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Influence of natural liquid organics on growth and biochemical attributes of blackgram (*Vigna mungo* L.)

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Abstract
A field experiment was conducted to investigate the effect of natural organics and recommended dose of fertilizers on growth and biochemical attributes of blackgram (*Vigna mungo* L.). The results revealed that the treatments receiving the recommended dose of fertilizers recorded significantly higher crop growth rate, net assimilation rate, leaf area index, leaf area duration and specific leaf weight compared to other treatments at all growth stages. Among organic treatments, the treatment receiving Seed treatment with Beejamrutha + Soil Application of Ghanajeevamruta as basal + Foliar sprays of Jeevamrutha @ 3% (Every 10 days) + Foliar sprays of Panchagavya @ 3% (Every 10 days) (T_{10}) and the treatment receiving foliar sprays of jeevamrutha @ 3% (every 10 days) recorded higher crop growth rate, net assimilation rate, leaf area index, leaf area duration and specific leaf weight compared to other treatments. Chlorophyll content, concentration of phenols and aminoacids, catalase and peroxidase activity were recorded higher in T_1 (RDF) and T_2 (RDF along with the seed treatment with water). Lowest chlorophyll content, concentration of phenols and aminoacids, catalase and peroxidase activity were recorded in the treatment receiving seed treatment with beejamrutha (T_3).

Keywords: Blackgram, chlorophyll, catalase, net assimilation rate, organics

Introduction
Pulses are annual leguminous crops grown in India for both food and feed. They serve as an important source of protein for a large portion of the global population. They also contribute to healthy soils and climate change mitigation through their nitrogen-fixing properties. India is the largest producer (25% of global production) and consumer (27% of world consumption) of pulses in the world. Black gram (*Vigna Mungo* L.) is one of the important pulses crop grown throughout India. It accounts to 13 % of total pulses area and 10 % of total pulses production in India. It can be grown successfully from sea level up to an elevation of 1800 meters. It is resistant to adverse climatic conditions. Also, blackgram improves the soil fertility by fixing atmospheric nitrogen in the soil. In India, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh are major blackgram growing states area-wise. It can be grown on variety of soils ranging from sandy soils to heavy cotton soils.

Agriculture in India is heavily dependent on the usage of fertilizers. Government data indicates that the fertilizer usage has averaged at around 500 Lakh Metric Tonnes per year in the last 10 years. (https://factly.in/). Use of chemical fertilizers is a costly approach and it is noticed that the excess use of fertilizers in soil has deprived the soil health to a greater extent. Natural Farming is a holistic alternative to the present paradigm of high-cost chemical inputs-based agriculture. It is very effective in addressing the uncertainties of climate change. Its principles are in harmony with the principles of Agroecology.

Farmers are well aware with the use of organic liquid manures such as Panchagavya, Beejamrutha, Jeevamrutha etc., in natural farming. These liquid organic manures play a key role in promoting growth and providing immunity to plant system. The spray of Panchagavya on chillies produces dark green coloured leaves within 10 days. Role of panchagvya as plant growth promoter has already been reported by Subhashini *et al.* (2001) [12] and Sreenivasa *et al.* (2009) [11]. The seed dipping in beejamrutha is known to protect the crop from harmful soil-borne and seed-borne pathogens (Sreenivasa *et al.* 2009) [11]. During the past few years, there has been increasing interest in the use and consumption of organic produce. Foliar application of nutrients using water soluble fertilizer is one of the possible ways to enhance the productivity of pulses like blackgram (Shyamrao *et al.* 2016) [10].

Hence the present investigation is taken up to compare different natural liquid organics and the recommended dose of fertilizers in terms of growth and biochemical attributes of blackgram.

Materials and Methods

The experiment was carried out at S.V. Agricultural College dryland Farm, Tirupati of Acharya N.G. Ranga Agricultural University during *kharif*, 2017 to check the effect of foliar application of organics on growth, biochemical attributes of blackgram. Soil of the experimental site is neutral with pH 7.1. It is low in organic carbon (0.45%) and available nitrogen (175kg ha^{-1}). The soil is medium in available phosphorus (28kg ha^{-1}) and potassium (204Kg ha^{-1}). Blackgram variety, TBG-104 was used for this experiment. The experiment was laid in randomized block design with three replications having 4mX3m ($12m^2$) plot size with the following treatments.

T_1: Recommended dose of fertilizers (RDF)
T_2: RDF + Seed treatment with water
T_3: Seed treated with Beejamrutha
T_4: Soil application of Ghanajeevamruta as basal
T_5: Foliar sprays of Jeevamrutha @3% (Every 10 days)
T_6: Foliar sprays of Panchagavya @3% (Every 10 days)
T_7: $T_3 + T_4$
T_8: $T_4 + T_5$
T_9: $T_4 + T_6$
T_{10}: $T_3 + T_4 + T_5 + T_6$

Methods of determination procedure

Crop growth rate was calculated adopting the formula as suggested by Watson (1952) [13] and was expressed in g m^{-2} day^{-1}

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

where, W_1 and W_2 are total dry weight of plant at times t_1 and t_2 and P is the land area and was expressed in g m^{-2} day^{-1}.

Net photosynthetic rate is the measure of amount of photosynthetic product getting accumulated per unit leaf area per unit time. It was calculated by using formula suggested by Gregory (1926) and was expressed in g dm^{-2} day^{-1}

$$NAR = \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1} \times \frac{W_2 - W_1}{t_2 - t_1}$$

where, W_1 and W_2 are the total plant dry weight and A_1 and A_2 are leaf area at times t_1 and t_2

Leaf area index was calculated by dividing the total leaf area with the corresponding ground area as suggested by Watson (1952) [13].

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

Leaf area duration was calculated by adopting the following formula

$$LAD = \frac{LAI_1 + LAI_2}{2} \times (t_2 - t_1)$$

where,
LAI_1 = Leaf area index at time interval t_1 and
LAI_2 = Leaf area index at time interval t_2.

For the determination of specific leaf weight, three leaves (3rd fully expanded leaf from the top of the main axis) were collected from each treatment in each replication. These leaves were cleaned and their leaf area was measured using a leaf area meter (LI-3100). They were dried in a hot air oven at 80ºC and dry weight was recorded. SLW is expressed as the ratio between leaf dry weight to leaf area.

$$SLW = \frac{WL}{A}$$

Chlorophylls are the essential components for photosynthesis, and occur in chloroplasts as green pigments in all photosynthetic plant tissues. They are bound loosely to proteins but are readily extracted in organic solvents such as dimethyl sulfoxide (DMSO), Acetone, or ether. To estimate the amount of chlorophyll, 0.1 g of fresh plant leaf material was placed in a 100ml volumetric flask and 10 ml of DMSO was added. The conical flasks were kept overnight. Chlorophyll extracted into DMSO solution was collected from conical flasks and concentration of chlorophylls a, b and total chlorophyll were quantified by reading the optical density at 663 nm and 645 nm. The chlorophylls a, b and total chlorophyll were calculated using the formulae. The amount of chlorophyll present in the extract in mg chlorophyll per g tissue were calculated using the following equations (Hiscox and Israelstam, 1979) [3].

mg chlorophyll 'a'/g tissue= 12.7(A663)-2.69(A645) X V/1000 X W
mg chlorophyll 'b'/g tissue= 22.9(A645)- 4.68(A663) X V/1000 X W
mg total chlorophyll /g tissue= 20.2(A645)+8.02(A663) X V/1000 X W

where,
A = Absorbance at specific wavelengths
V = Final volume of chlorophyll extract
W = fresh weight of tissue extracted

Phenols are the aromatic compounds with hydroxyl groups. They occur in all plant parts and they are said to offer resistance to diseases and pests in plants. Grains containing high amount of polyphenols are resistant to bird attack. Phenols include an array of compounds such as catechol, caffeic acid, tannins, flavonols, etc. To estimate total phenols, 1.0 g of the fresh leaf sample was homogemised with a pestle and mortar in 10 ml of 80 per cent ethanol. The homogenate was centrifuged at 10000 rpm for 20 min. The supernant was saved. The residue was re-extracted with five times the volume of 80 per cent ethanol. The supernatants were pooled. The supernatant was evaporated to dryness. The residue was dissolved in 10 ml of distilled water. 0.2 ml of sample was pipetted into test tubes. The volume in each tube was made up to 3 ml with distilled water. To this solution 0.5 ml of folin-ciocalteau reagent was added. After 3 min, 2 ml of 20 per cent sodium carbonate solution was added to each tube and mixed thoroughly. The tubes were then placed in boiling water for 1 min and allowed to cool. The absorbance was measured at 650 nm against a reagent blank. The standard curve was prepared using known concentrations of catechol at 650 nm. The total phenol content in the test samples was calculated from the standard curve and expressed as mg. catechol equivalent of phenol/ g. sample. (Malik and Singh, 1980) [6].

The aminoacids are the organic compounds that form the basic blocks of proteins. Free aminoacds are mostly water soluble in nature. Very often in plant during disease conditions, the free aminoacids composition exhibits a change

and hence, the measurement of the total free aminoacids gives the physiological and health status of the plants. To determine the aminoacid composition, 0.5 g of leaf was weighed and grinded in a mortar & pestle with five ml of 80% Ethanol. Centrifuged at 6,000 rpm at 28ºC for 30 min. Supernant (Sample extract) was collected. Added one ml of Ninhydrin solution to 0.1 ml of sample extract. Make up the volume to two ml. Heated in boiling water bath (85ºC) for 20 min. Then added five ml of diluent solvent and mixed well. After 15 minutes, purple colour was developed. Read intensity of purple color against a reagent blank in a spectrophotometer using photometric method at 570 nm. Different concentrations of leucine served as the working standard. From the standard curve, concentration of total free amino acids in different samples was determined using standard regression equation and expressed as µg ml^{-1}. (Moore and Stein, 1948) [7].

Catalase is the enzyme present in almost all plant and animal cells. It catalyzes the decomposition of hydrogen peroxide (to give water and molecular oxygen) and peroxidation of H donors (methanol, formic acid, phenol). To estimate the catalase activity, Fresh sample of 300 mg is grinded with 2.5 ml of 0.05 M sodium phosphate buffer (pH 7.0) and 1 ml of 1% PVP in precold mortar using pestle at 4°C. Then the sample is centrifuged at 10000 rpm for 15 min at 4°C. Collect the supernatant. 50 mM buffer solution of 2 ml, 0.95 ml of 0.03% hydrogen peroxide and 0.05 ml of enzyme extract were taken into a test tube and the resultant is mixed well. Then absorbance is read at 240 nm by UV-VIS spectrophotometer using kinetics method. Preparation without enzyme extract serves as a blank to calibrate the spectrophotometer. The enzyme activity is calculated using the formula (Maximum absorbance -Minimum absorbance) × 60 × 2 and expressed in min^{-1} g^{-1}. (Luck, 1974) [5].

Peroxidase (POD) includes in its widest sense a group of specific enzyme such as NAD-peroxidase, NADP-peroxidase, fatty acid peroxidase etc. As well as a group of very non-specific enzymes from different sources which are simply known as POD. POD catalyses the dehydrogenation of a large number of organic compounds such as phenols, aromatic amines, hydroquinones etc. To estimate the peroxidase activity in leaves, 0.5 g of fresh leaf sample was taken and grinded with 5 ml of 0.1 M Sodium phosphate buffer (pH : 7.0) in pre cold mortar using pestle at 4°C. The grounded leaf sample was centrifuged at 18,000 rpm for 15 minutes at 4°C. Supernatant was collected and refrigerated. 3 ml of 0.1 M sodium phosphate buffer, 50 µl of 20 mM guaiacol, 30 µl of 12.3 mM hydrogen perioxide and 50 µl of enzyme extract were taken in to a test tube and mixed well. Preparation of without enzyme extract serve as a blank to calibrate the spectrophotometer Then read absorbance (OD) at 436 nm by UV-VIS spectrophotometer using kinetics method. The enzyme activity is expressed as O.D min^{-1} g $f.wt^{-1}$ (Sadasivam and Manickam, 1992) [8].

Calculation: (Maximum absorbance-Minimum absorbance) × 60 × 2.

Results and Discussion

The crop growth rate (CGR) in response to application of natural organics was recorded from 15 DAS to harvest at 10 days interval in blackgram and is presented in table 1 and fig. 1. Irrespective of treatment, the CGR increased upto 35-45 DAS and thereafter it decreased. Significant differences among the treatments were observed throughout the crop growth. Similar significant differences were reported for CGR among organic treatments by Shashikumar (2012) [9] in blackgram. Among different treatments, inorganic nutrient management practices i.e., T_1 and T_2 recorded significantly higher CGR compared to other treatments at all growth stages. Among the organic treatments, T_{10} (17.29 g cm^{-2} $plant^{-1}$) recorded 6.76 and 3.64 per cent higher CGR than T_5 and T_8 at 35-45DAS. T_3 and T_4 reported lowest CGR (2.40 g cm^{-2} day^{-1} and 3.71 g cm^{-2} day^{-1}) at harvest compared to other treatments.

The net assimilation rate (NAR) as affected by different organics from 15-25 DAS to 55 DAS- harvest in blackgram was presented in Table 2 and Fig. 2. NAR increased up to 25-35 DAS and showed a decreasing trend thereafter irrespective of the treatment. Significant differences were observed between different treatments at 15-35 DAS, thereafter differences in NAR was non-significant. Net assimilation rate, an indirect measurement of photosynthetic activity was affected by different treatments, similar to crop growth rate. Increased NAR can be attributed to high dry matter accumulation and partitioning of blackgram. T_1 has recorded higher net assimilation rate (0.0070 g dm^{-2} day^{-1}) at 35-45 DAS compared to all other treatments. The sufficient nutrient availability with the supply of inorganics resulted in better assimilation rate. Among the organic treatments, T_{10} and T_8 has recorded higher net assimilation rate (0.0068 g dm^{-2} day^{-1}) over all other organic treatments.

In general, with advancement of crop growth, the leaf area index increased up to 55 DAS and thereafter declined till harvest in all the treatments. It is due to the decline of leaf area at final stage of the crop due to senescence. Leaf area index is used to predict photosynthetic primary production as a reference tool for crop growth. The data regarding the effect of different organics in terms of leaf area index of blackgram is presented in the table 3 and Fig. 3. Significantly higher LAI of blackgram was recorded in T_1 and T_2 i.e. 1.60 and 1.71 respectively at 55 DAS. Immediate availability of nutrients through inorganics resulted in increased chlorophyll content and enhanced leaf area. T_{10} recorded higher LAI (1.50) at 55 DAS compared to all other organic treatments except T_8. During the course of investigation, LAI was recorded least in the treatment T_3 (Seed treated with beejamrutha). It was also noticed that the jeevamrutha foliar spray has recorded beneficial effect on leaf area index at all stages of crop growth compared to panchagavya foliar spray and beejamrutha seed treatment due to the availability of higher micronutrient content.

Leaf area duration (LAD) as affected by different treatments in blackgram from 15 DAS to harvest is presented in table 4 and Fig 4. Leaf area duration indicates maintenance of photo synthetically active green leaf area for longer time in crop duration. It also indicates efficiency of photosynthetic system, with a high degree of association with dry matter accumulation (Chetti and Sirohi, 1995) [1]. Higher LAD specially during seed filling stage has profound influence on yield and its attributes. Significant differences among different organic treatments were observed in blackgram. Similar to LAI, T_1 and T_2 maintained higher LAD than other treatments. Treatments, T_3 and T_4 recorded lower LAD. Treatments receiving foliar sprays of jeevamrutha @ 3% (T_5) and soil application of ghanajeevamruta as basal + Foliar sprays of jeevamrutha @ 3% (T_8) has shown moderate LAD. RDF and RDF along with seed soaked in water also possessed higher leafyness compared to other treatments and thus proved efficient in current photosynthesis and higher seed filling characters.

The specific leaf weight, as affected by different treatments from at 10 days interval from 15 DAS to harvest was presented in Table 5 and Fig 5. Higher the specific leaf weight, thicker the leaves and higher the chlorophyll content per unit leaf area in a leaf. Significant differences in SLW were observed between the treatments. SLW increased significantly from 25 DAS to harvest irrespective of the treatment. Among all the organic treatments, Foliar sprays of jeevamrutha @ 3% (T_5) has recorded 1.9 to 18 per cent more SLW at harvest compared to other organic treatments. A significant influence of jeevamrutha on the specific leaf weight was observed in this investigation. The inorganic nutrient management practices (RDF and RDF with seed treatment with water) also recorded higher SLW over other organic treatments.

The data pertaining to the effect of different organic treatments on chlorophyll-a, chlorophyll-b and total chlorophyll recorded from 15 DAS to 60 DAS was presented in the table 6. The chlorophyll a, chlorophyll b and total chlorophyll content of the leaf increased from germination to flowering, thereafter decreased till harvest due to the ageing and leaf senescence. The chlorophyll a, chlorophyll b and total chlorophyll content of the leaf showed a significant difference among the treatments at all growth stages except at 15 DAS where a non- significant difference was observed. Significant differences in chlorophyll content of leaves among different organic treatments were also reported by Kumar *et al.* (2011) [4] in blackgram. Inorganic treatments (T_1 and T_2) and integrated organic treatments (T_{10}) recorded on par values for chlorophyll a, chlorophyll b and total chlorophyll at 60 DAS. However, these treatments recorded significantly higher chlorophyll content compared to all organic treatments. The total chlorophyll content was noticed to be lowest in the treatment seed treated with beejamrutha (T_3) after 15 DAS. The moderate chlorophyll content was recorded in the treatments receiving foliar spray of jeevamrutha (T_{10}, T_5, T_8) due to the presence of higher Fe content. However, Kumar *et al.* (2011) [4] reported that panchagavya @ 3% recorded significantly higher chlorophyll content compared to both NPK and control in blackgram.

The data in relation to the effect of different organic treatments on phenol content of leaf recorded at 30 DAS, 45 DAS and 60 DAS was presented in the table 7. Phenol content of leaves differed significantly among different organic treatments of blackgram. The phenol content of leaf increased initially from 30 DAS to 45 DAS and then it decreased during post flowering phase i.e., from 45 DAS to 60 DAS in all the treatments. The phenol content of leaf reported to be significantly higher in inorganic treatments (T_1 and T_2) at all the growth stages compared to the organic treatments. The higher phenol content of the inorganic treatments may be due to the increased supply of nitrogen through urea and higher growth and biochemical activity. Among the organic treatments, T_{10} has recorded higher phenol content due to the increased nutrient supply through different organics. Seed treated with beejamrutha (T_3) has recorded lower phenol content compared to other treatments. Zhang *et al.* (2016) [14] reported that increased nitrogen supply resulted in improved phenol content of the tomato leaves.

The data concerning the effect of different organic treatments on amino acid content of leaf was recorded at 30 DAS, 45 DAS and 60 DAS. Significant differences among the treatments in terms of aminoacid content of leaf was recorded from 30 DAS to 60 DAS (Table.7.). Similar significant differences were also reported by Zhang *et al.* (2017) [15] in leaves winter wheat. T_1 and T_2 have recorded significantly higher aminoacid content than all other organic treatments. The increased free aminoacid content in the above treatments is the result of the enhanced supply of nitrogen by the RDF compared to all other treatments. Significantly higher amino acid content of leaf was reported at 45 DAS in RDF (3723.63 µg ml^{-1}) and RDF along with the seed treatment with water (3464.59 µg ml^{-1}). Among the organic treatments, highest free amino acid content was recorded in the treatment receiving Seed treatment with beejamrutha + Soil application of ghanajeevamruta as basal + Foliar sprays of jeevamrutha @ 3% + Foliar sprays of panchagavya @3% i.e., 3343.85 µg ml^{-1}.

The data on catalase activity of leaves as influenced by different organics recorded at 30 DAS, 45 DAS and 60 DAS. Catalase is a powerful antioxidant enzyme in plant system. A decline in the catalase activity after flowering till harvest was observed in blackgram irrespective of the treatment (Table. 8.). Results indicated that the activity of catalase in leaves of blackgram was significantly influenced by different organic treatments. Among the treatments, catalase activity was significantly higher in the treatment receiving RDF (4.74 min^{-1} g^{-1}) at 30 DAS. Among organic treatments, Seed treated with beejamrutha + Soil application of ghanajeevamruta as basal + Foliar sprays of jeevamrutha @ 3% + Foliar sprays of panchagavya @ 3% recorded higher catalase activity (3.48 min^{-1} g^{-1}) followed by soil application of ghanajeevamruta as basal + Foliar sprays of jeevamrutha @ 3% (2.82 min^{-1} g^{-1}).

The data on peroxidase activity of leaves influenced by different organics recorded at 30 DAS, 45 DAS and 60 DAS was exhibited in table. 8. Peroxidase is also an antioxidant plant enzyme and play role in oxidative stress tolerance. The results indicated that the peroxidase activity declined with the age of the plant. Different organic treatments significantly influenced the peroxidase activity of leaves of blackgram. Significantly higher peroxidase activity was recorded in the treatment receiving inorganic practice i.e. RDF and RDF along with the seed treatment with water. While, the treatment receiving Seed treatment with beejamrutha + Soil application of Ghanajeevamruta as basal + Foliar sprays of jeevamrutha @ 3% + Foliar sprays of panchagavya @3% has recorded higher peroxidase activity among different organic treatments. During the investigation it was recorded that the jeevamrutha foliar spray has positive influence over the peroxidase activity of leaves, compared to other natural organics used in the experiment.

Table 1: Effect of natural liquid organics on Crop Growth Rate (g m^{-2} day^{-1}) of blackgram

Treatments	15 – 25 DAS	25 – 35 DAS	35 – 45 DAS	45 – 55 DAS	55 DAS-Harvest
T_1 : RDF	3.18	13.97	18.87	7.63	3.58
T_2 : RDF + Seed treatment with water	3.46	15.21	17.81	7.29	4.37
T_3 : Seed treated with Beejamrutha	1.92	10.23	14.23	5.01	2.4
T_4 : Soil application of Ghanajeevamruta as basal	2.22	10.62	14	5.2	3.71
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	2.7	13.09	16.12	7.44	5.13
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	2.5	11.59	13.97	6.72	2.81
T_7 : T_3 + T_4	2.46	11.77	14.44	6.55	4.14
T_8 : T_4 + T_5	2.62	12.92	16.66	6.8	5.07
T_9 : T_4 + T_6	2.42	11.34	13.87	6.08	4.5
T_{10} : T_3 + T_4 + T_5 + T_6	2.85	13.69	17.29	7.3	4.77
Mean	2.63	12.44	15.73	6.6	4.05
SE m ±	0.073	0.338	0.318	0.333	0.35
CD (P=0.05)	0.219	1.011	0.952	0.997	1.06

Table 2: Effect of natural liquid organics on Net assimilation rate (g dm^{-2} day^{-1}) of blackgram

Treatments	15 – 25 DAS	25 – 35 DAS	35 – 45 DAS	45 – 55 DAS	55 DAS-Harvest
T_1 : RDF	0.0071	0.0112	0.007	0.0022	0.001
T_2 : RDF + Seed treatment with water	0.0066	0.0104	0.0059	0.0019	0.0012
T_3 : Seed treated with Beejamrutha	0.006	0.0108	0.0061	0.0016	0.0008
T_4 : Soil application of Ghanajeevamruta as basal	0.0075	0.0124	0.0068	0.0018	0.0013
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	0.0075	0.0125	0.0066	0.0023	0.0016
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	0.0076	0.0125	0.0062	0.0022	0.0009
T_7 : T_3 + T_4	0.0073	0.0122	0.0062	0.0021	0.0013
T_8 : T_4 + T_5	0.0075	0.0127	0.0068	0.002	0.0015
T_9 : T_4 + T_6	0.0098	0.0147	0.0067	0.0021	0.0015
T_{10} : T_3 + T_4 + T_5 + T_6	0.0074	0.0126	0.0068	0.0022	0.0014
Mean	0.0074	0.0122	0.0065	0.002	0.0013
SE m ±	0.001	0.001	0	0	0
CD (P=0.05)	0.001	0.001	0	0	0

Table 3: Effect of natural liquid organics on leaf area index of blackgram

Treatments	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS	At harvest
T_1 : RDF	0.06	0.28	0.92	1.45	1.6	1.48
T_2 : RDF + Seed treatment with water	0.07	0.33	1.1	1.57	1.71	1.56
T_3 : Seed treated with Beejamrutha	0.05	0.2	0.75	1.32	1.36	1.27
T_4 : Soil application of Ghanajeevamruta as basal	0.04	0.18	0.67	1.18	1.3	1.21
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	0.05	0.22	0.81	1.38	1.47	1.38
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	0.05	0.2	0.72	1.29	1.42	1.31
T_7 : T_3 + T_4	0.05	0.2	0.76	1.33	1.4	1.31
T_8 : T_4 + T_5	0.05	0.21	0.8	1.39	1.5	1.41
T_9 : T_4 + T_6	0.04	0.15	0.64	1.23	1.35	1.26
T_{10} : T_3 + T_4 + T_5 + T_6	0.06	0.24	0.84	1.44	1.5	1.4
Mean	0.05	0.22	0.8	1.36	1.46	1.36
SE m ±	0.004	0.02	0.083	0.06	0.086	0.071
CD (P=0.05)	0.001	0.007	0.028	0.02	0.029	0.024

Table 4: Effect of natural liquid organics on Leaf area duration (days) of blackgram

Treatments	15 – 25 DAS	25 – 35 DAS	35 – 45 DAS	45 – 55 DAS	55 DAS-Harvest
T_1 : RDF	1.73	6.04	11.88	15.27	15.38
T_2 : RDF + Seed treatment with water	2.01	7.13	13.32	16.37	16.25
T_3 : Seed treated with Beejamrutha	1.23	4.73	10.35	13.41	13.16
T_4 : Soil application of Ghanajeevamruta as basal	1.12	4.25	9.25	12.43	12.38
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	1.38	5.16	10.94	14.26	14.14
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	1.23	4.6	10.06	13.53	13.24
T_7 : T_3 + T_4	1.27	4.8	10.41	13.64	13.54
T_8 : T_4 + T_5	1.33	5.07	10.95	14.46	14.38
T_9 : T_4 + T_6	0.94	3.96	9.35	12.87	13.02
T_{10} : T_3 + T_4 + T_5 + T_6	1.46	5.35	11.36	14.7	14.51
Mean	1.37	5.11	10.79	14.09	14
SE m ±	0.034	0.153	0.182	0.229	0.26
CD (P=0.05)	0.102	0.459	0.545	0.686	0.778

Table 5: Effect of natural liquid organics on specific leaf weight (mg cm^{-2}) of blackgram

Treatments	15 DAS	25 DAS	35 DAS	45 DAS	55 DAS	At harvest
T_1 : RDF	4.47	7.53	9.59	10.94	10.76	10.79
T_2 : RDF + Seed treatment with water	5.17	7.63	8.89	10.76	10.48	10.63
T_3 : Seed treated with Beejamrutha	4.06	7.65	8.39	9.6	9.67	9.28
T_4 : Soil application of Ghanajeevamruta as basal	4.22	8.96	9.77	10.83	10.29	9.87
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	4.43	8.37	10.12	10.89	11.15	11.28
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	4.06	8.97	9.8	10.35	10.02	9.92
T_7 : T_3 + T_4	3.92	8.9	9.57	10.16	10.28	10.24
T_8 : T_4 + T_5	4.47	8.74	9.87	10.9	10.7	10.79
T_9 : T_4 + T_6	5.08	11.95	10.8	10.7	10.29	10
T_{10} : T_3 + T_4 + T_5 + T_6	4.53	8.33	10.18	10.82	11.05	11.07
Mean	4.44	8.7	9.7	10.6	10.47	10.39
SE m ±	0.364	0.426	0.378	0.214	0.278	0.24
CD (P=0.05)	NS	1.276	1.132	0.639	0.833	0.718

Table 6: Effect of natural liquid organics on chlorophyll-a, chlorophyll-b and total chlorophyll content (mg g^{-1}) of blackgram

Treatments	15 DAS			30 DAS			45 DAS			60 DAS		
	Chl-a	Chl-b	Total	Chl-a	Chl-b	Total	Chl-a	Chl-b	Total	Chl-a	Chl-b	Total
T_1 : RDF	2.85	0.93	3.78	3.69	1.06	4.75	3.47	1.08	4.55	3.17	1.24	4.15
T_2 : RDF + Seed treatment with water	2.89	0.91	3.8	3.54	1.04	4.58	3.31	0.96	4.27	3.05	1.06	4.11
T_3 : Seed treated with Beejamrutha	2.41	0.81	3.23	3.07	0.65	3.72	2.12	0.44	2.56	2.02	0.52	2.55
T_4 : Soil application of Ghanajeevamruta as basal	2.4	0.91	3.31	3.15	0.72	3.87	2.24	0.56	2.8	2.12	0.56	2.69
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	2.31	0.91	3.21	3.36	0.93	4.29	3.25	0.82	4.07	2.92	0.87	3.79
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	2.42	0.91	3.33	3.28	0.87	4.15	2.62	0.66	3.28	2.4	0.7	3.11
T_7 : T_3 + T_4	2.41	0.82	3.23	3.29	0.89	4.18	2.64	0.69	3.33	2.48	0.73	3.21
T_8 : T_4 + T_5	2.5	0.81	3.31	3.37	0.92	4.29	3.31	0.74	4.05	2.94	0.81	3.75
T_9 : T_4 + T_6	2.32	0.82	3.15	3.25	0.83	4.08	2.69	0.62	3.31	2.47	0.66	3.13
T_{10} : T_3 + T_4 + T_5 + T_6	2.73	0.91	3.64	3.49	0.96	4.44	3.1	0.94	4.03	2.98	0.92	3.93
Mean	2.52	0.87	3.4	3.35	0.89	4.24	2.88	0.75	3.63	2.66	0.81	3.47
SE m ±	0.28	0.035	0.26	0.02	0.031	0.03	0.12	0.062	0.12	0.08	0.028	0.07
CD (P=0.05)	NS	NS	NS	0.06	0.093	0.08	0.37	0.186	0.35	0.22	0.085	0.22

Table 7: Effect of natural liquid organics on Phenols (mg g^{-1}) an aminoacids (µg ml^{-1}) in leaves of blackgram

Treatments	30 DAS		45 DAS		60 DAS	
	Aminoacids (µg ml^{-1})	Phenols (mg g^{-1})	Aminoacids (µg ml^{-1})	Phenols (mg g^{-1})	Aminoacids (µg ml^{-1})	Phenols (mg g^{-1})
T_1 : RDF	3398.18	8.78	3723.63	12.02	2922.48	8.48
T_2 : RDF + Seed treatment with water	3215.55	8.52	3464.59	11.48	2834.3	8.36
T_3 : Seed treated with Beejamrutha	1764.96	6.4	1897.19	9.2	1662.67	7
T_4 : Soil application of Ghanajeevamruta as basal	1810.67	6.84	2004.44	9.44	1777.46	7.28
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	2595.72	8.28	3045.15	10.58	2339.74	8.12
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	2154.26	7.4	2600.99	10.24	2040.3	7.76
T_7 : T_3 + T_4	2283.76	7.82	2723.61	10.32	2132.41	7.82
T_8 : T_4 + T_5	2537.38	8.08	2926.93	10.52	2274.11	8
T_9 : T_4 + T_6	2029.68	7.24	2223.17	10	1947.56	7.68
T_{10} : T_3 + T_4 + T_5 + T_6	3005.75	8.38	3343.85	10.96	2516.7	8.24
Mean	2479.59	7.78	2795.36	10.48	2244.77	7.88
SE m ±	74.845	0.063	46.753	0.154	28.96	0.074
CD (P=0.05)	224.098	0.19	139.986	0.46	86.713	0.223

Table 8: Effect of natural liquid organics on Catalase and peroxidase (O.D min^{-1} g $f.wt^{-1}$) in leaves of blackgram

Treatments	30DAS		45DAS		60DAS	
	Peroxidase (O.D min^{-1} g $f.wt^{-1}$)	Catalase (O.D min^{-1} g $f.wt^{-1}$)	Peroxidase (O.D min^{-1} g $f.wt^{-1}$)	Catalase (O.D min^{-1} g $f.wt^{-1}$)	Peroxidase (O.D min^{-1} g $f.wt^{-1}$)	Catalase (O.D min^{-1} g $f.wt^{-1}$)
T_1 : RDF	9.32	4.74	9.25	3.06	4.93	2.47
T_2 : RDF + Seed treatment with water	8.67	4.33	8.07	2.85	4.62	2.24
T_3 : Seed treated with Beejamrutha	2.83	1.48	2.45	0.96	1.86	1.11
T_4 : Soil application of Ghanajeevamruta as basal	3.64	1.64	3.14	1.00	2.23	1.32
T_5 : Foliar sprays of Jeevamrutha @3% (Every 10 days)	6.96	2.78	5.98	2.03	4.14	1.93
T_6 : Foliar sprays of Panchagavya @3% (Every 10 days)	4.85	2.55	4.23	1.24	3.66	1.63
T_7 : T_3 + T_4	5.33	2.64	4.44	1.52	3.83	1.71
T_8 : T_4 + T_5	6.71	2.82	5.85	1.94	4.04	1.88
T_9 : T_4 + T_6	4.08	2.26	3.88	1.12	2.95	1.54
T_{10} : T_3 + T_4 + T_5 + T_6	8.29	3.48	7.54	2.36	4.38	2.02
Mean	6.07	2.87	5.48	1.81	3.66	1.79
SE m ±	0.191	0.165	0.353	0.063	0.119	0.047
CD (P=0.05)	0.571	0.495	1.056	0.188	0.355	0.14

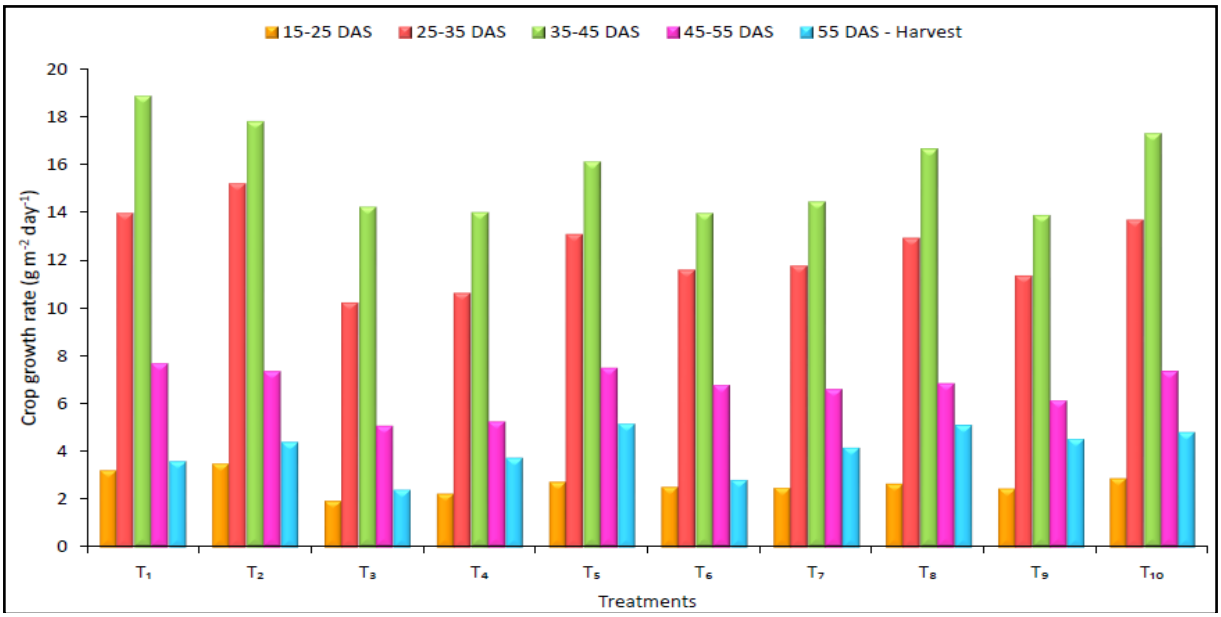

Fig 1: Effect of natural liquid organics on crop growth rate (g m^{-2} day^{-1}) of blackgram

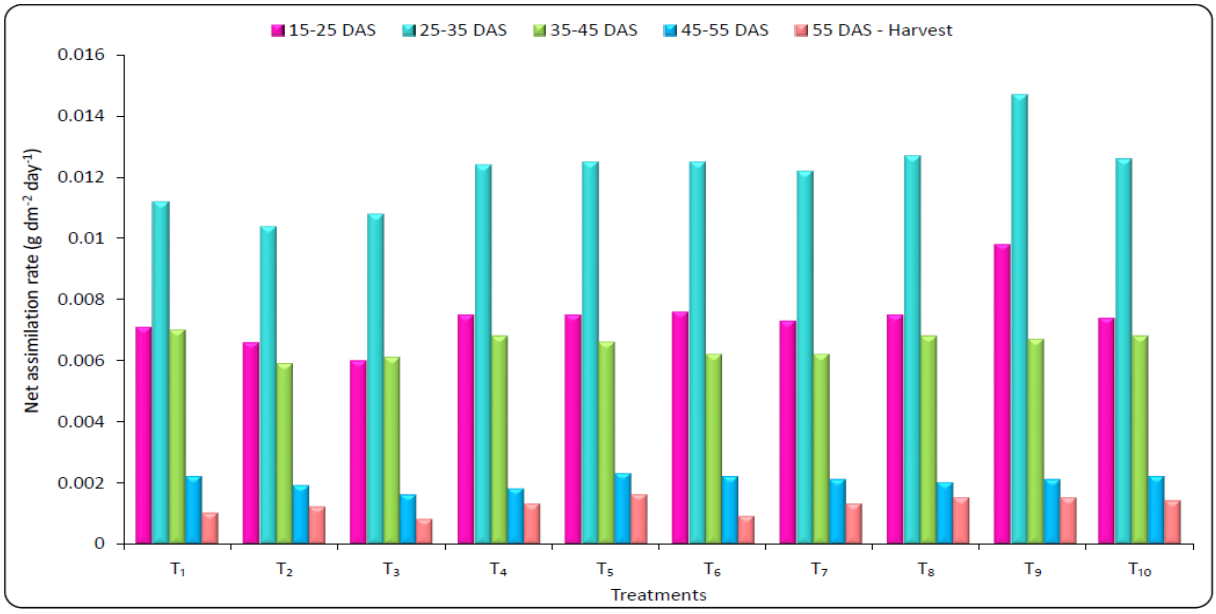

Fig 2: Effect of natural liquid organics on Net assimilation rate (g dm^{-2} day^{-1}) of blackgram

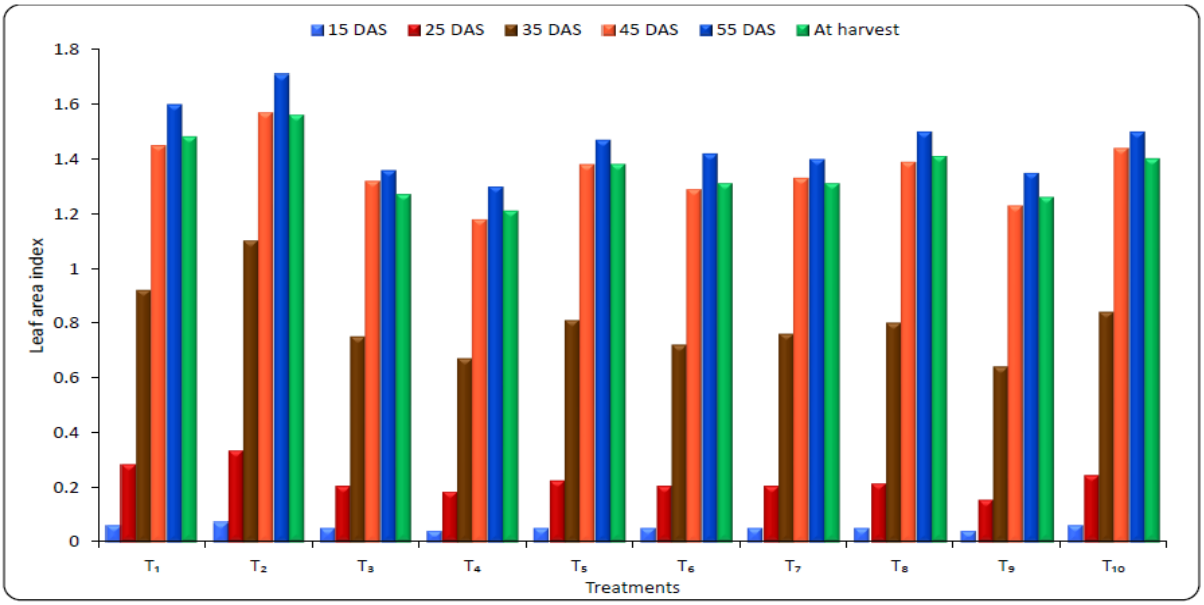

Fig 3: Effect of natural liquid organics on leaf area index of blackgram

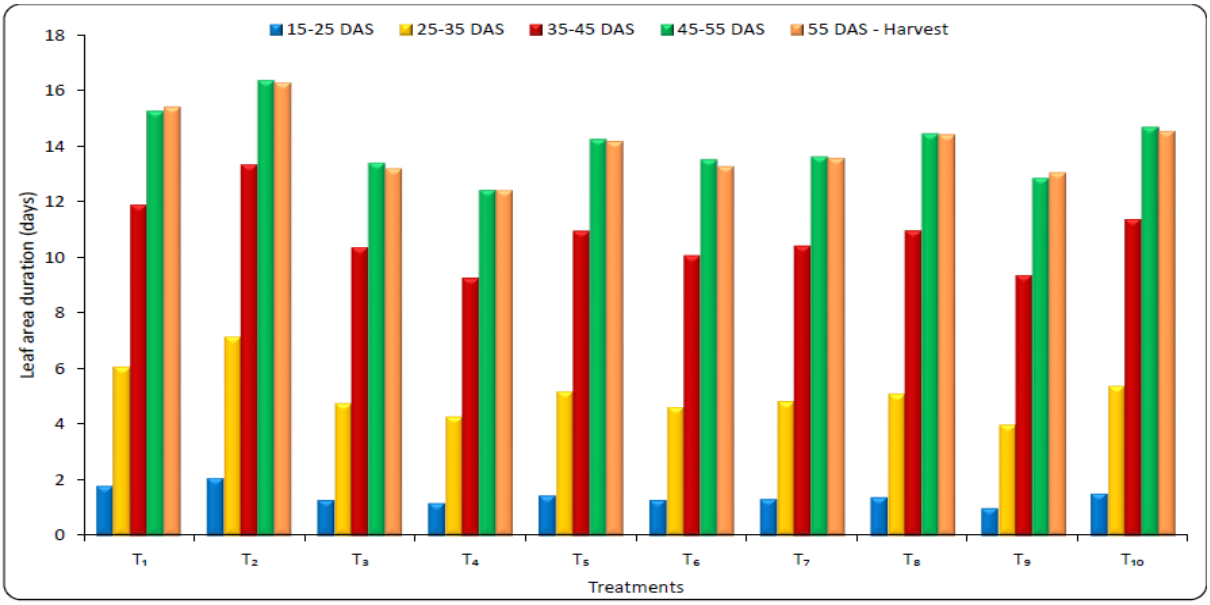

Fig 4: Effect of natural liquid organics on Leaf area duration (days) of blackgram

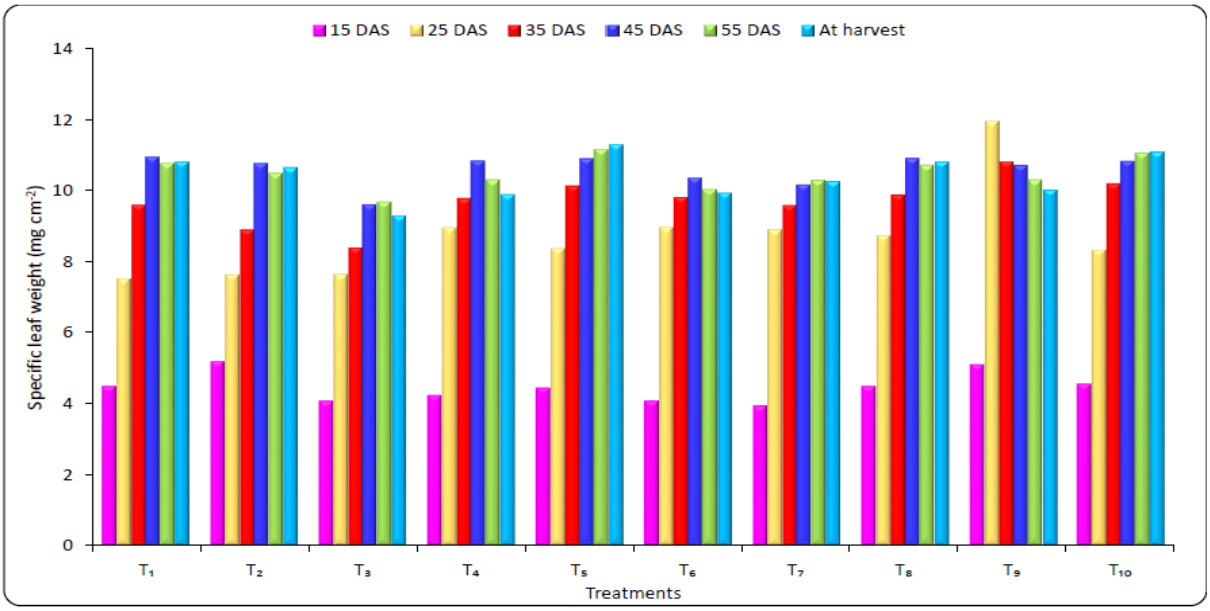

Fig 5: Effect of natural liquid organics on specific leaf weight (mg cm-2) of blackgram

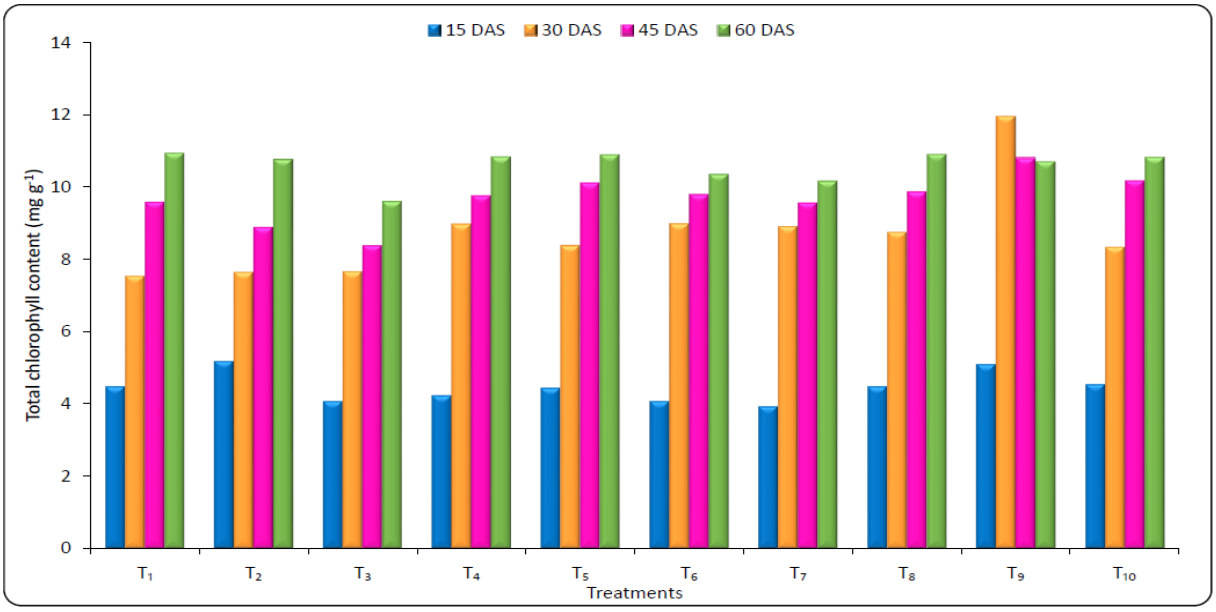

Fig 6: Effect of natural liquid organics on total chlorophyll content (mg g-1) of blackgram

Conclusion

A significant difference in growth and biochemical attributes of blackgram was observed among the inorganic and organic treatments. Significantly higher CGR, NAR, LAI and other biochemical attributes (chlorophyll, phenols, aminoacids) in inorganic treatments is attributed to the rapid availability of nutrients to the crop compared to all other organic treatments. Among other treatments, integrated use of all the organics recorded significantly higher growth and biochemical attributes. Treatments receiving jeevamrutha foliar spray recorded a significant influence on the growth of blackgram due to the presence of essential micronutrients. Further study to compare the efficiency of organic and inorganic treatments in terms of biochemical and growth attributes in different crops is required. Integrated use of organic and inorganic elements may help make the agriculture sustainable.

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