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# Pattern of dry matter accumulation in chickpea (*Cicer arietinum* L.) as influenced by organic nutrient management practices in vertisol

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**ABSTRACT :** Field trials were conducted on vertisols at Agricultural Research Station, Annigeri, UAS, Dharwad during *Rabi* season of 2009-2010 and 2010-2011 to study the pattern of dry matter accumulation in chickpea as influenced by organic nutrient management practices in vertisol. Soil application of various organic manures and foliar spray of liquid organic manures at flower initiation and 15 days after flowering (DAF) significantly influenced the dry matter accumulation in leaves, stem, reproductive parts and total dry matter production. Among the treatment combinations, application of enriched compost (EC) (1/3) + vermicompost (VC) (1/3) + glyricidia leaf manure (GLM) (1/3) equivalent to 100 per cent RDN and foliar spray of panchagavya @ 3 per cent at flower initiation and 15 DAF had recorded significantly higher dry matter accumulation in leaves(4.59g/plant) at 90 DAS, stem(5.00g/plant) at harvest, reproductive parts(16.99g/plant) at harvest and total dry matter production(24.34g/plant) at harvest as compared to other treatment combinations.

**Key Words :** Organic manures, Liquid organic manures, Chickpea, Dry matter accumulation

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Chickpea (*Cicer arientinu* L.) remarkably predominates among other pulse crops in terms of both area and production. The year 2009-2010 marked significant increase in area under chickpea (8.56 million ha) which is highest in last 10 years. Similarly, the chickpea production (7.35 million tonnes) also surpassed last 50 years record with highest productivity (858 kg/ha) ever recorded in the history of India. The area under chickpea has increased from 6.45 million ha in 1992-1993 to 8.56 million ha in 2009-2010. Similarly, in Karnataka, the area under chickpea increased 2.7 times and production increased 4.4 times during the same period. During the period 1991-93 to 2006-08, highest increase in productivity of chickpea has been recorded in Andhra Pradesh (124%), followed by Karnataka (63%), Maharashtra (52%) and Gujarat (40%). Still there is scope for productivity enhancement in states like Karnataka, Gujarat, Bihar, Haryana etc. to make more availability of chickpea at national level (Anonymous, 2010).

The dry matter production and its accumulation are the best measure and index of the total performance and response of a crop to weather conditions (Mall *et al*., 2000). The yield of a crop does not largely depend on the dry matter production alone but also in its distribution to reproductive parts; as major part of the dry matter is translocated to sink from source (Acevedo *et al*., 1990). Optimum plant population utilizes available moisture and nutrients from the soil more effectively and leads to better dry matter production and accumulation which reflects in yield of crop. The pre-requisite for high yield is related to the ability of a genotype to produce high amounts of total dry matter. The manner in which the net dry matter produced will determine the economic yield. The total nutritional consumption from chemical fertilizers is about 20.34 million tons (Anonymous, 2006) in India. To augment this, India is endowed with enormous potential of natural resources and industrial by products (Katyal, 2000). India with the second largest human population and the highest cattle population is sustained seventh largest on the geographical area, which is seventh largest in the world with tropical and sub-tropical climate has greater pressure on natural resources. However, it

offers a great potential for organic matter availability. Under arable production system, organic manures suffer from the drawback of slow release of nutrients, which may cause significant reduction in crop yield and net farm income. This could be overcome by use of judicious combination of organic manures. Combined application of green manures, crop residues and composts along with liquid manures mainly panchagavya, bio-digester, beejamrut, jeevamrut, biogas slurry and vermiwash, cow urine etc. in a more synchronized system, which can release the nutrients as per the need of crop and sustain higher productivity (Kanwar *et al*.,2006). With these objectives in view, the present investigation was undertaken to study the pattern of dry matter accumulation and its partition in different plant parts of chickpea as influenced by organic nutrient management practices.

## RESEARCH PROCEDURE

The experiment was carried out at Agricultural Research Station, Annigeri, UAS, Dharwad, Karnataka, during *Rabi* season of 2009-10 and 20010-11. The soil of the experimental plot was clayey in texture ( 64.63% clay, 13.12% sand and 22.25% silt) with bulk density of 1.27 g/cc, alkaline in reaction (pH 7.9), low in organic carbon (0.51%), low in available nitrogen (202 kg/ha), and phosphorus (18.90 kg/ha) and medium in available potassium (347 kg/ha).

The experiment was laid out in RCBD with three replications. There were 18 treatment combinations consisting of four main factors mainly soil application of four organic manures $OM_1$: Farmyard manure (FYM) (1/3rd) + vermi compost (VC) (1/3rd) + glyricidia leaf manure (GLM) (1/3rd) equivalent to 100 per cent RDN, $OM_2$: EC (1/3rd) + VC (1/3rd) + GLM (1/3rd) equivalent to 100 per cent RDN, $OM_3$: FYM (1/3rd) + VC (1/3rd) + neem cake (NC) (1/3rd) equivalent to 100 per cent RDN, $OM_4$: EC (1/3rd) + VC (1/3rd) + NC (1/3rd) equivalent to 100 per cent RDN and sub-factors consisting of foliar spray of four liquid manures mainly $LM_1$ : Panchagavya @ 3 per cent at flower initiation and 15 days after flower initiation (DAF), $LM_2$ : Biodigester @ 10 per cent at flower initiation and 15 DAF, $LM_3$: cow urine @ 10 per cent at flower initiation and 15 DAF, $LM_4$ : Vermiwash @ 10 per cent at flower initiation and 15 DAF in addition to two control treatments RDF and absolute control (water spray).

The crop was shown on 10-10-2009 and 13- 10- 2010 with a spacing of 30 cm × 10 cm. The recommended dose of nutrients for chickpea were supplemented through different combination of organic manures on nutrient equivalent bases and additional phosphorus was balanced through application of rock phosphate with PSB. The required quantity of organic manures and rock phosphate with PSB as per treatment was incubated for 30 days before sowing of crop under shade with regular watering and were applied at the time of sowing as per the treatments. For RDF treatments, DAP was applied at the time of sowing.

The plant samples were partitioned into leaves, stem (including petioles) and reproductive parts (pod) and dried separately at $70^0$C + 5 in hot air oven till a constant weight. Completely dried samples were weighed and the dry weight of different plant parts was expressed in grams per plant.

## RESEARCH ANALYSIS AND REASONING

The organic manures had no significant effect on dry matter accumulation in leaves of chickpea except at 90 DAS. Liquid organic manures and its interaction with organic manures influenced the dry matter accumulation in leaves significantly at all the stages of crop growth except 30 DAS. At 60 DAS, liquid organic manures spray with panchagavya 3 per cent spray (2.25 g/plant), cow urine 10 per cent spray (2.19 g/plant) recorded significantly higher dry matter accumulation in leaves as compared to other treatments. Interaction effects of various combination, $OM_2LM_1$ recorded significantly, higher dry matter accumulation in leaves (2.38 g/plant) compared to other treatment combinations except organic manure combination with panchagavya 3 per cent spray. At 90 DAS, the treatment $OM_2$ recorded higher dry matter accumulation in leaves (4.13 g/plant) which was significantly superior to other organic manures except $OM_4$.Liquid organic manure spray with $LM_1$ (4.26 g/plant) and $LM_3$ (4.05 g/plant) recorded significantly higher dry matter accumulation in leaves as compared to other liquid organic manures spray. Interaction of $OM_2LM_1$ recorded significantly higher dry matter accumulation in leaves (4.59 g/plant) compared to other treatment combination. At harvest, liquid organic manure spray, cow urine 10 per cent spray ($LM_3$) recorded significantly higher dry matter accumulation in leaves (2.85 g/plant) than other treatments except panchagavya 3 per cent spray ($LM_1$). Among the treatment combinations $OM_2LM_1$ recorded higher dry matter accumulation in leaves (2.99 g/plant) compared to other treatments of $OM_1LM_2$, $OM_1LM$, $OM_2LM_2$, $OM_3LM_3$, $OM_3LM_4$, $OM_4LM_2$, $OM_4LM_4$, $C_1$, $C_2$ and remained at par with other treatments (Table 1).The dry matter accumulation in leaves showed an increasing trend up to 90DAS and declined thereafter. This decline in the leaf dry matter was observed between 90 DAS and harvest. This may be due to leaf fall and senescence of leaves and translocation of photosynthates towards pod and seed development (Bever *et al*., 1985).

The dry matter accumulation in stem had significantly influenced by application of organic manures at all the stages of crop growth except at 30 and 60 DAS. Whereas, liquid organic manures and its interaction with organic manures had also significantly influenced on dry matter accumulation in stem at all the stages of crop growth except 30 DAS. At 60 DAS, liquid organic manures *viz.*, panchagavya 3 per cent (2.52 g/plant) and cow urine 10 per cent spray recorded significantly higher dry matter accumulation in stem (2.46 g/plant) compared to

biodigester 10 per cent spray and vermiwash 10 per cent spray. Interaction effects, $OM_2LM_1$ recorded significantly higher dry matter accumulation in stem (2.65 g/plant) compared to other treatments except $OM_1LM_1$, $OM_1LM_2$, $OM_2LM_3$, $OM_3LM_1$, $OM_4LM_1$ and $OM_4LM_3$, while the lowest (1.50 g/plant) was recorded with water spray ($C_2$). At 90 DAS, application of organic manures $OM_2$ recorded higher dry matter accumulation in stem (3.50 g/plant) which was significantly superior over other treatments. Liquid organic manure spray with LM1 and $LM_3$ recorded the maximum dry matter accumulation in stem (3.56 and 3.45 g/plant, respectively) which were significantly higher than other treatments. Among the interactions, $OM_2LM_1$

**Table 1 : Influence of organic nutrient management practises on dry matter accumulation in leaves at different growth stages of chickpea (Pooled data of 2009-10 and 2010-11)**

| Treatments | Dry matter accumulation in leaves (g/plant) | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| Organic manures (OM) | | | | |
| $OM_1$ : FYM 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 0.46 | 2.10 | 3.82 | 2.64 |
| $OM_2$ : EC 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 0.48 | 2.19 | 4.13 | 2.79 |
| $OM_3$ : FYM 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 0.45 | 2.06 | 3.76 | 2.66 |
| $OM_4$ : EC 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 0.46 | 2.12 | 3.90 | 2.63 |
| S.E.± | 0.01 | 0.05 | 0.08 | 0.08 |
| C.D. (P=0.05) | NS | NS | 0.23 | NS |
| Liquid organic manures (LM) | | | | |
| $LM_1$: Panchagavya @ 3 % at flower initiation and 15 DAF | 0.49 | 2.25 | 4.26 | 2.82 |
| $LM_2$: Biodigester @ 10% at flower initiation and 15 DAF | 0.45 | 1.93 | 3.49 | 2.38 |
| $LM_3$: Cow Urine @ 10% at flower initiation and 15 DAF | 0.45 | 2.19 | 4.05 | 2.85 |
| $LM_4$: Vermiwash @ 10% at flower initiation and 15 DAF | 0.47 | 2.11 | 3.81 | 2.67 |
| S.E.± | 0.01 | 0.05 | 0.08 | 0.08 |
| C.D. (P=0.05) | NS | 0.13 | 0.23 | 0.22 |
| Interaction | | | | |
| $OM_1LM_1$ | 0.48 | 2.25 | 4.26 | 2.82 |
| $OM_1LM_2$ | 0.45 | 1.86 | 3.52 | 2.44 |
| $OM_1LM_3$ | 0.45 | 2.20 | 3.78 | 2.79 |
| $OM_1LM_4$ | 0.46 | 2.11 | 3.71 | 2.53 |
| $OM_2LM_1$ | 0.51 | 2.38 | 4.59 | 2.99 |
| $OM_2LM_2$ | 0.46 | 1.98 | 3.58 | 2.39 |
| $OM_2LM_3$ | 0.46 | 2.27 | 4.34 | 2.90 |
| $OM_2LM_4$ | 0.48 | 2.13 | 4.02 | 2.87 |
| $OM_3LM_1$ | 0.47 | 2.16 | 4.08 | 2.77 |
| $OM_3LM_2$ | 0.44 | 1.91 | 3.40 | 2.39 |
| $OM_3LM_3$ | 0.45 | 2.10 | 3.90 | 2.93 |
| $OM_3LM_4$ | 0.45 | 2.08 | 3.66 | 2.55 |
| $OM_4LM_1$ | 0.48 | 2.21 | 4.10 | 2.71 |
| $OM_4LM_2$ | 0.45 | 1.96 | 3.48 | 2.31 |
| $OM_4LM_3$ | 0.45 | 2.20 | 4.17 | 2.78 |
| $OM_4LM_4$ | 0.46 | 2.12 | 3.86 | 2.72 |
| Control | | | | |
| $C_1$ – RDF | 0.45 | 1.82 | 3.32 | 2.25 |
| $C_2$ – Water spray | 0.41 | 1.33 | 2.65 | 2.04 |
| S.E.± | 0.02 | 0.09 | 0.16 | 0.15 |
| C.D. (P=0.05) | NS | 0.25 | 0.45 | 0.41 |

FYM – Farm yard manure VC – Vermicompost GLM – Glyricidia leaf manure
NC – Neem cake EC – Enriched compost RDN – Recommended dose of nitrogen (25 kg/ha)
RDF – Recommended dose of fertilizer (25:50:0 N:$P_2O_5$ kg/ha)
DAS – Days after sowing DAF – Days after flower initiation NS – Non-significant

recorded higher dry matter accumulation in stem (3.89 g/plant) compared to all the treatments except with $OM_2LM_3$ (3.64 g/plant). At harvest, application of $OM_2$ recorded significantly higher dry matter accumulation in stem (4.67 g/plant) compared to other treatments. Liquid organic manures with $LM_3$ and $LM_1$ had recorded significantly higher dry matter accumulation in stem (4.73 and 4.71 g/plant, respectively) compared to $LM_2$ and $LM_4$.Interaction effects $OM_2LM_1$ recorded the maximum dry matter accumulation in stem (5.00 g/plant), which was found significantly higher than other treatments except $OM_1LM_1$, $OM_1LM_3$, $OM_2LM_3$, $OM_2LM_4$, $OM_3LM_3$, $OM_4LM_1$ and $OM_4LM_3$, while the lowest (3.54 g/plant) was recorded in water

**Table 2 : Influence of organic nutrient management practices on dry matter accumulation in stem at different growth stages of chickpea (Pooled data of 2009-10 and 2010-11)**

| Treatments | Dry matter accumulation in stem (g/plant) | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **Organic manures (OM)** | | | | |
| $OM_1$ : FYM 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 0.58 | 2.37 | 3.26 | 4.38 |
| $OM_2$ : EC 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 0.56 | 2.44 | 3.50 | 4.67 |
| $OM_3$ : FYM 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 0.57 | 2.31 | 3.17 | 4.33 |
| $OM_4$ : EC 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 0.58 | 2.39 | 3.30 | 4.39 |
| S.E.± | 0.01 | 0.04 | 0.06 | 0.09 |
| C.D. (P=0.05) | NS | NS | 0.18 | 0.25 |
| **Liquid organic manures (LM)** | | | | |
| $LM_1$: Panchagavya @ 3 % at flower initiation and 15 DAF | 0.59 | 2.52 | 3.56 | 4.71 |
| $LM_2$: Biodigester @ 10% at flower initiation and 15 DAF | 0.56 | 2.16 | 2.97 | 3.94 |
| $LM_3$: Cow Urine @ 10% at flower initiation and 15 DAF | 0.56 | 2.46 | 3.45 | 4.73 |
| $LM_4$: Vermiwash @ 10% at flower initiation and 15 DAF | 0.58 | 2.37 | 3.24 | 4.38 |
| S.Em ± | 0.01 | 0.04 | 0.06 | 0.09 |
| CD @ 5% | NS | 0.13 | 0.18 | 0.25 |
| **Interaction** | | | | |
| $OM_1LM_1$ | 0.60 | 2.52 | 3.51 | 4.71 |
| $OM_1LM_2$ | 0.55 | 2.11 | 2.98 | 3.94 |
| $OM_1LM_3$ | 0.56 | 2.47 | 3.42 | 4.53 |
| $OM_1LM_4$ | 0.57 | 2.39 | 3.13 | 4.35 |
| $OM_2LM_1$ | 0.60 | 2.65 | 3.89 | 5.00 |
| $OM_2LM_2$ | 0.56 | 2.21 | 3.07 | 4.08 |
| $OM_2LM_3$ | 0.56 | 2.51 | 3.64 | 4.94 |
| $OM_2LM_4$ | 0.60 | 2.40 | 3.40 | 4.65 |
| $OM_3LM_1$ | 0.56 | 2.43 | 3.37 | 4.49 |
| $OM_3LM_2$ | 0.54 | 2.13 | 2.90 | 3.86 |
| $OM_3LM_3$ | 0.56 | 2.37 | 3.30 | 4.68 |
| $OM_3LM_4$ | 0.57 | 2.31 | 3.11 | 4.27 |
| $OM_4LM_1$ | 0.58 | 2.49 | 3.48 | 4.63 |
| $OM_4LM_2$ | 0.58 | 2.19 | 2.94 | 3.89 |
| $OM_4LM_3$ | 0.55 | 2.48 | 3.46 | 4.77 |
| $OM_4LM_4$ | 0.57 | 2.38 | 3.30 | 4.27 |
| **Control** | | | | |
| $C_1$ – RDF | 0.57 | 2.03 | 2.82 | 4.31 |
| $C_2$ – Water spray | 0.52 | 1.50 | 2.27 | 3.54 |
| S.E.± | 0.02 | 0.09 | 0.12 | 0.17 |
| C.D. (P=0.05) | NS | 0.24 | 0.35 | 0.49 |

FYM – Farm yard manure VC – Vermicompost GLM – Glyricidia leaf manure
NC – Neem cake EC – Enriched compost RDN – Recommended dose of nitrogen (25 kg/ha)
RDF – Recommended dose of fertilizer (25:50:0 N:$P_2O_5$ kg/ha)
DAS – Days after sowing DAF – Days after flower initiation NS – Non-significant

spray ($C_2$)(Table 2). Differences in dry matter production and its distribution in different plant parts were attributed to varying morpho-physiological characters during crop growth.

Dry matter accumulation in reproductive parts was significantly influenced by organic manures, liquid organic manures and their interactions at all the stages of crop growth except at 60 DAS. At 60 DAS liquid organic manures $LM_1$ recorded higher dry matter accumulation in pods (0.64 g/plant), which was significantly higher than $LM_2$ and $LM_4$. All the interaction treatments were at par with each other, but significantly superior over to water spray ($C_2$) and in RDF ($C_1$). At 90 DAS, organic manure $OM_2$ has recorded the maximum

**Table 3 : Influence of organic nutrient management practices on dry matter accumulation in reproductive parts at different growth stages of chickpea (pooled data of 2009-10 and 2010-11)**

| Treatments | Dry matter accumulation in reproductive parts (g/plant) | | |
|---|---|---|---|
| | 60 DAS | 90 DAS | At harvest |
| **Organic manures (OM)** | | | |
| $OM_1$ : FYM 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 0.62 | 5.61 | 14.52 |
| $OM_2$ : EC 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 0.62 | 6.02 | 15.53 |
| $OM_3$ : FYM 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 0.60 | 5.48 | 14.25 |
| $OM_4$ : EC 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 0.61 | 5.69 | 14.54 |
| S.E.± | 0.01 | 0.10 | 0.29 |
| C.D. (P=0.05) | NS | 0.28 | 0.81 |
| **Liquid organic manures (LM)** | | | |
| $LM_1$: Panchagavya @ 3 % at flower initiation and 15 DAF | 0.64 | 6.18 | 15.82 |
| $LM_2$: Biodigester @ 10% at flower initiation and 15 DAF | 0.57 | 5.08 | 12.97 |
| $LM_3$: Cow Urine @ 10% at flower initiation and 15 DAF | 0.63 | 6.01 | 15.55 |
| $LM_4$: Vermiwash @ 10% at flower initiation and 15 DAF | 0.61 | 5.54 | 14.50 |
| S.E.± | 0.01 | 0.10 | 0.29 |
| C.D. (P=0.05) | 0.03 | 0.28 | 0.81 |
| **Interaction** | | | |
| $OM_1LM_1$ | 0.63 | 6.05 | 15.81 |
| $OM_1LM_2$ | 0.58 | 5.06 | 12.88 |
| $OM_1LM_3$ | 0.65 | 5.95 | 15.08 |
| $OM_1LM_4$ | 0.60 | 5.39 | 14.32 |
| $OM_2LM_1$ | 0.65 | 6.74 | 16.99 |
| $OM_2LM_2$ | 0.56 | 5.26 | 13.44 |
| $OM_2LM_3$ | 0.65 | 6.33 | 16.21 |
| $OM_2LM_4$ | 0.61 | 5.76 | 15.50 |
| $OM_3LM_1$ | 0.64 | 5.78 | 15.05 |
| $OM_3LM_2$ | 0.56 | 4.97 | 12.72 |
| $OM_3LM_3$ | 0.59 | 5.76 | 15.21 |
| $OM_3LM_4$ | 0.59 | 5.39 | 14.02 |
| $OM_4LM_1$ | 0.64 | 6.14 | 15.42 |
| $OM_4LM_2$ | 0.57 | 5.01 | 12.86 |
| $OM_4LM_3$ | 0.61 | 5.99 | 15.71 |
| $OM_4LM_4$ | 0.62 | 5.63 | 14.16 |
| **Control** | | | |
| $C_1$ – RDF | 0.53 | 4.82 | 13.51 |
| $C_2$ – Water spray | 0.38 | 3.83 | 11.03 |
| S.E.± | 0.02 | 0.20 | 0.55 |
| C.D. (P=0.05) | 0.06 | 0.55 | 1.55 |

FYM – Farm yard manure VC – Vermicompost GLM – Glyricidia leaf manure
NC – Neem cake EC – Enriched compost RDN – Recommended dose of nitrogen (25 kg/ha)
RDF – Recommended dose of fertilizer (25:50:0 N:$P_2O_5$ kg/ha)
DAS – Days after sowing DAF – Days after flower initiation NS – Non-significant

dry matter accumulation in pods (6.02 g/plant), which was significantly superior over other organic manure treatments.

Among the liquid organic manures, $LM_1$ (6.18 g/plant) and $LM_3$ (6.01 g/plant) recorded higher dry matter accumulation in pods than other liquid organic manures. The treatment combination of $OM_2LM_1$ has recorded the maximum dry matter accumulation in pods(6.78 g/plant) which was significantly superior over rest of the treatments except $OM_2LM_3$ (6.33 g/plant) while the lowest (3.83 g/plant) dry matter accumulation in pods was recorded in water spray ($C_2$) (Table 4).

Organic manures did not influence the total dry matter production per plant at all the stages except 90 DAS. Whereas,

**Table 4 : Influence of organic nutrient management practices on total dry matter production at different growth stages of chickpea (Pooled data of 2009-10 and 2010-11)**

| Treatments | Total dry matter production (g/plant) | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **Organic manures (OM)** | | | | |
| $OM_1$ : FYM 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 1.03 | 5.09 | 12.75 | 21.07 |
| $OM_2$ : EC 1/3rd + VC 1/3rd + GLM 1/3rd equivalent to 100% RDN | 1.06 | 5.24 | 13.69 | 22.43 |
| $OM_3$ : FYM 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 1.01 | 4.97 | 12.38 | 20.74 |
| $OM_4$ : EC 1/3rd + VC 1/3rd + NC 1/3rd equivalent to 100% RDN | 1.03 | 5.12 | 12.91 | 21.11 |
| S.E.± | 0.02 | 0.09 | 0.24 | 0.46 |
| C.D. (P=0.05) | NS | NS | 0.68 | NS |
| **Liquid organic manures (LM)** | | | | |
| $LM_1$: Panchagavya @ 3 % at flower initiation and 15 DAF | 1.07 | 5.41 | 14.00 | 22.81 |
| $LM_2$: Biodigester @ 10% at flower initiation and 15 DAF | 1.01 | 4.66 | 11.54 | 18.92 |
| $LM_3$: Cow Urine @ 10% at flower initiation and 15 DAF | 1.01 | 5.27 | 13.58 | 22.53 |
| $LM_4$: Vermiwash @ 10% at flower initiation and 15 DAF | 1.04 | 5.08 | 12.62 | 21.09 |
| S.E.± | 0.02 | 0.09 | 0.24 | 0.46 |
| C.D. (P=0.05) | NS | 0.26 | 0.68 | 1.29 |
| **Interaction** | | | | |
| $OM_1LM_1$ | 1.08 | 5.41 | 13.82 | 22.73 |
| $OM_1LM_2$ | 1.00 | 4.55 | 11.54 | 18.88 |
| $OM_1LM_3$ | 1.00 | 5.31 | 13.39 | 21.87 |
| $OM_1LM_4$ | 1.04 | 5.10 | 12.23 | 20.80 |
| $OM_2LM_1$ | 1.11 | 5.68 | 15.22 | 24.34 |
| $OM_2LM_2$ | 1.02 | 4.75 | 11.91 | 19.52 |
| $OM_2LM_3$ | 1.02 | 5.43 | 14.47 | 23.36 |
| $OM_2LM_4$ | 1.08 | 5.12 | 13.18 | 22.50 |
| $OM_3LM_1$ | 1.03 | 5.23 | 13.22 | 21.88 |
| $OM_3LM_2$ | 0.98 | 4.62 | 11.28 | 18.54 |
| $OM_3LM_3$ | 1.01 | 5.06 | 12.86 | 22.15 |
| $OM_3LM_4$ | 1.03 | 4.98 | 12.16 | 20.39 |
| $OM_4LM_1$ | 1.06 | 5.33 | 13.72 | 22.29 |
| $OM_4LM_2$ | 1.03 | 4.72 | 11.42 | 18.74 |
| $OM_4LM_3$ | 1.01 | 5.29 | 13.58 | 22.74 |
| $OM_4LM_4$ | 1.03 | 5.12 | 12.91 | 20.66 |
| Control | | | | |
| $C_1$ – RDF | 1.01 | 4.38 | 10.96 | 20.05 |
| $C_2$ – Water spray | 0.94 | 3.22 | 8.75 | 16.41 |
| S.E.± | 0.05 | 0.18 | 0.47 | 0.87 |
| C.D. (P=0.05) | NS | 0.51 | 1.32 | 2.46 |

FYM – Farm yard manure VC – Vermicompost GLM – Glyricidia leaf manure
NC – Neem cake EC – Enriched compost RDN – Recommended dose of nitrogen (25 kg/ha)
RDF – Recommended dose of fertilizer (25:50:0 N:$P_2O_5$ kg/ha)
DAS – Days after sowing DAF – Days after flower initiation NS – Non-significant

liquid organic manures and interaction of organic manures and liquid organic manures significantly influenced the total dry matter production per plant at all the stages of crop growth except 30 DAS. At 60 DAS, the liquid organic manure $LM_1$ recorded significantly higher TDMP (5.41 g/plant) as compared to other treatments except $LM_3$ (5.27 g/plant). Interaction of organic manures and liquid organic manures, $OM_2LM_1$ recorded the maximum total dry matter production (5.68 g/plant) which was significantly superior over other treatment except $OM_1LM_1$, $OM_1LM_3$, $OM_2LM_2$, $OM_3LM_1$, $OM_4LM_1$ and $OM_4LM_3$, while the lowest was in $C_2$-water spray (3.22 g/plant). At 90 DAS, the organic manure $OM_2$ recorded the maximum total dry matter production (13.69 g/plant) which was significantly superior over other organic manures. Spraying of liquid organic manure $LM_1$ recorded the maximum (14.00 g/plant) followed by $LM_3$ (13.58 g/plant) and both of these were significantly superior to $LM_2$ and $LM_4$. The interaction effect of $OM_2LM_1$ recorded the maximum total dry matter production (15.22 g/plant) which was significantly superior to other treatments except $OM_2LM_3$ (14.47 g/plant), while the lowest was recorded in water spray (8.75 g/plant). At harvest, the liquid organic manure $LM_1$ (22.81 g/plant) and $LM_3$ (22.53 g/plant) recorded the maximum total dry matter production and both were significantly superior to $LM_2$ and $LM_4$. The treatment combination of $OM_2LM_1$ recorded the maximum total dry matter production (24.34 g/plant), which was significantly superior to rest of treatments except $OM_1LM_1$, $OM_2LM_3$, $OM_2LM_4$, $OM_3LM_1$, $OM_3LM_3$, $OM_4LM_1$ and $OM_4LM_3$, while the lowest was recorded in water spray ($C_2$) (16.41 g/plant) (Table 4).

This increased dry matter accumulation in different stages of plant growth might be due to the better availability of nutrients from organic and foliar source of nutrients and effective conversion of nutrients from organics such as Fe, Mg and Zn available at the site of photosynthesis (pigment). Also, *Azospirillum* and coconut water present in panchagavya which contains kinetin along with other enzymes and might have increased the chlorophyll content of the leaves. Thus, it might have lead to higher leaf area production and capture of more solar radiation resulting in higher photosynthesis and consequent improvement in all growth attributes and these results were also supported by the Sanjutha *et al*. (2008); Somasundaram *et al.* (2003); De Britto and Girija (2006) and Kumaravelu and Kadambian (2009).

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