, and then further irrigations were scheduled based on available soil moisture content. As per the treatments, organic liquid manures were administered as a foliar spray application on 30, 45 and 60 DAS. Except for the use of synthetic chemicals, all other agronomic cultural practices and management practices were shadowed as per recommendation TNAU agro site. (http://agritech.tnau.ac.in/horticulture/horti vegetables cluste.html)

From sampling rows, five plants were randomly selected and uprooted on 30, 45, 60 DAS and harvest stage. Then, the plants were shade dried and oven dried at 65 - 70°C for 24 hours. Total dry weight and separate dry weight of root, stem and leaves were documented with help of electronic weighing balance and expressed in grams per plant

Leaf area index (LAI) was computed from five plant leaf area average on 30, 45, 60 DAS and harvest stage of the crop by using the formula given by Watson (1952)

Leaf area index = Total leaf area of a plant (cm^2)/ Ground area per plant (cm^2)

The crop growth rate (CGR) is the rate at which dry matter is produced per unit of ground area per unit of time. CGR was determined using Watson (1952) formula and expressed in grams per square meter each day (g m^{-2} day^{-1}).

$$\text{Crop growth rate} = \frac{W_2 - W_1}{P\,(t_2 - t_1)}$$

Where, W_1 and W_2 means plant total dry weight at time t_1 and t_2, respectively; P is plant spacing in square meters and; $t_2 - t_1$ is the time interval in days.

The relative growth rate (RGR) is the rate of increase in dry weight per unit dry weight already existent, and it is measured in milli grams per gram of dry weight every day (mg $g^{-1}day^{-1}$) (Blackman, 1919).

$$\text{Relative growth rate} = \frac{\text{Loge } W_2 - \text{Loge } W_1}{t_2 - t_1}$$

Where, W_1 - Whole plant dry weight at time t_1; W_2- Whole plant dry weight at time t_2; t_1 and t_2 - Time interval in days.

The absolute growth rate (AGR) is defined as the dry matter production per unit time (g day^{-1}), which was computed using Radford (1967) formula.

$$\text{Absolute growth rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W1 = Plant dry weight (g) at time t_1 ;W_2 = Plant dry weight (g) at time t_2. ; t_1 and t_2 - Time interval in days. Using Agres software, the experimental data was statistically analysed using analysis of variance (ANOVA). The level of significance (P =0.05) was preserved at 5%.

Fig. 1. Foliar spray application of *Panchagavya* and banana pseudostem sap.

RESULTS AND DISCUSSION

Effect of organic nutrient source on dry matter portioning of vegetable cluster bean. Accumulation of dry-mater is the reliable index of crop growth. The mean data of root, stem, leaves and total dry weight per plant and pod dry weight in vegetable cluster bean was presented in the Table 1. The data clear depicts that with advancement of crop, the dry-matter accumulation in roots, stem, leaves and total dry matter were in increasing trend from 45 to 60 DAS later decreased at harvest stages due to ageing and leaf fall and also due to translocation of photosynthates into green tender pods which were harvested at multiple pickings (Gupta *et al.*, 2015).

Higher root (0.62, 0.57 and 0.43 g per plant on 45,60 and 90 DAS, respectively), stem (1.47, 1.65 and 1.41 g per plant on 45, 60 and 90 DAS, respectively), leaves (2.59, 2.33 and 2.17 g per plant on 45, 60 and 90 DAS, respectively), total dry weight (4.68, 7.52 and 8.80 g per plant on 30, 45 and 60 DAS, respectively) and pod dry weigh (1757 g per plant) of cluster bean plants was recorded due tothe application of RDF along with a foliar spray of TNAU pulse wonder (T_{11}), but statistically on par with organic farmers' practice (T_1) and FYM @ 25 tonnes per hectare in addition to foliar spray of 3% Panchagavya (T_2). This might be due to rapid availability of macro nutrients from RDF and micro nutrients from TNAU pulse wonder (Ramesh *et al.*, 2020) might have enhanced the metabolic and physiological activity like photosynthate partitioning and efficient translocation of food material in the plant. Eventually, the amount of dry matter accumulation had increased, similar results were noted with (Pooja *et al.*, 2021).

In organic treatments organic manures along with chemolithotrops and autotropicnitrifiers present in *Panchagavya*, which colonize in the leaves have increased the ammonia uptake (Devakumar *et al.*, 2014). Nitrogenous compounds play a vital role in amino acid synthesis, protein synthesis and chlorophyll synthesis (Shu *et al.*, 2012), which results into efficient photosynthesis and photosynthate production, consequently increase in dry matter accumulation in leaves, stems, root, and pods. Thus, resulting overall higher dry matter accumulation in plant.

Less accumulation of root, stem, leaves, total plant dry matter and pod dry weight was noted in absolute control (T_{12}) was many due to lack of nutrients.

Effect of organic manures on physiological parameters. Growth analysis like leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and absolute growth rate (AGR) were used to evaluate photosynthesis, assimilation and therefore yield of a crop.

Leaf area index denotes photosynthetic area in a unit crop area, which has direct contribution to yield and acts like an indicator for plant growth. Leaf area index (LAI) of clusterbean, was computed and furnished in the Table 2. On perusal of data, the LAI was increased up to 45 DAS, thereafter it tended to decrease gradually. At all stages of crop growth, remarkable difference was noted with LAI. Significantly higher LAI (0.338, 0.461, 0.235 and 0.134 on 30, 45, 60 and 90 DAS, respectively) was enumerated with recommended dose of fertilizer (RDF) in addition to foliar spray application of TNAU pulse wonder (T_{11}) and statistically on par with organic farmers' practice (T_1) and FYM @ 25 t/ha in addition to foliar spray of 3% *Panchagavya* (T_2). This was due to synchronized nutrient release matching to the crop requirement from basal and foliar application of fertilizers resulted in production of higher number of leaves with larger leaf area (Rawat *et al.*, 2015). Lesser LAI (0.140, 0.189, 0.097 and 0.055 on 30, 45, 60 and harvest stages, respectively) was under absolute control (T_{12}).

AGR, CGR, RGR was calculated for each treatment at 30 days interval and statistical computation was done and highlighted in the Table 2.

Table 1: Effect of organic manures on root, stem, leaves, total plant dry weight and pod dry weight (g) of vegetable clusterbean.

	Root dry weight (g)				Stem dry weight (g)				Leaf dry weight (g)				Total plant dry weight (g)				Pod dry weight
Treatment	**30 DAS**	**45 DAS**	**60 DAS**	**Harvest**	**30 DAS**	**45 DAS**	**60 DAS**	**Harvest**	**30 DAS**	**45 DAS**	**60 DAS**	**Harvest**	**30 DAS**	**45 DAS**	**60 DAS**	**Harvest**	**Harvest**
T_1	0.45	0.57	0.52	0.40	0.79	1.35	1.53	1.30	1.84	2.38	2.14	2.00	3.08	4.31	7.13	8.51	1737
T_2	0.44	0.57	0.52	0.40	0.79	1.34	1.51	1.29	1.83	2.37	2.13	1.99	3.06	4.28	7.37	8.49	1899
T_3	0.44	0.51	0.47	0.36	0.78	1.22	1.37	1.17	1.66	2.14	1.93	1.80	2.87	3.88	6.60	7.75	1675
T_4	0.44	0.52	0.48	0.36	0.78	1.23	1.39	1.18	1.67	2.17	1.95	1.82	2.90	3.92	6.93	7.99	1847
T_5	0.43	0.51	0.47	0.36	0.77	1.21	1.36	1.16	1.64	2.13	1.92	1.79	2.85	3.85	6.62	7.62	1703
T_6	0.44	0.52	0.48	0.36	0.78	1.23	1.38	1.17	1.67	2.16	1.94	1.81	2.89	3.90	6.95	7.93	1864
T_7	0.43	0.45	0.41	0.32	0.77	1.07	1.20	1.02	1.45	1.88	1.69	1.58	2.65	3.39	5.76	6.66	1459
T_8	0.43	0.45	0.42	0.32	0.77	1.08	1.21	1.03	1.46	1.89	1.70	1.59	2.66	3.42	6.00	6.96	1578
T_9	0.43	0.46	0.42	0.32	0.77	1.08	1.22	1.04	1.47	1.90	1.71	1.60	2.67	3.44	5.83	6.83	1470
T_{10}	0.43	0.51	0.46	0.35	0.77	1.20	1.35	1.15	1.63	2.11	1.90	1.77	2.83	3.82	6.40	7.40	1591
T_{11}	0.45	0.62	0.57	0.43	0.80	1.47	1.65	1.41	2.00	2.59	2.33	2.17	3.25	4.68	7.52	8.80	1757
T_{12}	0.43	0.40	0.36	0.28	0.76	0.94	1.06	0.90	1.28	1.66	1.49	1.39	2.47	3.00	5.41	6.41	1479
SEd	**0.02**	**0.03**	**0.02**	**0.02**	**0.03**	**0.07**	**0.07**	**0.04**	**0.08**	**0.11**	**0.09**	**0.10**	**0.14**	**0.21**	**0.33**	**0.37**	**86**
CD(P=0.05)	**NS**	**0.06**	**0.05**	**0.04**	**NS**	**0.14**	**0.15**	**0.07**	**0.17**	**0.22**	**0.19**	**0.20**	**0.30**	**0.44**	**0.68**	**0.77**	**178**

FYM: Farm yard manure

Table 2: Effect of organic manures on leaf area index, absolute growth rate, crop growth rate and relative growth rate of vegetable clusterbean.

	Leaf area index				Absolute growth rate (g day^{-1})			Crop growth rate (g m^{-2} day^{-1})			Relative growth rate (mg g^{-1} day^{-1})		
Treatments	**30 DAS**	**45 DAS**	**60 DAS**	**Harvest**	**0-30 DAS**	**30-60 DAS**	**60-90 DAS**	**0-30 DAS**	**30-60 DAS**	**60-90 DAS**	**0-30 DAS**	**30-60 DAS**	**60-90 DAS**
T_1	0.287	0.390	0.200	0.114	0.103	0.135	0.046	1.52	2.00	0.68	37.5	28.0	5.9
T_2	0.283	0.387	0.198	0.112	0.102	0.144	0.037	1.51	2.13	0.55	37.3	29.3	4.7
T_3	0.233	0.317	0.161	0.092	0.096	0.124	0.038	1.42	1.84	0.57	35.1	27.8	5.4
T_4	0.238	0.323	0.165	0.094	0.097	0.134	0.035	1.43	1.99	0.53	35.4	29.1	4.8
T_5	0.230	0.313	0.159	0.091	0.095	0.126	0.033	1.41	1.86	0.49	34.9	28.1	4.7
T_6	0.237	0.322	0.164	0.094	0.096	0.135	0.033	1.42	2.01	0.48	35.3	29.3	4.4
T_7	0.178	0.243	0.124	0.071	0.088	0.104	0.030	1.31	1.54	0.44	32.5	25.9	4.8
T_8	0.182	0.247	0.126	0.072	0.089	0.111	0.032	1.31	1.65	0.48	32.6	27.1	5.0
T_9	0.184	0.250	0.128	0.073	0.089	0.105	0.033	1.32	1.56	0.49	32.7	26.0	5.3
T_{10}	0.226	0.307	0.157	0.089	0.094	0.119	0.033	1.40	1.76	0.49	34.7	27.2	4.8
T_{11}	0.338	0.461	0.235	0.134	0.108	0.142	0.043	1.60	2.11	0.63	39.2	28.0	5.2
T_{12}	0.140	0.189	0.097	0.055	0.082	0.098	0.033	1.22	1.45	0.49	30.2	26.1	5.7
SEd	**0.016**	**0.020**	**0.014**	**0.004**	**0.005**	**0.006**	**0.002**	**0.07**	**0.09**	**0.03**	**2.0**	**1.2**	**0.3**
CD (P=0.05)	**0.033**	**0.042**	**0.029**	**0.008**	**0.010**	**0.013**	**0.004**	**0.15**	**0.19**	**0.06**	**4.1**	**2.2**	**0.5**

FYM: Farm yard manure

In general, the data shown that AGR, CGR and RGR increased by multiple folds with increase in plant growth rate from 0-30 DAS to 30-60 DAS stages, later on it was decreased up to harvest under various organic manure application.

On review of the data, different organic manure application resulted in a significant influence on AGR, CGR, RGR of cluster bean at all stages. RDF along with foliar spray of TNAU pulse wonder (T_{11}) had shown significantly prominent AGR (0.108 g day^{-1} between 0-30 DAS, 30-60 DAS and 60-90 DAS, respectively), CGR (1.60, 2.11 and 0.63 g m^{-2} day^{-1} between 0-30 DAS, 30-60 DAS and 60-90 DAS, respectively) and RGR (39.2 mg g^{-1} day^{-1} between 0-30 DAS, 30-60 DAS and 60-90 DAS, respectively). Although RDF with TNAU pulse wonder has superior AGR, CGR and RGR compared to other treatments, it was statistically on par with organic farmers' practice (T_1) and FYM @ 25 tonnes per hectare in addition to foliar spray application of 3% *Panchagavya* (T_2). This was due to better utilization of available nutrients and solar radiation to promote physiological and metabolic activities of crop. Thus, leading to better accumulation of dry matter with the rate of advancement of the vegetable clusterbean crop. Similar findings were observed with (Lodha, 2016). Remarkably lower AGR (0.082, 1.45 and 0.49 g day^{-1}), CGR (1.22g $m^{-2}day^{-1}$**)** RGR (30.2 mg g^{-1} day^{-1}) was documented under absolute control (T_{12}).

CONCLUSION

Along with food security, it is necessary to consider the safety of environment, human health and in agriculture and food production system. So, it is concluded that the farmer's practice – basal application of farm yard manure (FYM) @ 10 tonnes per hectare, along with *Jeevamruth* @ 500 litres per hectare application along with irrigation water and foliar spray application of *Panchagavya* @ 3 per cent is found to provide better growth rate and better partitioning of photosynthates to sink for higher yields in vegetable clusterbean.

FUTURE SCOPE

Nutrient release pattern and impact of organic manures like *Ganajeevamruth* on various other crops under different types of soils have to be carried out.

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