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Residual effect of enriched arecahusk compost on growth and yield of green gram in maize-greengram cropping sequence under Southern transition argo-climatic zone of Karnataka

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Abstract
A potential supply of organic materials and nutrients is lost when arecahusk trash is currently burned as a form of disposal. There is still much to be learned about the utility of arecanut waste as an organic resource. Shortage, high price and adverse effect of fertilizers drive to hunt alternative sources as compost. Arecahusk was composted using microbial consortia and enriched with plant growth promoting rhizobacteria. Two field experiments were conducted in maize – green gram cropping sequence to evaluate residual effect of enriched arecahusk compost applications on growth and yield of green gram under rainfed conditions in two consecutive years (2019–2020 and 2020–2021). The design includes ten treatments replicated thrice in a randomized complete block design. The residual treatment supplemented with enriched arecahusk compost (AHC) and NPK fertilizer (75% RDN+ enriched AHC + 25% N through enriched AHC) significantly increased the growth (plant height up to 29.94%, number of leaves up to 38%, drymatter up to 35.97%), yield parameters (grain and straw yield up to 29.21% and 37.90% respectively). It can be concluded that arecahusk compost could be a potential alternative to FYM, which overcomes the problem of procuring FYM and disposal of arecahusk by areca growing farmers and it also minimize the dependence on chemical fertilizers.

Keywords: Residue effect, integrated nutrient management, organic residue, green gram, enrichment, FYM and AHC (arecahusk compost)

Introduction

India produces more than half of the world's arecanut, making it a significant plantation crop. Numerous agricultural, social, religious, political and medicinal uses for arecanut exist. Millions of people use it as a masticator. The husk obtained (dry/green) after kernel extraction in native scale operations is being dumped in the backyards and all along the roadside ultimately subjected to burning. India produced 8.3 lakh tonnes of arecanut fruit on 4.9 lakh acres of cultivable land in 2017-18 (National Horticultural Board- 2019) [38]. The arecanut husk makes up between 65-70% of the fruit's total weight and volume, which means that in India alone, 3.3 lakh tonnes of husk were produced as biomass. Due to its heterogeneous, three-dimensional lignocellulosic composition, which is composed of oxyphenyl propanoid units that take a while to decay (Deshmukh *et al*. 2019) [7].

Solid waste disposal has recently grown to be a major problem because of a scarcity of dump sites and stringent environmental restrictions. One possible example of such produced trash is "Arecanut husk." India continues to be the world's leader in the production and productivity of arecanuts, as well as in the utilisation of its husk fibres, an uncontrolled agricultural waste that is seldom exploited as a source of energy for processing the nut. (Anuar *et al*. 2021) [1]. Since burning has historically been the main method of disposing of these solid wastes, it has contributed to a number of environmental problems, including carbon build-up and global warming. A potential source of organic materials and vital plant nutrients is also lost (Vasudeva *et al*. 2019) [58]. The arecahusk has multiple applications in other fields (Anuar *et al*. 2021) [1] but only a few related researches on arecahusk as organic source in agriculture and applications were emphasised (Uma *et al*. 2015 and Kevin. 2021) [57, 29].

The value of arecanut waste as an organic material for composting has not yet fully been recognised in our nation. Composting, a widely accepted method of recycling organic waste in agriculture, ensures that these agro-industrial wastes' organic content is stabilised and sanitised

(Komolafe *et al*. 2021) [30]. It's a biological aerobic transformation of an organic by-product into a new hygienic organic product via a rapid succession of microbial populations that may be fed to the soil without harming crop growth (Sifolo *et al*. 2019) [53]. The viable strategy to control deterioration in soil quality is to add the organic matter in the form of compost. The conversion of agricultural residues into value-added compost and its incorporation in soil with cheap nutrient sources. However, to increase crop yield and soil quality, crop leftovers must be composted before being employed as manure in agricultural areas (Doodhawal. 2021) [11].

Pulses are an imperative component of a balanced vegetarian food diet, hence, known to be the 'poor man's meat'. Pulses play a vital role in soil fertility restoration through atmospheric nitrogen fixation in association with root nodule bacteria (Dhinagaran *et al*. 2021) [10]. Green gram as a pro-portion to fix atmospheric nitrogen (30-40 kg ha^{-1}). Green gram major dietary crop is grown over the countries, out of which 70% of the world's production comes from India (Greengram outlook, 2019) [16]. The nutrient profile of the charted as protein (18 -25%), carbohy-drates (50%), fat 3%), ash (4-5%), fibre (3-4.5%), phosphorus (367 mg) and calcium (132 mg) per hundred-gram seed (Faruque *et al*. 2000) [13]. Most of Indian populations are vegetarian and pulses also contribute to about 14% of total protein supplementation of a usual diet of India. Pulses occupy a leading place in various cropping system and grow as main crop, residue crop cover crop, catch crop, inter crop and green manure crop (Mallikarjun *et al*. 2021) [37]. Green gram can be grown in all season where sufficient irrigation dexterity is feasible. In summer season less extra rainfall, less cloudy condition, higher temperature and less humidity provide less infestation of pest and disease. Growth and productivity of Mungbean affected by.

Due to the decreased number of cattle, Farmyard Manure (FYM) is relatively scarce in the current situation. In order to overcome this problem one has to look for alternative sources of organics like arecanut husk compost. The effects of arecahusk compost field application on crop development, yield, and soil characteristics has not yet been thoroughly investigated. As an alternative to FYM in this situation, the experiment was designed to use and assess arecahusk compost, which is a significant source of organic carbon and other nutrients for preserving soil health and enhancing crop output. With the aim of assessing the residual impact of AHC on the growth and yield characteristics of green gram when AHC was used as a substitute for FYM on a N equivalent basis and 25% less inorganic N as AHC.

Materials and Methods

Experimental Site and Field Management

Two-year field experiments were conducted at the Experimental Farm, Agricultural and Horticultural Research Station (AHRS), Bhavikere, Tarikere taluk, Chikkamagaluru district, Karnataka, India, from October to December (*Rabi*) in 2020 and 2021. The experimental location is at a height of 695 metres above mean sea level and is located at 13°42 N latitude and 75°51 E longitude (Fig.1 and Fig.2). Table 3 shows the weather data for the study area throughout both crop period. The soil texture at the experimental site was sandy loam, and samples were obtained at random depths of 0–20 cm from the soil surface preceding land preparation and evaluated for different physicochemical qualities during both growing seasons, as shown in Table 2 (Prashanth *et al*. 2022) [46].

The field was prepared through well conventional rotavator to a depth of 15 cm, soil was homogenised and levelled manually without disturbing the treatment and replication blocks. The treatments were applied using a Randomized Block Design (RBD) with three replications. The size of the plot was 7.2 × 4.5 m^2 consisting of four ridges of 3.0 length. Nitrogen fertilizer in the form of urea (46% N) and DAP (18% N) was applied as basal application, phosphorus is applied as DAP (46% P_2O_5), Potassium is applied as MOP (60% K_2O) after the harvest of preceding crop maize. Zinc sulphate @ 10 kg/hectare was applied during soil preparation for main crop. Both phosphorus and Potassium applied as basal dose during sowing operation. No organic fertilizers were applied for this crop as it involved in studies of residual effect of organic sources.

Green gram (*Vigna radiata* (L.) Wilczek) variety KKM-3 was taken as a test crop. Seeds were collected from seed unit, Navile, KSNUAHS, Shivamogga. Variety KKM-3 released from AHRS, Kathalagere, matures in 65-70 days. Seeds are bold and of shinning green colour. It is moderately tolerant to powdery mildew and yellow mosaic virus (YMV) and pod borer. Thereafter, the seeds were surface sterilized with 1% sodium hypochlorite for 5 min, washed with sterilized water and then treated with the microbial inoculants (Rhizobium) before sowing. Then, seeds were sowed on 15 October 2020 and 2021 in hills, 2-3 grains were applied per hill on one side of the ridge. After two weeks the plants were thinned to a one healthy plant per hill.

Composting technology for arecahusk compost and its enrichment

Compost was produced at the Bhavikere Experimental Site (KSNUAHS) to assess the impact of microbial consortia on composting as well as the nutritional value of arecahusk compost. The study used *Pleurotus florida*, *Phanerochaete chrysosporium*, *Trichoderma viridae* and *Aspergillus awamorii* microbial consortia that were mass grown on potato dextrose broth. Composting was carried out in an artificial pit that was perforated for air circulation and measured 10 feet by 3 feet by 4 feet (L x W x H). The substrate, 2.5 quintals of arecahusk, was stacked to the height of one leg (one feet) sprayed with water to maintain 60% moisture, then Glycidia, which weighs 6.25 kg per layer, was applied together with a slurry of microbes. 25 kg of cow dung was diluted with 62.5 litres of water and 250 g of microbial consortia to create the slurry, which required 15.5 liters of consortium every shift and these shifts are repeated until the tank is full. The top layer was then covered with polyethylene and topped with a combination of cow dung and soil. Spray water on the compost tank once a week. Every two weeks, the substrate was shifted up and down as per guidelines given by Gurumurthy *et al*. (2018). This process was repeated for up to 150 days after 150 days, the compost was fortified with PGPR (plant growth-promoting rhizobacteria) such as rhizobium, azotobacter, phosphate solubilizer and potassium mobilizer (5 L / ton compost) which wass cured for 15 days. Compost was utilised for the experiment after 15 days of enrichment, and FYM that was on hand at the research station underwent a similar enrichment procedure. The Microbial Consortium and PGPR were acquired from the Faculty of Microbiology laboratory at the Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, located in Navule, Shivamogga, Karnataka, India.

Fig 1: Map showing location of the experiment

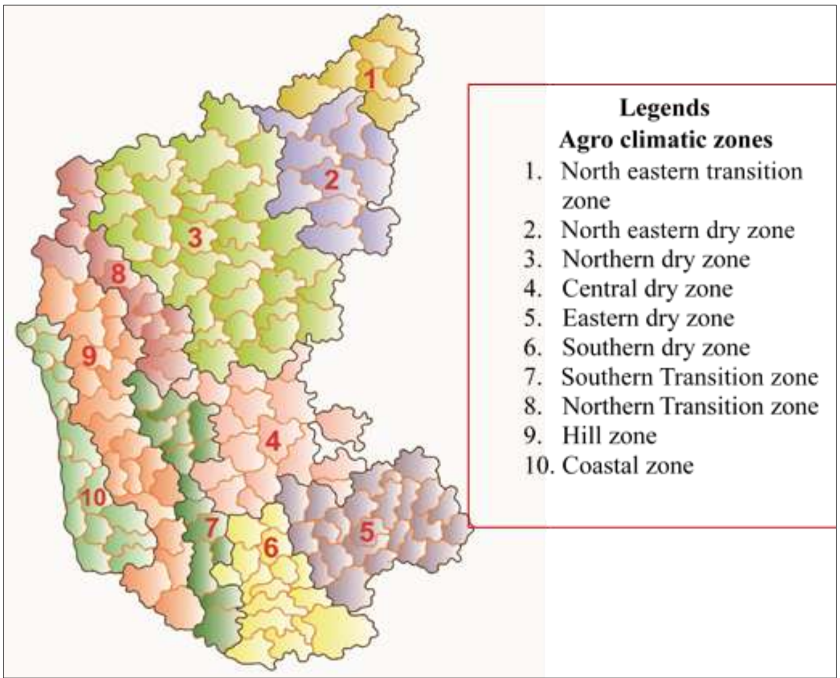


Fig 2: Agroclimatic zones of Karnataka

Characterization of organic source (AHC and FYM)

The compositions shown in Table 1 were analysed both after compost and FYM preparation, before and after concentration. The pH and EC values were determined using a pH and EC meter in a 1:10 compost / FYM: aqueous suspension extract (Kacar, 1994) [26]. Then, using the Dumas method, the Leco TruSpec-CHNS tool was applied and the total C and N contents were calculated by microwave decomposition of 0.5 g of dry sample (compost / FYM). Was decided. The total P content was determined using a spectrophotometer (Shimadzu UV-160) at a wavelength of 430 nm by applying the vanadomolibdrinate yellow method, and the total K content was determined by a flame photometer, (Kacar 1994) [26].

The physical properties of soils such as sand, silt and clay were determined using the hydrometer method (Demiralay 1993) [8]. Maximum water capacity, bulk density, and total porosity were determined as reported by Hillel (1982) [20]. Soil chemistry analysis including pH and EC was measured in a 1: 1 soil: water suspension using a pH and EC meter (Jackson, 1973) [23]. Soil organic carbon content was determined by the potassium dichromate oxidation method (Nelson and Sommers 1982) [39]. The potentially available N soil of soil was distilled with 25 mL of 0.32% potassium permanganate ($KMnO_4$) and 25 mL of 2.5% NaOH. The released ammonia was trapped in a mixed indicator containing 4% boric acid and titrated against standard sulfuric acid (Subbiah and Asija, 1956) [56]. P_2O_5 available in soil samples was extracted with Brays-1 reagent (NH_4F + HCl). Phosphorus content in the extract was determined using the ascorbic acid-molybdate complex method and blue intensity was recorded at 660 nm using a spectrophotometer (Jackson 1973) [23]. Available soil potassium extracts soil with normal neutral ammonium acetate (pH 7.0) and estimated by using a flame photometer as described by Jackson (1973) [23].

Morpho-Physiological Traits

In each plot, five representative plants were chosen at random and tagged to record observations on plant height, number of functional leaves, no of pods bearing auxiliary branches per plant, number of pods per plant, pod length and number of seeds per pod. Dry matter partitioning (30 DAS and harvest). The grain yield and straw yield were recorded on whole plot basis and converted into q/ha. Thousand-seed weight was determined by weighing 1,000 randomly selected dry seeds from the harvested net plot using a sensitive balance and the weight adjusted to 10% seed moisture content. Above-ground dry biomass (kg ha^{-1}) was recorded by harvesting from each net plot. It was sun-dried up to constant weight, weighed and then converted into kg ha^{-1}. Grain and straw yield were determined by harvesting from net plot and adjusting moisture content at 10%.

The Treatment Details

Treatments with the Chemical, Organic Fertilizers with and without enrichment of PGPR were performed as follows: T_1: 100% RDN + FYM, T_2: 100% RDN + Enriched FYM

T_3: 100% RDN + AHC, T_4: 100% RDN + Enriched AHC, T_5: 75% RDN + FYM + 25% N through FYM, T_6:75% RDN + Enriched FYM + 25% N through enriched FYM, T_7: 75% RDN + FYM + 25% N through AHC, T_8:75%RDN+Enriched FYM + 25% N through enriched AHC

T_9: 75% RDN+AHC + 25% N through AHC, T_{10}:75% RDN+ Enriched AHC + 25% N through enriched AHC. AHC was applied alternative to FYM on the basis of N – equivalent basis (in the ratio of 1:2.66). These are the treatments which applied for preceding crop maize, since experiment was taken as a residue crop no changes has been done in treatments.

AHC was applied alternative to FYM on the basis of N – equivalent (in the ratio of 1:2.69). Recommended dose of P_2O_5 (50 kg/ha), K_2O (25 kg/ha), and $ZnSO_4$ (10 kg/ha) is common for all the treatments. *RDN (Recommended dose of nitrogen) (100 kg/ha). *AHC (Areca husk compost), *FYM (Farmyard manure) (7.5 t/ha), *En- Enriched with PGPR (Plant Growth Promoting Rhizobacteria) @ 5ltr/ton of compost (Prashanth *et al*. 2022) [46].

Statistical analysis

The experimental data were statistically analysed using Fisher's ANOVA, as stated by Gomez and Gomez (1984). The F-test has a significance level of 5%. When the F-test is significant, the critical difference (CD) values for the data are presented at a 5% significance level. Using R software, a simple link between several growth, yield components and yields were observed, further percentage contribution of each component was computed using a method given by Singh, D. (1981) [49].

Results and Discussions

Residual effect of enriched AHC on growth parameters of green gram

Data pertaining to growth parameters of green gram *viz.*, plant height, number of leaves and total drymatter accumulation at two different intervals (30 DAS and Harvest) as influenced by residual effect of different levels of enriched AHC and FYM application is presented in Figure 3,4 and 5.

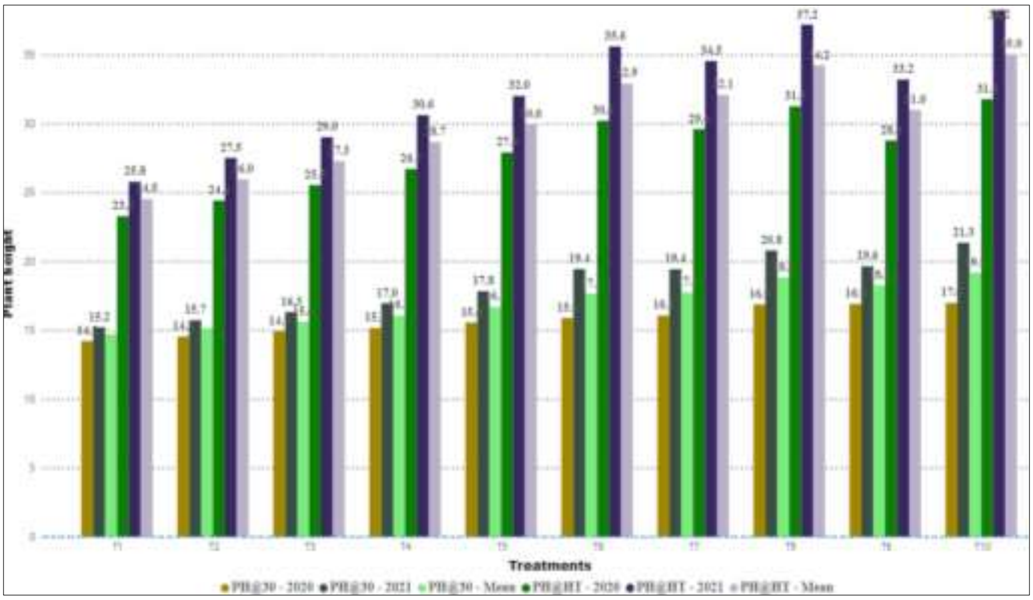
Plant height differed significantly by applied different levels of enriched AHC and FYM (Figure 3). At 30 DAS, significantly higher plant height was recorded in the treatment T_{10} which, received that 25% N through En-AHC + FYM @ 10 t ha^{-1} through En-AHC+ RDN (16.97 and 21.34 cm) followed by the treatment, T_9 (75% RDN+ AHC + 25% N through AHC) which recorded 16.86 and 20.78 cm and lower values were observed in control T_1 (14.21 and 15.20 cm). Similarly, significantly taller plant at harvest was noticed in the treatments with residual effect of 25% N through En-AHC + FYM @ 10 t ha^{-1} through En-AHC+ RDN (T_{10}) (31.77 and38.24 cm) it was followed by the treatment, T_9 (75% RDN+ AHC + 25% N through AHC) which recorded 31.25 and 37.18 cm and lower values were observed in control T_1 (23.27 and 25.77 cm) with respect to the pooled data similar trend was followed.

It is apparent from the data presented in Figure 4 that number of leaves of green gram @ 30 DAS significantly influenced by application of different fertility levels and enriched compost as compared to control. Significantly maximum number of leaves (17.55 and 19.55) was recorded with application of 75% RDN+ Enriched AHC + 25% N through enriched AHC (T_{10}) over control (13.14 and 13.34) T_1(100% RDN+ 100% FYM). Likewise, the significantly highest number of leaves (24.86 and 28.02) was observed with application of 25% N through En-AHC + FYM @ 10 t ha^{-1} through En-AHC+ RDN (T_{10}) over control (15.40 and 15.80) T_1 (100% RDN+ 100% FYM) @ harvest stage.

Application of 25% N through En-AHC + FYM @ 10 t ha^{-1} through En-AHC+ RDN recorded significantly higher total dry matter (g/plt) (9.77 and 10.82) during both the years @ 30 DAS. The lowest mean total dry matter (g/plt) was recorded in 100% RDN+ 100% FYM application during both the years (5.00 and 5.07). During both the years the application of 25% N through En-AHC + FYM @ 10 t ha^{-1} through En-AHC+ RDN recorded the maximum total dry matter (g/plt) @ 60 DAS (55.76 and 57.37). The treatment 100% RDN+ 100% FYM registered the lowest total dry matter (g/plt) (36.13 and 36.31) during both the years which was illustrated in Figure 5.

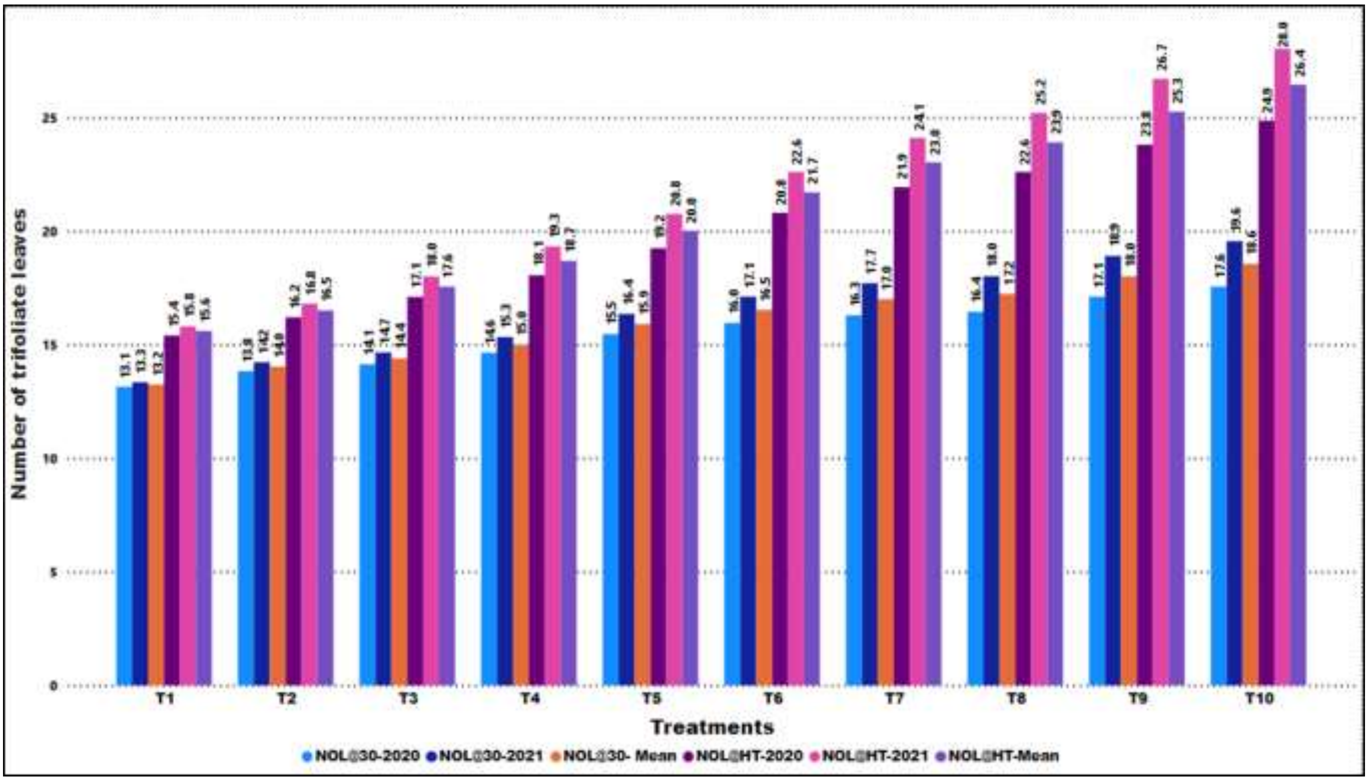
The application of enriched AHC compost significantly increased the plant height number of leaves and dry matter accumulation of green gram. It is an established fact that enriched compost improves the physical and biological properties of soil including supply of almost all the essential plant nutrients for the growth and development of plants. Thus, balanced nutrition under favourable environment might have helped in production of new tissues and development of new shoots. The beneficial effect of enriched compost on these parameters might also be due to its contribution in supplying additional plant nutrients and increasing the availability of native soil nutrients due to increased microbial activity. Another reason could be efficient and greater partitioning of metabolites and adequate location of nutrients to developing plant structures. Organic matter also functions as source of energy for soil microflora which bring about the transformation of inorganic nutrients present in soil in available form or applied in the form of fertilizers which are readily utilized by growing plants (Patil *et al*. 2011) [42]. As a result, almost all growth attributes of crop resulted into significant improvement due to application of enriched compost. These results are in agreement with that of Mali *et al.* (2017) [31] and Meena (2017) [33]. The higher nutrient availability under INM and enriched treatments resulted into increased conversion of carbohydrates into protein which in turn elaborated into protoplasm and cell wall material increased the size of the cell, which expressed morphologically in terms of plant height, number of branches and ultimately dry matter accumulation. Cellulose is a highly persistent composition material, which requires longer time for decomposition. Thus, FYM, AHC have not been fully utilized by the maize crop in first crop season and notably benefitted the succeeding green gram crop. These results are in agreement with that of Patel *et al*. (2016) [25]. Similarly, the beneficial residual effect of INM under cropping system on growth attributes of succeeding crops was recorded in rice-green gram Imade (2014) [21] and maize- green gram Sindhi (2016) [54] cropping sequence.

Farmyard manure and Arecahusk compost is highly persistent bulky organic manure with a wider C: N ratio which results in slower decomposition. Therefore, nutrients from organic sources have not been fully exploited by the maize crop in the first crop season and possibly utilised by the following greengram crop. The slower release of nutrients for a longer duration due to mineralisation of undecomposed FYM and AHC favoured suitable microclimate by enhancing soil organic matter content; thus, reducing bulk density compaction of soils. As a result, the plant gets an appropriate growing condition which facilitates better growth processes of green gram. Additionally, dual inoculation of Rhizobium, PSB and KSB to green gram helps the crop by providing atmospheric nitrogen for nitrogen fixation and supplying the insoluble phosphorus and potassium into a soluble form. The poor growth attributes of greengram under control treatment were noted due to more intra-species competitiveness for infliction of available native soil nutrients, which results in lesser plant height, the number of leaves and dry matter accumulation. These findings are closely related to the results of Bahadur and Tiwari (2014) [4], Armin *et al*. (2016) [2] and Meena *et al*. (2017) [33]. Application of Rhizobium consortia resulted in better root nodulation, PSB which is helped in better root development and enriched carbohydrate metabolism which resulted in enhanced source-sink relationship. All these resulted in increased nutrient availability and uptake was increased resulting in vigorous plant growth and plant dry biomass. Similar line of results was also reported by Kalsaria *et al*. (2017) [28] and Onte *et al*. (2019) [40].



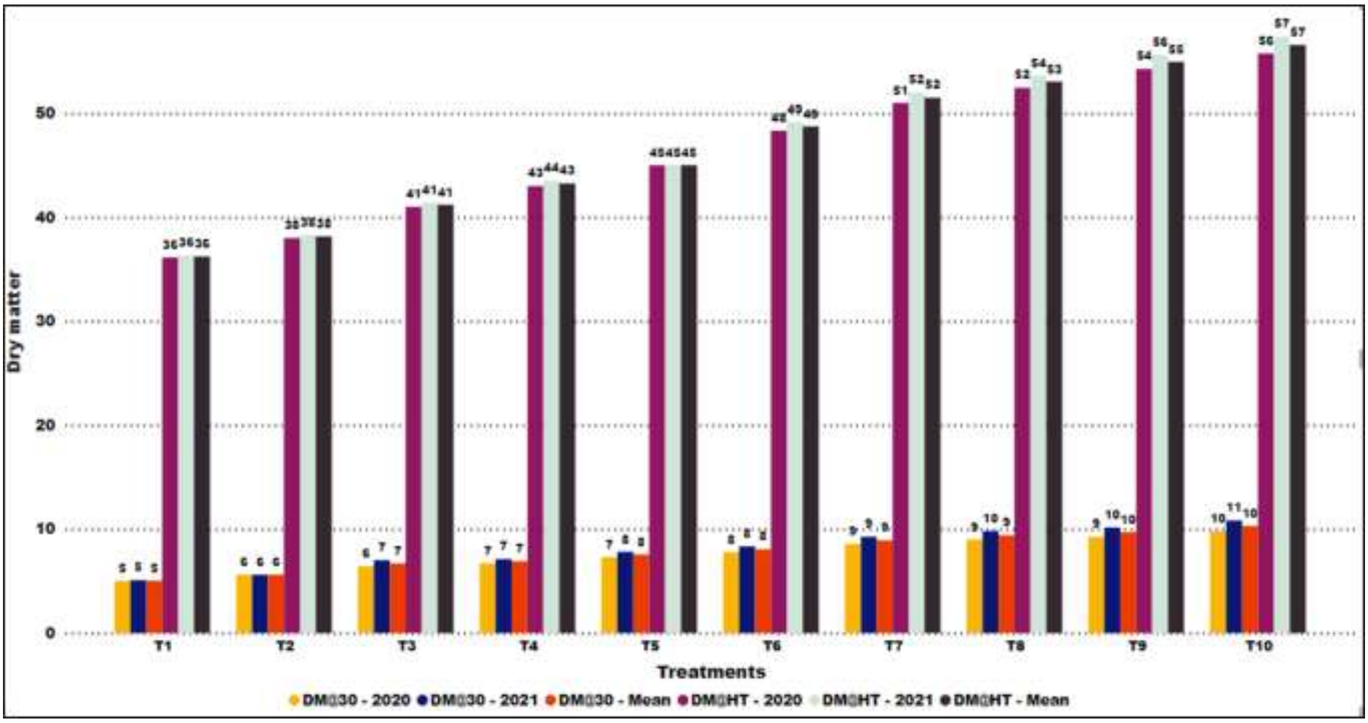
*Recommended dose of P, K and $ZnSO_4$ @10 kg/ha is common for all the treatments. *AHC and FYM Enriched with PGPR (Plant Growth Promoting Rhizobacteria) @ 5ltr/ton of compost. AHC: Arecahusk compost FYM: Farmyard manure, PH: Plant height, HT – Harvest.

Fig 3: Residual effect of enriched arecahusk compost on number plant (cm) height of green gram at different growth stages



*Recommended dose of P, K and $ZnSO_4$ @10 kg/ha is common for all the treatments. *AHC and FYM Enriched with PGPR (Plant Growth Promoting Rhizobacteria) @ 5ltr/ton of compost. AHC: Arecahusk compost FYM: Farmyard manure, NOL – Number of trifoliate leaves, HT – Harvest

Fig 4: Residual effect of enriched arecahusk compost on number of leaves of green gram at different growth stages



*Recommended dose of P, K and $ZnSO_4$ @10 kg/ha is common for all the treatments. *AHC and FYM Enriched with PGPR (Plant Growth Promoting Rhizobacteria) @ 5ltr/ton of compost. AHC: Arecahusk compost FYM: Farmyard manure, DM: Drymatter, HT – Harvest.

Fig 5: Residual effect of enriched arecahusk compost on total dry mater (g/plt) of green gram at different growth stages

Residual effect enriched AHC on yield parameters and yield of green gram

Data on yield parameters of green gram at harvest *viz* seed and stover yield as influenced by the residual effect of AHC and FYM are presented in Table 4.

Data presented in Table 4 revealed that nutrients supplementation through organic sources significantly increased the green pod yield of green gram. The maximum significant increase in green pod yield was recorded with the application of 75% RDN+ Enriched AHC + 25% N through enriched AHC (T_{10}) which was (8.47 and 9.20 q/ha) over control (T_1) (6.10 and 6.40 q/ha). Whereas treatment T_9 (75% RDN+ AHC + 25% N through AHC) (8.15 and 9.00 q/ha) T_8 (7.92 and 8.70 q/ha) was found statistically at par to treatment T_{10}. Similarly, data for haulm, revealed that nutrients supplementation through organic sources significantly increased the haulm yield of green gram. The maximum significant increase in green haulm yield was recorded with the application of 75% RDN+ Enriched AHC + 25% N through enriched AHC (T_{10}) which was (17.60 and 20.41 q/ha) over control (T_1) (11.66 and 12.35 q/ha). Whereas treatment T_9 (75% RDN+ AHC + 25% N through AHC) (16.52 and 18.94 q/ha) was found statistically at par to treatment T_{10}. With respect to test weight is considered no significant differences were observed due to various treatments on test weight. However, it ranged from 4.10 and 4.22 g (RDN and FYM without enrichment) to 4.56 g and 6.56 g (75% RDN + 25% N through En-AHC).

Most of the yield attributing characters of green gram - *viz.*, the number of pods plant^{-1}, seeds pod^{-1}, pod bearing branches and pod length, were recorded due to residual treatment receiving 75% RDN + 25% RDN through enriched AHC+100% enriched AHC to maize. Efficient utilisation of nitrogen generated by mineralisation from carrying over FYM, AHC and fertiliser N would have increased the availability of N throughout the growth period and thereby increased the assimilation of photosynthates which in turn transfers photosynthates from source to sink, leading to higher yield attributes of fallow green gram. Meena *et al*. (2017) [33] also reported similar results due to the combined application of chemical fertiliser with rhizobium and PSB, KSB inoculation. Similarly, pooled data suggested that higher grain yield (847and 920 kg/ha) and stover yield (1760 and 2041 kg/ha) were recorded by the residual treatment of 75% RDN + 25% RDN through enriched AHC+100% enriched AHC to green gram, respectively. It could be due to synergistic and cumulative carry-over effect of FYM and AHC addition which supplies nutrients on the one hand as well as a propensity to ameliorate the physicochemical and biological condition of soils, helping to achieve sustainable productivity of green gram crop for the long run under rainfed conditions. And also due to a wider C:N ratio, the persistent material present in organic manures requires more time for decomposition so that almost 25% to 33% of nitrogen and a small fraction of phosphorus and potassium in FYM and AHC might be available to succeeding greengram crop. The increase in straw yield was probably because of high nitrogen availability to the plants from an optimal combined source of inorganics and organics. An enhancement in yield due to biofertilizer inoculation might not be only due to nitrogen fixation or phosphate solubilisation, but because of various factors - such as the release of growth promoters, plant-pathogen control, and accretion of beneficial organisms in the rhizosphere. A similar result was suggested by Parihar (2004) [45] (Subba Rao, 1986) [51]. The lowest seed yield was obtained in control treatment this might be due to decreased growth in terms of biomass accumulation during vegetative phases leading to decreased bearing capacity and could not get the required quantity of nutrients matching its demand which ultimately decreased the grain yield. The results are in the line with the findings of Singh *et al*. (2015) [50], (Somani, 2002) [52], El-Azab (2016) [12] and Pandey *et al*. (2019) [41].

Significant response in respect with yield attributes and yield than sole application of chemical fertilizer or bio-fertilizer due to increased concentration of N and P ions of soil solution and ultimately lead to enthusiastic root development with deep rooted system and cell multiplication leading to more absorption of other nutrients from deeper layers of soil ultimately resulting increased growth parameters, seed and haulm yields., better N fixation and better development of plant growth chief to higher photosynthetic activity and translocation of photosynthates from source to the sink which in turn resulted in better development of yield attributes *i.e.*, better pod formation and number of branches plant^{-1} in green gram. These results were in close conformity with the reports of Shariff *et al*. (2015) [48], Gohain and Kikon (2017) [14]. Gohil *et al*. (2017) [15], Meena *et al*. (2017) [33] and Kalaiyarasi *et al*. (2019) [27].

Hulm yield was recorded higher value under treatment T_{10}. Moreover, the positive influence of these treatments through instantaneous supply of nutrients from inorganic sources especially at the early stage of the crop commanded to more meristematic activities of the plant. Slow and steady supply of nutrients through combination of inorganic fertilizer along with biofertilizer and compost throughout the crop growth period improved suitable biomass production which resulted into higher pod and haulm yield and as Rhizobium, PSB, KSB strains enhanced greater amount of availability of N, P_2O_5 and K_2O which enabled the plant to absorb more N P and K resulting in increased biomass production and their translocation in plants which improve haulm yield. These results were in close conformity with results reported by Gohil *et al.* (2017) [15], Saha *et al*. (2017) and Kalaiyarasi *et al*. (2019) [27].

Table 1: Characterization of Farmyard manure and Arecahusk compost

Parameters	FYM	Enriched FYM	Areca husk	Arecahusk Compost	Enriched Areca husk Compost
pH (1:10)	7.24	7.21	6.42	6.89	6.92
EC (dS m^{-1}) (1:10)	0.46	0.47	1.72	2.62	2.63
Organic Carbon (%)	11.81	11.81	59.92	26.8	27.00
Total N (%)	0.56	0.57	0.69	1.51	1.53
Total P (%)	0.29	0.30	0.36	0.74	0.76
Total K (%)	0.52	0.54	0.91	1.41	1.44
C:N ratio	21.08	21.07	86.84	17.74	17.64

Table 2: Initial soil properties of experimental site. 2020 and 2021

Physical properties	2020	2021
Sand (%)	62.26	61.84
Silt (%)	15.49	15.82
Clay (%)	21.51	21.71
Textural class	Sandy loam	Sandy loam
Bulk density (g cm^{-3})	1.38	1.33
MWHC (%)	32.18	35.12
Porasity (%)	25.82	30.12
Chemical properties		
pH	5.62	5.66
Electrical conductivity (dS m^{-1})	0.21	0.24
OC (g kg^{-1})	10.20	10.50
Available macro nutrient status		
Available N (kg ha^{-1})	236.00	258.00
Available P_2O_5 (kg ha^{-1})	52	59.00
Available K_2O (kg ha^{-1})	240	248.00

Table 3: Monthly meteorological data for the years 2020 and 2021 against normal for 11 years (2009-2019) recorded at meteorological observatory, AHRS Bhavikere

Month	Rainfall (mm)			Monthly maximum temperature (°C)			Monthly minimum temperature (°C)			Relative Humidity (%)			Sun shine hours (hour day^{-1})		
	Normal	2020	2021	Normal	2020	2021	Normal	2020	2021	Normal	2020	2021	Normal	2020	2021
January	0.7	0	0.4	30.64	31.66	29.9	14.71	15.30	15.9	59.36	67.36	59	9.1	8.6	8.8
February	0.4	0	0.5	32.60	32.42	31.3	17.51	15.71	13.8	55.34	59.12	61	9.0	8.5	8.7
March	4.6	0	0	36.91	35.44	32.8	20.04	19.85	28.1	54.74	56.57	59	7.8	8.1	8.4
April	66.1	4	62.3	34.51	35.32	33.9	21.30	20.86	19.7	56.89	58.34	62	7.7	7.8	7.9
May	77.7	88.7	120.6	33.49	33.48	33.0	21.06	21.52	20.2	62.42	63.93	66	7.4	6.9	7.2
June	124.2	116.2	112.4	29.79	29.84	29.8	19.83	21.16	19.7	66.94	75.92	79	6.5	6.5	6.8
July	247.4	157.9	378.1	28.35	28.46	27.8	20.28	20.38	19.9	77.34	81.55	88	4.6	5.1	4.9
August	206.5	257.5	138.1	30.86	29.67	27.6	21.52	20.39	19.9	81.53	85.97	84	4.9	5.3	5.6
September	175.9	182.5	145.5	30.79	29.34	29.0	19.68	20.22	20.3	77.45	81.62	76	4.9	5.6	5.9
October	93.8	138.8	207.6	31.57	29.20	30.5	19.44	19.34	19.6	75.80	80.24	82	6.4	6.3	6.6
November	42.6	32.5	165.5	29.89	30.65	28.2	17.53	16.91	19.2	69.79	74.78	78	7.3	7.2	7.5
December	14.6	10.8	11.2	30.06	30.14	29.9	17.80	15.56	15.7	65.77	72.95	70	7.0	6.9	7.2

Table 4: Residual effect of enriched arecahusk compost on grain and haulm yield of green gram at harvest

Treatments	Grain			Haulm		
	2020	2021	Pooled	2020	2021	Pooled
T_1: 100% RDN + FYM	6.10	6.40	6.25	11.66	12.35	12.01
T_2: 100% RDN + Enriched FYM	6.30	6.70	6.50	12.69	13.53	13.11
T_3: 100% RDN + AHC	6.77	7.00	6.88	13.23	14.61	13.92
T_4: 100% RDN + Enriched AHC	7.10	7.45	7.28	13.46	15.02	14.24
T_5: 75% RDN + FYM + 25% N through FYM	7.30	7.90	7.60	14.24	16.01	15.13
T_6:75% RDN + Enriched FYM + 25% N through enriched FYM	7.43	8.10	7.77	14.49	16.50	15.49
T_7: 75% RDN + FYM + 25% N through AHC	7.68	8.33	8.04	15.51	17.59	16.55
T_8:75%RDN+Enriched FYM + 25% N through enriched AHC	7.92	8.70	8.31	15.99	18.16	17.08
T_9: 75% RDN+AHC + 25% N through AHC	8.15	9.00	8.57	16.52	18.94	17.73
T_{10}:75% RDN+ Enriched AHC + 25% N through enriched AHC	8.47	9.20	8.83	17.60	20.41	19.01
S.Em±	0.25	0.27	0.17	0.51	0.32	0.34
CD at 5%	0.75	0.79	0.51	1.52	0.95	1.02

Note: *Recommended dose of P, K and $ZnSO_4$ @10 kg/ha is common for all the treatments.
*AHC and FYM Enriched with PGPR (Plant Growth Promoting Rhizobacteria) @ 5ltr/ton of compost.
AHC: Arecahusk compost, FYM: Farmyard manure

Conclusions

Organic wastes contain valuable nutrients that promote crop growth, yield and soil environmental health. Both macro and micro-nutrients and other growth promoting substances are present in the wastes in various proportions that however depend on the type of waste. Organic wastes are mainly from animal and agricultural wastes. With the increase in population that demand increase in food production and rise in demand of organic food crops, organic wastes become an ideal input for the farmers as it will supply plant nutrients and other soil stimulants for crop growth and yield, soil quality and public health. Hence it becomes important to establish the ideal rate of application of organic wastes in order to achieve this noble objective.

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