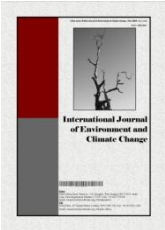

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Effect of Organic Management on Growth, Yield and Economics of Green Gram, Pigeon Pea and Sunflower under Rainfed Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Kharif*, 2021 at Gungal (around 43 km from Hyderabad) Research Farm of ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India. The soil was Sandy clay loam in texture, slightly acidic in reaction, low in organic carbon, available nitrogen, available phosphorus and medium in available potassium. The experiment was laid out in a randomized complete block design with three treatment combinations *viz.,* Organic (recommended 100% N equivalent FYM), Integrated (recommended 25% N equivalent FYM + 75% N and 100% P and K through chemical fertilizers) and Control (recommended 100 % NPK through chemical fertilizer) replicated nine times. Based on the results, it was found that the growth, yield attributes, yield, and economics with respect to all the three crops viz., green gram, pigeon pea and sunflower were significantly higher with organic treatment which was followed by integrated treatment and control.

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1. INTRODUCTION

Oilseeds are India's second most important agricultural product after grains. It accounts for 13% of the gross cropped area and they contribute around 3% of the gross national product (GNP) and 10 % of all the agricultural commodities. DOD, [1]. Despite being one of the major producers of oilseeds, India, with its large population, is unable to supply the demand for edible oils. India is paying substantial foreign currency to import edible oils to meet domestic demand.

Sunflower (*Helianthus annuus* L.) is a popular oilseed crop in India due to its ability to adapt to a variety of agro-climatic zones and cropping patterns. Sunflower is grown on 2.25 lakh hectares in the country, with a yield of 2.28 lakh tonnes and productivity of 1,011 kg ha^{-1} Indiastat [2]. Karnataka is the country's most prolific producer. Telangana covers 7000 hectares, with a yearly yield and productivity of 1,6390 tonnes and 2,342 kg ha^{-1}, respectively Indiastat [2].

Pulses are a strong source of protein in the diet and can help satisfy the demands of a rapidly rising population. The output of pulses is exceedingly low, which has become a difficult challenge in light of our country's rapidly rising population. Pulses contain approximately 21-25% protein and it also contains a limited amount of essential amino acids such as tryptophan, methionine, lysine, and cystine Tiwari and Singh [3]. Besides the nutritional benefit, pulses can potentially fix atmospheric nitrogen symbiotically in the soil through root nodules, which helps them maintain and improve soil fertility.

Green gram (*Vigna radiata* L.) popularly known as mungbean is grown on 51.3 lakh hectares in India, with a total yield of 30.85 lakh tonnes and productivity of 601 kg ha^{-1} Indiastat [2]. The top green gram producing states are Rajasthan, Maharashtra, Andhra Pradesh, Gujarat, Bihar, and Karnataka. Green gram covers 75,000 ha in Telangana, with yield and productivity of 38,050 tonnes and 507 kg ha^{-1}, respectively Indiastat [2]. It requires less water than other crops because of its shorter duration. In the *Kharif* and summer seasons, it is commonly planted as an intercrop, mixed crop, or single crop. Among grain legumes, it is one of India's most important conventional pulse crops. It is only second to chickpeas in terms of productivity. Its seed is tastier, more nutritious, easier to digest, and less flatulent than other pulses growing in that particular region.

Pigeon pea (*Cajanus cajan*) is India's second most important pulse crop after chickpea, commonly known as red gram (Arhar or Tur) in local languages. It is grown on 4.72 million hectares in India, with a yield of 4.31 million tonnes and productivity of 914 kg ha^{-1} Indiastat [2]. Telangana has a total area of 3.25 lakh hectares with annual production and productivity of 2.52 lakh tonnes and 775 kg ha^{-1}, respectively Indiastat [2]. As it is an important nitrogen-fixing crop, it is widely grown for soil enrichment in rainfed areas. Its deep penetrating roots help move nutrients from deeper soil layers to the surface. Effective rhizobium nodulation can average up to fix up to 160-200 kg nitrogen ha^{-1} $year^{-1}$.

Climate change and variability are a considerable threat to agricultural communities, particularly in India. This threat includes the likely increase in temperature, extreme weather conditions, increased water stress and drought, and desertification. Traditional crop production methods may be jeopardised by seasonal differences in weather events, either owing to a lack of water or a surplus of water, resulting in erosion. Soil stability will become increasingly important in order to store water in the soil profile, withstand extreme weather events, and reduce soil losses. These changes will bring new challenges to farmers. Farmers require a new production system to assist them in adapting to these changing circumstances. Organic farming is one such alternative that has the potential to both mitigate and adapt to climate change, especially in rainfed agriculture. Organic agriculture is claimed to be the most sustainable approach in food production. It emphasizes recycling techniques and low external input and high output strategies. It is based on enhancing soil fertility and diversity at all levels and makes soils less susceptible to erosion Niggli et al. [4].

Scientific investigations are restricted in their capacity to reveal the productivity levels, stability, and profitability that may be obtained through pure organic sources of nutrient delivery in comparison to inorganic sources. It is critical to design robust feasible and compatible packages of nutrient management using organic sources for varied crops and cropping systems to fit local circumstances while being economically viable.

2. MATERIALS AND METHODS

The field experiment was conducted in Gungal (around 43 km from Hyderabad) Research Farm (17.08°N latitude and 78.66°E longitude and 542 m above MSL) of ICAR-Central Research Institute for Dryland Agriculture, Hyderabad, India, during *Kharif* 2021. The farm represents a semi-arid tropical region with a mean annual temperature of 25.58 ◦C and rainfall of 835.7 mm received during the crop period of 52 rainy days. The soil of the experimental field was clay loam in texture, with soil pH 6.51, low in organic carbon (0.43%), available nitrogen (179.0 kg/ha), high in available P_2O_5 (24.7 kg/ha) and medium in available K_2O (218.1 kg/ha). The experiment was laid out in a randomized complete block design with three treatment combinations viz., Organic (recommended 100 % N equivalent FYM), Integrated (recommended 25 % N equivalent FYM + 75 % N and 100 % P and K through chemical fertilizers) and Control (recommended 100 % NPK through chemical fertilizer) and replicated nine times. In the plots under organic management, farmyard manure was thoroughly incorporated into 15 cm surface soil on the recommended N equivalent basis to all three crops at two weeks before sowing of crops and the P requirement was supplemented by rock phosphate. The initially available K status of the experimental site was high hence no potassium was applied. In the plots under integrated management, 25% of the equivalent recommended N was applied through farmyard manure. The remaining 75% N and 100% P and K were applied through chemical fertilizers. The plots under inorganic management were applied with a recommended dose of chemical fertilizers (20:50 kg N and P_2O_5 ha^{-1} for pigeon pea and green gram; 60:60:30 kg N, P_2O_5 and K_2O ha^{-1} for sunflower). The quantity of manure and fertilizer applied in field is represented in Table 1. The FYM used in the field were analysed for N, P, K and other micronutrients. On average it contains 0.5% N, 0.27% P, 0.4% K, 452 ppm Fe, 228.7 ppm Mn, 143.1 ppm Zn and 27.9 ppm Cu. Further, this FYM was treated with *Trichoderma viridan* at 2.5 kg ha^{-1} and incubated in the soil for about 20 days as a prophylactic measure against various soil-borne diseases. The sources of fertilizers for NPK were urea (46% N), SSP (16% P_2O_5, 12% S) and MOP (60% K_2O). Varieties used in the experiment are WGG-37 (green gram), PRG-158 (pigeon pea) and DRSH-1 (sunflower). Sowing was done during the first fortnight of July using healthy, well-filled, and matured seeds of pigeon pea, green gram, and sunflower at 15, 20, and 6 kg ha^{-1} seed rate. For pigeon pea, green gram, and sunflower, seeds were sown by hand dibbling @ two seeds $hill^{-1}$ at a depth of 3-5 cm, with 90 cm, 30 cm, and 60 cm between rows and 20 cm, 10 cm, and 30 cm between plants within the row, respectively. Thinning and gap filling were completed after 15 DAS, with one healthy seedling $hill^{-1}$ remaining. In conformity with organic standards, no chemical herbicides, insecticides, or fungicides were employed in the organically managed plots. Manual weeding was used once, followed by two hoeing using a manually driven wheel-hoe. As a preventative treatment, Azadirachtin *(Azadirachta indica* - based formulation) was applied against insect pests at 20-25 days intervals during crop growth. Crop-specific prescribed herbicides and pesticides were applied in the control plots to manage weeds, insect pests, and diseases. Recommended

Fig. 1. Satellite view of the experimental site (Downloaded from Google Earth)

Table 1. Application rates of organic manure and mineral fertilizers in different treatments

Treatments		Manure (t ha^{-1})	Chemical fertilizer (kg ha^{-1})			Rock phosphate (kg ha^{-1})
	Crops		N	P	K	
Organic	Green gram	6.0	0.0	0.0	0.0	167.0
	Pigeon pea	6.0	0.0	0.0	0.0	167.0
	Sunflower	18.0	0.0	0.0	0.0	0.0
Integrated	Green gram	1.5	15.0	50.0	0.0	0.0
	Pigeon pea	1.5	15.0	50.0	0.0	0.0
	Sunflower	4.5	45.0	60.0	30.0	0.0
Inorganic	Green gram	0.0	20.0	50.0	0.0	0.0
	Pigeon pea	0.0	20.0	50.0	0.0	0.0
	Sunflower	0.0	60.0	60.0	30.0	0.0

integrated pest management (IPM) modules were applied in the integrated management plots. Green gram was harvested first due to its short duration, followed by sunflower, and finally pigeon pea. Sunflower is harvested by cutting the heads after the green base of the head has become yellow and eventually brown while pigeon pea and green gram are harvested by picking the pods when they are brown and dried. The data on growth and yield attributes were recorded from randomly selected five plants in each plot and seed and haulm/stalk yield was recorded from plot and converted on a hectare basis. Data obtained were statistically analysed as mentioned by Gomez and Gomez [5].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

In green gram, application of organic treatment has recorded significantly highest plant height at harvest stage (41.6 cm) compared to rest of the treatments which was followed by integrated treatment (37.7 cm) and it was found be at par with control (37.1 cm). In pigeon pea under organic plots being on par with those under integrated plots (132.6 cm) recorded significantly higher plant height (137.6 cm) compared to control plots (127.1 cm). However, the integrated treatment was in turn at par with control. In sunflower, the application of organic source of nutrients results in a significantly highest plant height (152.3 cm) over control and which is statistically at par with integrated treatment (143.9 cm). Integrated treatment was also statistically at par with the control (138.8 cm).

Significantly highest plant height was recorded with organic source of nutrients compared to integrated and control. Organically treated crops outperformed all other treatments because of enhanced cell division, cell elongation, and chlorophyll content of leaves, which improves photosynthetic activity and consequently plant height. While the plants in control were short in statured owing to poor growth as compared to organic plants. The present results were in accordance with the findings of Mishra et al. [6], Mohbe et al. [7], Yadav et al. [8] and Muhsin et al. [9].

3.1.2 Number of branches

In green gram, the highest number of branches at harvest (8.9) were recorded with organic treatment and it was at par with integrated treatment (8.8) but significantly highest over control (8.6). However, integrated treatment was statistically on par with the control. At harvest pigeon pea under the organic source of nutrients (14.3) was on par with integrated source of nutrient (14.0) and significant over control (13.9). However, the integrated treatment were statistically at par with the control.

Increased number of branches in the organic treatment could be ascribed to the increased availability of nutrients due to enhanced microbial activity with the application of organic manures results in enhanced of cellular activity and cell division results in the greater number of branches. Similar results were documented by Mishra et al. [6], Rao et al. [10] and Muhsin et al. [9].

3.1.3 Dry matter accumulation (kg ha^{-1})

Highest dry matter accumulation at harvest in green gram was recorded in organic treatment (2,463 kg ha^{-1}) over control (2,201 kg ha^{-1}) but organic treatment was at par with integrated

treatment (2,343 kg ha^{-1}). With respect to pigeon pea, organic treatments was on par with integrated source of nutrients (4,572 kg ha^{-1}) and registered significantly the highest dry matter accumulation (4,843 kg ha^{-1}) as compared to control plots (4,327 kg ha^{-1}). However, the integrated treatment was statistically at par with control. Similarly in sunflower application organic source of nutrients resulted in significantly higher dry matter accumulation at harvest (4,666 kg ha^{-1}) over the control and which was statistically at par with integrated treatment (4,428 kg ha^{-1}). However, this integrated treatment was also statistically at par with the control (4,325 kg ha^{-1}).

Higher dry matter production in organic plots could be attributed to higher plant height and higher leaf area maintained throughout the crop phase resulting in enhanced assimilate synthesis, which finally led to higher dry matter production. The results are in close conformity with Daniel et al. [11], Ullasa et al. [12], Rao et al. [10] and Thiagarajan and Somasundaram [13].

3.2 Yield Attributes

3.2.1 Number of pods plant^{-1}

Greengram has recorded a significantly higher number of pods plant^{-1} in the plots with organic management (22.0), and it was on par with integrated managment (20.0). While the lowest number of pods were recorded with control (19.7). whereas, Pigeon pea under organic plots was recorded with significantly the highest number of pods plant^{-1} (36.3) compared to crops under integrated plots (33.4) which is statistically at par. However, this integrated treatment is at par with control (32.4).

This might be due to an adequate availability of nearly all plant essential plant nutrients, enhanced photosynthetic activity as well as the translocation and storage of photosynthates to sink. The results algin with with findings of Mishra et al. [6], Shariff et al. [14], Muhsin et al. [9] and Rao et al. [15].

3.2.2 Capitulum diameter (cm)

Data revealed that the capitulum diameter of sunflower did not vary significantly due to the different production systems applied. Among all the treatments, organic treatment recorded the highest capitulum diameter (15.1 cm) which is statistically at par with both integrated treatment (14.9 cm) and control (13.9 cm).

Higher capitulum diameter was recorded with the organic production system this is because organic manures are the store house of several macro and micronutrients that are released during the process of mineralization by stimulating the activity of microorganisms to make the plant nutrients readily available to crops therefore synthesis of more photosynthates may take place which might be resulted in better partitioning of photosynthates from source to sink and improved the yield attributes like capitulum diameter. This was supported by Chaithra and Sujith [16] and Muhsin [9].

3.2.3 Number of filled seeds pod^{-1}

There was no significant difference between the treatments. In green gram, among different treatments tried, a higher number of filled Seeds Pod^{-1} were resulting in the organic treatment (11.22), and it is on par with seed number resulted due application of both integrated treatment (11) and control (10.67). with respect to pigeon pea, higher number of filled seeds pod^{-1} was resulting with the organic (4.22), and it is on par with both integrated treatment (4.00) and control (3.89).

In sunflower, number of filled seeds head^{-1} differed significantly among different production systems. Crops under organic source of nutrients recorded higher number of filled seeds head^{-1} (630.3) compared to an integrated source of nutrients and control. However, integrated source of nutrients (583.3) was on par with the control (545.4).

The combined effect of improved growth parameters (plant height, leaf area and dry matter accumulation) through efficient metabolic activity, increased photosynthetic rate and a steady supply of photosynthates from source to sink might have led to the maximum expression of yield attributing characters. Similar results are found with Chaithra and Sujith [16] and Muhsin [9].

3.2.4 Test weight (g)

Application of different production systems on test weight among all three crops is found to be non-significant. The maximum test weight of green gram seeds was recorded in organic treatment (30.2 g) and it was at par with both integrated treatment (30 g) and control (29.6 g) while in pigeonpea the highest test weight was

Table 2. Effect of different production systems on Green gram, Pigeon pea and Sunflower growth at harvest

	Plant height (cm)			No. of branches		Dry matter accumulation (kg ha^{-1})		
Treatments	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Green gram**	**Pigeon pea**	**Sunflower**
Organic	41.6	149	152.3	8.9	14.3	2463	4843	4666
Integrated	37.7	142.9	143.9	8.6	14	2299	4572	4428
Control	37.1	138.7	138.8	8.3	13.9	2162	4327	4325
SEm±	1.1	3.3	3.9	0.2	0.4	97	130	110
CD (P=0.05)	3.1	9.9	11.6	0.6	1.1	292	389	329

Table 3. Effect of different production systems on yield attributes in Green gram, Pigeon pea and Sunflower

	Pods plant^{-1}		Capitulum diameter (cm)	Filled seeds pod^{-1} /head^{-1}			Test weight (g)		
Treatments	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**
Organic	22	36.3	15.5	11.22	4.2	630.3	30.2	81.6	44.6
Integrated	20	33.4	14.9	11	4	583.3	30	81	44.4
Control	19.7	32.4	13.8	10.67	3.9	545.4	29.6	80.6	43.9
SEm±	0.7	1.1	0.5	0.3	0.2	14.6	0.2	0.2	0.3
CD (P=0.05)	2.2	3.4	1.5	NS	NS	43.9	NS	NS	NS

recorded in organic treatment (81.6 g) and was on par with both integrated treatment (80 g) and control (80.6 g). on the other hand, in sunflower, the maximum test weight was recorded in organic treatment (44.6 g) which were statistically at par with both integrated treatment (44.4 g) and control (43.9 g).

3.3 Yield

3.3.1 Seed yield (kg ha^{-1})

Organic source of nutrient resulted in a significantly highest seed yield of green gram (673 kg ha^{-1}) over control and was at par with the integrated source of nutrient (661 kg ha^{-1}) and integrated treatment was statistically at par with control (630 kg ha^{-1}). Similarly, organic treatment resulted a significantly highest seed yield of Pigeon pea (383 kg ha^{-1}) compared to integrated treatment (358 kg ha^{-1}). However, which remains at par with integrated treatment. The lowest seed yield among the treatments was recorded in control (323 kg ha^{-1}). similarly in sunflower, significantly highest seed yield was recorded in organic treatment (944 kg ha^{-1}) over control (835 kg ha^{-1}) but comparable with that resulted seed yield of integrated treatment (920 kg ha^{-1}).

Higher seed yield in organic management might be attributed to the increased in the availability of practically all plant essential macro and micro nutrients coupled with high photosynthates produced under the effect of the organic nutrient source. Furthermore, high photosynthate translocation and accumulation improved yield characteristics, chlorophyll content and nitrate reductase activity, resulting in higher seed production. The similar results are found by Pradeep et al. [17], Chongre et al. [18], Makkar et al. [19] and Muhsin et al. [9].

3.3.2 Haulm/stalk yield (Kg ha^{-1})

Green gram under organic plots being on statistically par with those under integrated plots (1,879 kg ha^{-1}) recorded significantly higher haulm yield (1,908 kg ha^{-1}) compared to control (1,797 kg ha^{-1}). However, the integrated treatment is in turn at par with control. Pigeon pea under organic plots being on par with those under integrated plots (2,521 kg ha^{-1}) recorded significantly higher stalk yield (2,647 kg ha^{-1}) compare to crops under control (2,402 kg ha^{-1}). However, the crops under the integrated treatment will be statistically at par with the control. Among the different sources of nutrients tried, incorporation of organic treatment recorded the significantly higher stalk yield (2,484 kg ha^{-1}) in sunflower which was however statistically at par with the integrated source of nutrient (2,434 kg ha^{-1}) and the lowest stalk yield was recorded under control (2,216 kg ha^{-1}).

The higher haulm/stalk yield due to the application of organic treatment might be attributed to improved vegetative growth and greater dry matter production as a result of the availability of all plant nutrients and improved soil physical qualities. The present result was in accordance with the findings of Rekha et al. [20], Pradeep et al. [17] and Muhsin et al. [9].

3.3.3 Harvest index (%)

In green gram, among the different sources of nutrients tried, incorporation of organic treatment recorded the higher harvest index (26.1%) which is at par with both integrated source of nutrient (26.0%) and control (26.0%). Similarly, at pigeon pea, incorporation of organic treatment recorded a higher harvest index (12.6%) which is at par with both integrated source of nutrient (12.5%) and control (11.9%) and at sunflower, incorporation of organic treatment recorded the higher harvest index (27.6%) which were with integrated treatment (27.5%) and statistically at par with control (27.4%).

3.4 Economics

3.4.1 Gross returns (Rs. ha^{-1})

In green gram, application of an organic source of nutrients fetched the highest gross returns (51,160 Rs ha^{-1}) among all the treatments in comparison. The next best treatment was integrated treatment which resulted in gross returns of 50,088 Rs ha^{-1}. The lowest gross returns were recorded with control (47,750 Rs ha^{-1}). In pigeon pea application of an organic source of nutrients fetched significantly highest gross returns (26,818 Rs ha^{-1}) among all the treatment in comparison. The next best treatment was integrated treatment which resulted in gross returns of 25,159 Rs ha^{-1}. The lowest gross returns were recorded with control (22,772 Rs ha^{-1}). In sunflower application of an organic source of nutrients resulted the highest gross returns (58,137 Rs ha^{-1}) among all the treatment in comparison. The next best treatment was integrated treatment which resulted in gross returns of 56,635 Rs ha^{-1}. The lowest gross returns were recorded with control (51,389 Rs ha^{-1}).

Since the organic produce is grown purely under chemical free conditions, the quality of the produce will be excellent compared to integrated and inorganic produce. So, to compensate for the high cost of cultivation under organic due to high cost of FYM per kg of nutrient supply we would like add the premium price of 15% for green gram and pigeon pea organic produce and 30% for sunflower organic produce and sold at a fixed premium price. Therefore, the gross returns of organically produced green gram were increased by 15% and results in the gross returns of 58,546 Rs ha^{-1} compared to normal gross returns of 51,160 Rs ha^{-1}. Similarly, in pigeon pea and sunflower gross returns had increased to 30,443 and 75,210 ₹ ha^{-1} respectively.

3.4.2 Net returns (Rs ha^{-1})

Among the treatments, the application of an integrated source of nutrients registered the highest net returns (26,614 Rs ha^{-1}) followed by inorganic source of nutrients (control) which gained a net return of 26,135 Rs ha^{-1}. The lowest net returns were noticed in the treatment where an organic source of nutrients was applied (25,075 Rs ha^{-1}). Among the different treatments in pigeon pea, the application of integrated source of nutrient registered the highest net returns (1,885 Rs ha^{-1}) followed, by the inorganic source of nutrients (control) which gained a net return of 1,357 Rs ha^{-1}. The lowest net returns were noticed in the treatment where an organic source of nutrients applied (933 Rs ha^{-1}). Among the different treatments in sunflower, application of integrated source of nutrients registered the highest net returns (30,789 Rs ha^{-1}) followed by inorganic source of nutrients (control) which gained a net return of 30,403 Rs ha^{-1}. The lowest net returns were noticed in the treatment where organic source of nutrients were applied (22,502 Rs ha^{-1}). Similar results are found by Arbad and Sayad [21], Choudhary et al. [22] and Verma et al. [23].

Organically produced green gram which is sold at 15% premium price will have net returns of 32,411 Rs ha^{-1} compared to normal gross returns of 25,075 Rs ha^{-1}. Similarly, pigeonpea and sunflower net returns had increased to 4,506 and 39,543 Rs ha^{-1} respectively.

3.4.3 Benefit cost (B:C) ratio

In green gram, higher B: C was recorded with the control plots (2.21) followed by integrated plots (2.13). Whereas, lower B: C ratio was recorded with organic plots (1.96). In pigeon pea, higher B: C was recorded with the integrated plots (1.08) followed by control plots (1.06). Whereas, lower B: C ratio was recorded with organic plots (1.04). In sunflower, higher B: C was recorded with the control plots (2.45) which was followed by integrated plots (2.19). Whereas, lower B: C ratio was recorded with organic plots (1.63).

Organically produced green gram which sold at 15% premium price, B: C ratio were increased to 2.24 compared to normally sold pigeonpea which is having 1.96 B: C ratio. Similarly, pigeon pea and sunflower have B: C ratio of 1.18 and 2.11 respectively. This was supported by Meena and Sharma [24], Verma et al. [23] and Somalraju et al. [25].

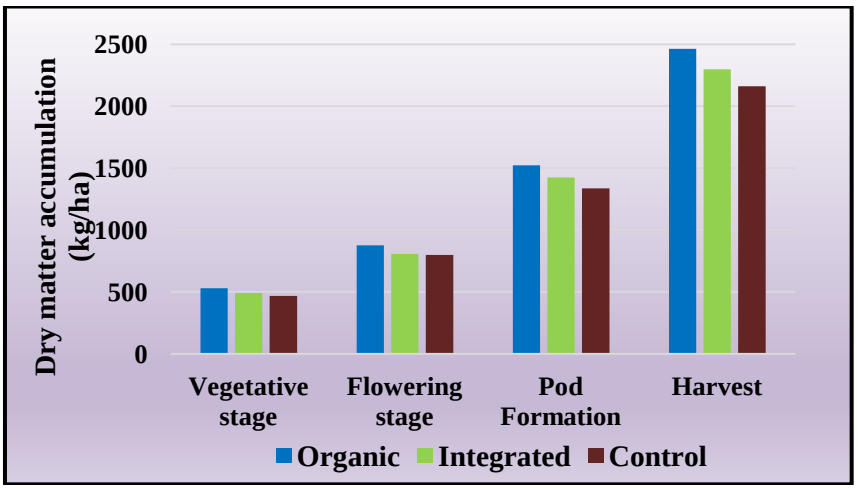

Fig. 2. Dry matter accumulation (kg ha^{-1}) of green gram as influenced by different production systems

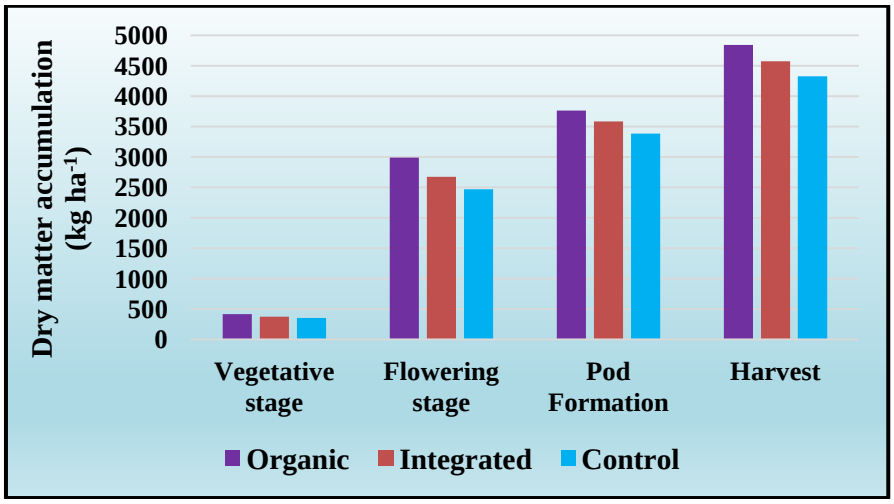

Fig. 3. Dry matter accumulation (kg ha^{-1}) of pigeonpea as influenced by different production systems

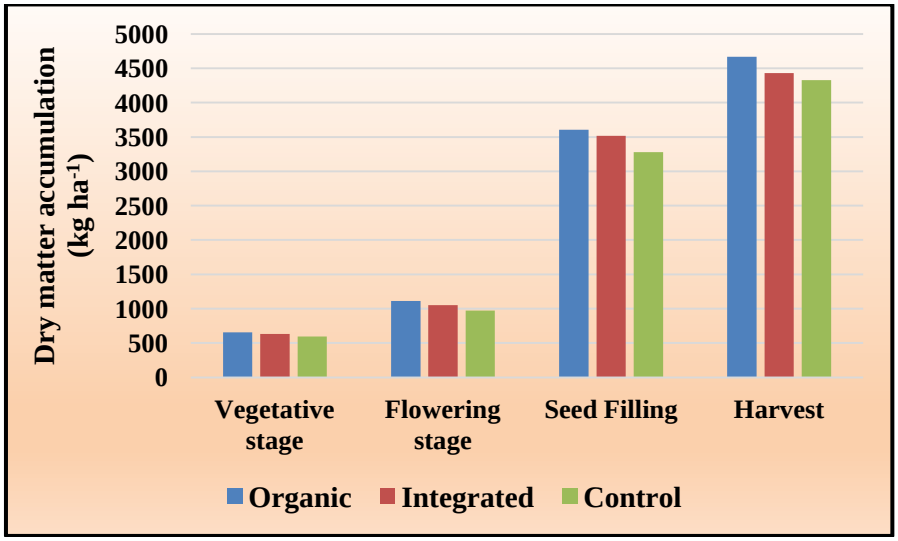

Fig. 4. Dry matter accumulation (kg ha^{-1}) of sunflower as influenced by different production systems

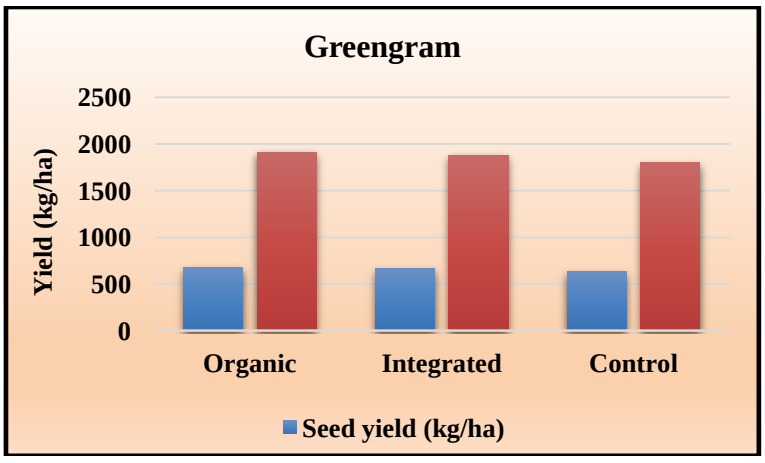

Fig. 5. Yield (kg ha^{-1}) of green gram as influenced by different production systems

Table 4. Effect of different production systems on yield in Green gram, Pigeon pea and Sunflower

	Seed yield (kg ha^{-1})			Haulm/Stalk yield (kg ha^{-1})			Harvest index (%)		
Treatments	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**
Organic	673	383	944	1908	2647	2484	26.1	12.6	27.6
Integrated	661	358	920	1879	2521	2434	26	12.5	27.5
Control	630	323	835	1797	2402	2216	26	11.9	27.4
SEm±	14	9	25	36	61	65	0.5	0.3	0.8
CD (P=0.05)	42	29	74	108	184	196	NS	NS	NS

Table 5. Effect of different production systems on economics in Green gram, Pigeon pea and Sunflower

	Cost of cultivation (₹ ha^{-1})			Gross returns (₹ ha^{-1})			Net returns (₹ ha^{-1})			Benefit Cost ratio		
Treatments	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**
Organic	26085	25885	35635	51160	26818	58137	25075	933	22502	1.96	1.04	1.63
Integrated	23474	23274	25846	50088	25159	56635	26614	1885	30789	2.13	1.08	2.19
Control	21615	21415	20986	47750	22772	51389	26135	1357	30403	2.21	1.06	2.45

Table 6. Effect of different production systems on economics in Green gram, Pigeon pea and Sunflower when sold at premium for organic product

	Cost of cultivation (₹ ha^{-1})			Gross returns (₹ ha^{-1})			Net returns (₹ ha^{-1})			Benefit Cost ratio		
Treatments	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**	**Green gram**	**Pigeon pea**	**Sunflower**
Organic	26085	25885	35635	58546	30443	75210	32411	4506	39543	2.24	1.18	2.11
Integrated	23474	23274	25846	50088	25159	56635	26614	1885	30789	2.13	1.08	2.19
Control	21615	21415	20986	47750	22772	51389	26135	1357	30403	2.21	1.06	2.45

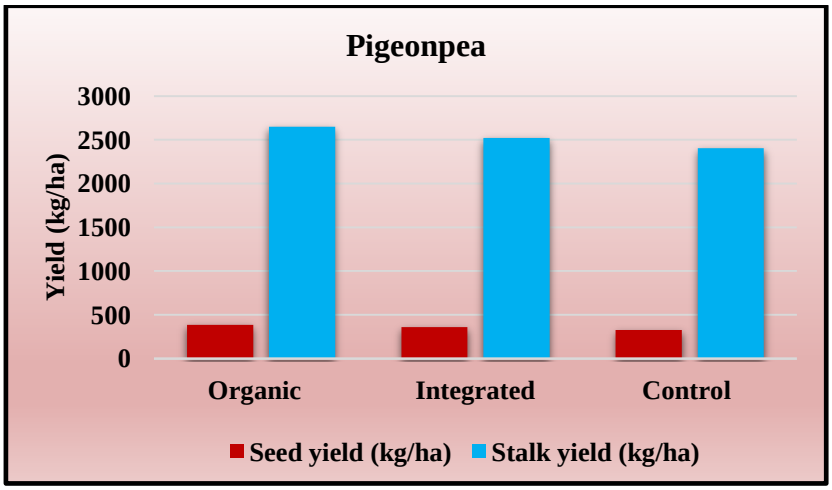

Fig. 6. Yield (kg ha^{-1}) of pigeonpea as influenced by different production systems

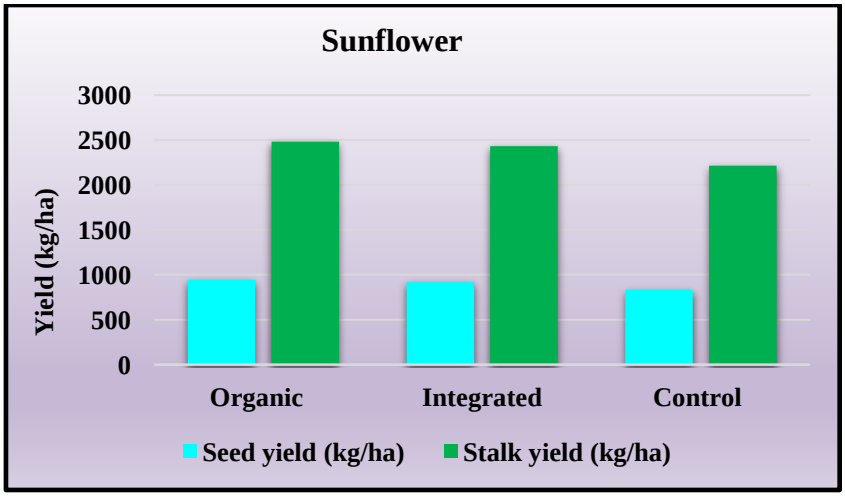

Fig. 7. Yield (kg ha^{-1}) of sunflower as influenced by different production systems

4. CONCLUSION

Climate change is affecting us severely all over the world and farming is one of the main victims. There is a need to find a solution on which scientists are working relentlessly. Organic farming could be one of the best possible solutions to minimize the impact of climate change on farming. There has been an increased awareness about organic farming in our country which has resulted in enhancement in area under organic farming. Pulses and oilseeds could be cultivated under organic management practices to fetch better prices which ultimately benefits the farmers. From the results of the present experiment, it is concluded that green gram, pigeon pea and sunflower crops under organic farming have performed well in terms of growth, productivity and economics as compared to integrated as well as inorganic farming.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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