INTEGRATED NUTRIENT MANAGEMENT IN RAINFED SUNFLOWER (*Helianthus annuus* L.) AND PIGEONPEA (*Cajanus cajan* (L.) Mill sp.) INTERCROPPING SYSTEM

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BY

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CERTIFICATE

This is to certify that the thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT IN RAINFED SUNFLOWER (*Helianthus annuus* L.) AND PIGEONPEA (*Cajanus cajan* (L.) Mill sp.) INTERCROPPING SYSTEM"** submitted by **Mr. U.K. SHANWAD** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY** of University of Agricultural Sciences, Dharwad, is a record of bonafide research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

DHAR WAD
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INTRODUCTION

I. INTRODUCTION

The greatest challenge of the 21st century in many developing countries is to produce the basic necessities food, fodder, fuel and fibre for human consumption and rearing of domestic animals from the limited available land. Nearly 90 per cent of food requirements will have to come from land based farming. But the availability of land for agriculture is shrinking every day as it is occupied for non-agricultural purpose. Under this situation, the additional food production would become possible through intensive cropping programme. Intensive farming which makes greater demands for plant nutrients and soil fertility should be maintained at a reasonably high level to sustain farming as a profitable endeavour. This would be possible only through judicious use of organic manures along with reduced level of chemical fertilizers.

At present situation with intensive farming involving promising hybrids and varieties, demands for chemical fertilizers has been increased. Due to energy crisis, prohibitive costs of fertilizers and poor purchasing power of marginal and small farmers, it is very difficult to meet the demand of plant nutrients through chemical fertilizers alone. It is also felt that there is degradation in soil physical and chemical properties with continuous use of chemical fertilizers and intensive cultivation. Use of organic manures along with optimum rate of

fertilizer application is essential under rainfed agriculture for sustained production. Addition of nutrients in the form of fertilizer will accelerate the decomposition rate of organic sources. Response of crop to plant nutrients like nitrogen, phosphorus and potassium can be increased by the application of organic sources along with chemical fertilizer and thus the yields of crops are improved (Hegde, 1998).

In India next to food grains, oilseeds and pulses are considered as major agricultural crops. India stands first in the world in area and production of both oilseeds and pulses. Annually, we need 38 kg and 20 kg of pulses and edible oil respectively on per capita consumption, but at present, we are able to supply only 14 and 6.5 kg pulses and edible oil per capita per annum. In order to alleviate the shortage, India is importing edible oil every year. The shortage of pulses and oilseeds has aggravated the problem of malnutrition. Thus, there is an urgent need to increase the production of both oilseeds and pulses to meet the requirements by manipulating the production practices appropriately. The production of oilseeds and pulses can be increased mainly through two ways, that is (1) by increasing area under these crops and (2) by increasing the production per unit area (Hegde and Kiresur, 1999).

The first one can be achieved only by substituting area under food crops by oilseeds and pulse crops as the total area available is generally constant. But the area under oilseeds

and pulses does not seem to expand as there is equally ubiquitous demand for other crops and commodities. The solution therefore, lies in the second option, that is in boosting the productivity of these crops in the existing area. The area increase *per se* can be achieved without affecting the food production through many ways and intercropping or mixed cropping is the most important among them.

The main concept of intercropping is to get increased total productivity per unit land area and time and also judicious and equitable utilisation of land resources and farming inputs including labour, not to mention of insurance against failure of one or other crops. One of the main reasons for intercropping advantage is that, in intercropping, component crops are able to use growth resources differently, so that when grown together, they complement each other and make better use of growth resources than when grown separately (Willey, 1979). A careful selection of crops can reduce mutual competition to a considerable extent. The classic example of temporal effect is when fast growing early maturing crop is grown with a slow growing, late maturing one. The demands of the two crops complement each other in time. Spatial effects can also be important. The growth rhythm, duration and capacity to photosynthesize at low light intensities are some of the important considerations in selection of component crops. As such, in intercropping system, combined leaf canopy may make better use of nutrients and water (Virupakshappa and Kiresur, 1997).

Among the seven oilseed crops grown in Karnataka, sunflower occupies the second place in area and production next only to groundnut. In Karnataka, sunflower is grown over an area of 11.08 lakh ha with a production of 4.12 lakh tonnes (Hegde and Kiresur, 1999). In transitional tract sunflower is grown as entire crop in *kharif* season under rainfed condition. In transitional tract, the rainfall of about 800 mm is well distributed during both *kharif* and *rabi* season and there is no dirth of moisture for crop covering from June to October - November . Hence, there is a possibility of taking a compatible intercrop with diversity in growth habit and duration. Pigeonpea occupying maximum area under pulses in Karnataka (4.95 lakh ha) is one of such crops. Sunflower and pigeonpea are the plants of contrasting growth habits both morphologically and physiologically . Pigeonpea is being long duration and deep rooted crop fits well between short duration and shallow rooted crops like sunflower . Besides, growth of pigeonpea is very slow in the early stages of growth, during which the more rapidly growing intercrops dominates and utilize the early resources efficiently . Pigeonpea picks-up growth is increased with profuse branching only after the harvest of associated short duration intercrops and yields substantial quantity of seeds. Marginal and small farmers cannot afford to invest more on fertilizers due to high fertilizer cost. Hence, there is a need to develop low cost input technology to get higher production from intensive cropping apart from maintaining soil fertility .

In view of the existing situation, the present investigation was carried out at Agricultural College Farm, Dharwad during *kharif* season of 1998-99 with the following objectives.

1. To study the effects of organic manures and inorganic fertilizers on growth and yield of sunflower and pigeonpea crops.

2. To know the effect of organic manures and intercrops on soil fertility and

3. To determine a suitable combination of organic and inorganic nutrient management for sunflower - pigeonpea intercropping system.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

It is imperative to make use of the organics along with inorganic manures to maintain soil fertility and get sustained yields. The review of literature pertaining to intercropping systems, the effect of organic and inorganic sources of nutrient on growth and yield components, yield, change in soil physical and chemical properties and economics are presented in this chapter.

2.1 Intercropping systems

Intercropping is an age old practice of growing simultaneously two or more crops in the same piece of land. Intercropping has been a regular practice followed by farmers of India, Africa, Sri-Lanka and West Indies (Ayyangar and Ayyer, 1942). Intercropping is mainly practiced to cover the risk of failure of one of the component crops due to vagaries of weather or pest and disease incidence (Ayyangar and Ayyer, 1942 and Singh and Katyal, 1966).

Intercropping may also lead to increase in production per unit area per unit time without affecting the production of main crop to a great extent. When legumes are used as intercrops, they provide beneficial effect on soil fertility by fixing atmospheric nitrogen. Best utilisation of nutrients, moisture, space and solar energy can be derived through

mixed/ intercropping system of cultivation (Ayyer, 1963; Donald, 1963 and Francis and Heichel, 1973).

Yield advantages in intercropping system is mainly because of differential use of growth resources by the component crops. The main way for complimentarity to occur is when the growth pattern of component crops differ in time. The yield advantages in intercropping system are associated with a fuller use of environmental resources over time (Willey *et al.*, 1986).

Pujari *et al.* (1996) reported that pigeonpea was intercropped with maize, sunflower, *Hibiscus cannabinus*, sesame and blackgram in a 1:2 or 1:3 row proportion and found that pigeonpea yields were higher in a 1:2 row proportion.

2.2 Crop competition and biological basis for intercropping advantages

2.2.1 Resource use

Donald (1963) opined that intercropping system involves growing together two or more crop species with the assumption that they could exploit the environmental resources better than one crop. If the two species grown together are mutually beneficial then there is a co-operation. On the contrary, competition results when they tend to be mutually harmful and this competition is mainly for water, light and nutrients. The relationships for co-operation and competition are density

dependent. At low densities there is a co-operation and finally active competition comes into play as the density increases.

Willey and Natarajan (1978) observed that, component crops in a sorghum/ pigeonpea intercropping system are in some way able to use resources rather differently, so that, when grown together they complement each other and make better use of resources than when grown separately.

2.2.2 Spatial complementarity

In addition to temporal complementarity between component crops, spatial complementarity may also be possible. It is often suggested that a combined leaf canopy may make better spatial use of light or a combined root system may make better spatial use of nutrients and water in general.

2.2.2.1 Light interception

Willey and Roberts (1976) emphasised that, light was the most important factor when better temporal use of resources was achieved due to the better distribution of leaf area over time. Yield advantage of more than 20 per cent was achieved in sunflower and radish intercropping but peak light interception values were not higher than those of the sole crops (Lakhani, 1976).

At ICRISAT, measurement of light interception showed that intercropping did not intercept more light energy than

sole cropping, but this energy was more efficiently converted into dry matter (Reddy *et al.*, 1980).

Shinde *et al.* (1996) reported that, sunflower and groundnut intercropping system harvested more LUE than the sole groundnut crop.

At Pune, mean Intercepted PAR was highest in sole sunflower and lowest in sole pigeonpea upto around 80 days after sowing. After sunflower harvest, sole pigeonpea intercepted more PAR than the inter-cropping treatments (Lakudzode *et al.*, 1998).

2.2.2.2 Nutrients and water

Competition presumably may occur for any nutrient added for plant growth. In a situation where there is finite supply of readily available nutrient, the competitive success of any plant is governed by number of individuals drawing on the supply and by the relative rates at which they taken up the nutrients. An alternate situation is one in which a nutrient is present in a range of physical and chemical forms and the competitive ability of different species may be determined by their capacity to make use of the forms (Donald, 1963).

Slatyer (1955) reported that, the success of any species in competition for water will depend on the rate and competitiveness with which it can make use of soil moisture

supply. Better water use was probably a common cause of yield advantages in semi-arid tropical area because this was basically the most limiting resource (Baker and Norman, 1975).

2.3 Economic returns

Economic returns obtained from the systems viz., intercropping or sole cropping depends mainly on the component crops, their yield and the price prevailing during the period when the study was undertaken.

Singh and Singh (1977) reported that, intercropping of sunflower and cowpea gave the highest additional monetary returns (Rs. 703/ha) followed by sunflower + greengram (Rs. 489/ha) and sunflower + groundnut (Rs. 473/ha) intercropping.

Umrani *et al.* (1987) realised the highest monetary returns (Rs. 9,270/ha) under intercropping of sunflower and pigeonpea in 2:1 row proportion at 45 cm when compared to other intercropping treatments.

Intercropping of pigeonpea and sunflower in 2:1 row proportion with 67:33 per cent recommended plant populations of pigeonpea and sunflower recorded the highest additional net income (Rs. 2210/ha) over sole crop of sunflower and Rs. 873 per ha over sole crop of pigeonpea (Biradar *et al.*, 1988).

Subbareddy and Venkateshwaralu (1988) found that, intercropping of sunflower and pigeonpea in 2:1 row proportion gave the highest gross returns (Rs. 5308/ha) when compared to

other treatment combinations and sole crops of sunflower and pigeonpea.

Intercropping of pigeonpea and sunflower in 1:1 row proportion with 45 x 20 cm spacing recorded highest B:C ratio at Bangalore and Hiriyur and intercropping of sunflower + pigeonpea in 1:1 row at 45 x 20 cm spacing registered higher LTR of 1.37 and 1.67 at Bangalore and Hiriyur, respectively followed by intercropping at 30 x 20 cm in 1:1 row proportions (Balakrishna *et al.*, 1994).

Kulmi (1996) reported that, intercropping of wheat and sunflower in 4:1 row ratio was more productive and remunerative, which recorded 9.1 per cent higher wheat-equivalent yield, 9.0 per cent higher productive efficiency, 11.8 per cent higher net returns, 51.3 per cent higher net returns/Re. investment with the higher monetary advantage and the highest land equivalent ratio than the other treatment combinations.

2.4 Combined use of organic and inorganic sources of nutrients on growth and yield

Intensive agriculture with very high nutrient turnover in soil plant system coupled with low and imbalanced fertilizer use results in deterioration of native soil fertility and poses a serious threat to long term sustainability of crop production. Long term studies in many cropping systems have clearly indicated that neither chemical fertilizers nor organic sources of nutrient could sustain high productivity of intensive

cropping systems. Nevertheless, integrated use of fertilizers and organic sources has helped in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing the efficiency of applied nutrients and providing favourable soil physical environment.

Satyanarayana Rao (1987) studied at Bijapur (Karnataka), he did not find any significant difference in plant height of sunflower due to combined use of organic and inorganic source of nutrients. Similar results were reported by Bellakki (1991) and Patel *et al.* (1992). Niranjan and Arya (1992) studied an effect of organic and inorganic sources on groundnut yield at Jhansi, during *kharif* and *rabi* in sandy loam soil, reported that 100 per cent RDF significantly increased the plant height followed by 50 per cent RDF plus six per cent FYM/ha.

Goudreddy *et al.* (1989) recorded application of farm yard manure at the rate of 5 t/ha increased the grain number per ear, grain weight per ear, 1000 grain weight of *rabi* sorghum on medium black soils of Dharwad. Patel *et al.* (1992) did not find significant difference in panical length, spikelet per ear, grain per panicle, 1000-grain weight of wheat, due to use of inorganic fertilizer alone or incombination with organic fertilizer in loamy sand soil of Sardar Krishinagar during winter season. Incorporation of wider C:N ratio materials with inorganic fertilizers were found beneficial over inorganic fertilizer application alone. Lakshminarasimhan *et al.* (1973)

observed 28 per cent increase in rainfed maize grain yield over that of NPK fertilizer alone.

Verma *et al.* (1981) in rainfed conditions of Rajasthan on clay loam soil noticed the significant increase in grain and stalk yield of sorghum in sorghum - pigeonpea intercropping system with RDF (1856, 3854 kg/ha) over 5 t/ha FYM application (549, 2263 kg/ha). Further, they noticed no significant differences in yield of FYM plus RDF over RDF alone.

Helkaih *et al.* (1981) worked at Coimbatore reported that, combined application of organic sources with inorganic fertilizers increased the grain and stover yield of sorghum significantly over control or inorganic fertilizer alone. Singh and Brar (1985) studied the effect of organic manures and nitrogen on grain yield in a maize-wheat rotation on loamy sand at Ludhiana and obtained significantly increased grain yield with the incorporation of 20 tonnes per hectare of cowpea as a green manure (35 q/ha) over FYM application of 20 tonnes/ha (30.2 q/ha). However, the yield obtained with cowpea as a green manure was equal to that obtained at 120 kg N per ha fertilizer application (32.7 q/ha).

Sharma *et al.* (1988) conducted experiment on alluvial soil of Jalandhar with FYM and green manure dhiancha and reported that these treatments increased yield of potato tubers by 55 and 51 q/ha in the absence of nitrogen, which was equivalent to 38 and 35 kg N/ha. Both organic manures increased the wheat yield. The increase in wheat yield was

equivalent to residual effect of 80 kg N/ha of fertilizer applied to potato.

Results obtained with organic and inorganic source of nutrients in vertisols of Bijapur (Karnataka) under dryland condition showed that application of 50 per cent organic source plus 50 per cent inorganic source helped not only increase the yield of sorghum and safflower but also improved the soil physical and chemical properties (Anon., 1989).

Goudreddy *et al.* (1989) studied the response of *rabi* sorghum to nitrogen and farmyard manure on a medium black soil at Dharwad and found that application of 60 and 120 kg N/ha produced the higher grain yield of 57 q/ha (32.80%) and 64 q/ha (48.70%) respectively compared to no nitrogen application (44 q/ha). Application of FYM at 5 t/ha significantly increased the grain yield. The increase in yield due to FYM application was to the tune of 9.8 per cent over control.

Minhas and Anilsood (1994), the field study conducted on acid alfisol at Palampur, noticed, significant increase in crop yields of potato and maize with the increase in farmyard manure application along with the chemical fertilizers. Reddy *et al.* (1996) reported that in a intercropping system of sunflower and groundnut, sunflower yields decreased by decreasing the NPK rates to the sunflower crop.

To assess the feasibility of uniform planting of pigeonpea intercropped with greengram, under varying levels of fertility at Bijapur (Karnataka), recommended fertilization (30 kg N/ha + 60 kg P_2O_5/ha for pigeonpea and 20 kg N/ha + 40 kg P_2O_5/ha for greengram) seperately drilled gave higher grain yield (15.44 q/ha pigeonpea + 8.30 q/ha greengram) than either sole pigeonpea (16.84 q/ha) or greengram (8.92 q/ha) or rest of the intercropping treatments followed (Rajput *et al.*, 1995).

Gupta and Rathore (1995) reported from Arjia (Rajasthan) that, application of full recommended dose of fertilizer to both the component crops in pigeonpea + sesame intercropping system significantly increased the growth attributes (plant height and dry matter production/plant), yield attributes (number of pods/plant, number of seeds/plant and seed yield/plant) seed and stover yields of both the component crops and number of branches/plant and 1000 seed weight of pigeonpea (main crop) over all other lower doses of fertilizer applied.

Singh and Jagadev Singh (1998) opined that, application of farmyard manure (FYM) @ five and ten tonnes per ha significantly increased the growth, yield attributes and yield of sunflower over no FYM and Azotobactor inoculation. There was 10 and 16 per cent yield increase with five and ten tonnes per ha of FYM respectively over no FYM. Increasing levels of N and P significantly increased plant height, yield attributes and

seed yield upto 80 kg N and 40 kg P_2O_5/ha and leaf area, dry matter and stalk yield upto 120 kg N and 60 kg P_2O_5/ha increase in seed yield over the control was 36.7 and 58.7 per cent with 40 and 20 kg and 80 and 40 kg N and P_2O_5/ha respectively.

Ujjinaiah *et al.* (1994) reported that, application of organic manure exhibited a significant influence on the sunflower yield with increase in the dose of FYM there was a significant increase in the yield of sunflower crop upto 10 tonnes FYM per ha; beyond which the enhancement was not discernible. The response could be attributed to the enhanced growth interms of plant height, stem diameter which reflected in substantial increase in head diameter. The 100 seed weight and oil content were not significantly altered by the different doses of FYM.

2.5 Influence of organic and inorganic sources on soil properties

Use of organic sources as a source of plant nutrient is essential to supply balanced nutrients to the plants and return at least a part of the nutrients drawn from the soil. Due to prohibitive costs of fertilizers, the organic sources play an important role in increasing the crop yield and improving soil physical properties. Different kinds of materials such as FYM, vermicompost, poultry manure and crop residues are used to substitute part of fertilizers in order to increase and sustain the yields of crops.

2.5.1 Soil physical properties

The physical properties of soils are more important in determining how best soils can be used. They range from properties that determine a soils suitability for the production of different crop plants.

It is well known fact that organic materials which are more resistant to decomposition have a more long- lasting effect on soil aggregation (Martin and Waksman, 1940). Kanwar and Prihar (1962a) noticed the beneficial effect on the formation of large size aggregates in silt loam soils, when fertilizers supplied in balanced proportion, singly or in combination with organic manures.

Ilavanagi and Mann (1970) observed more number of waterstable aggregates with the incorporation of green manure (sunhemp) and farmyard manure over control in black soil at IARI, New Delhi. Subramanian *et al.* (1975) on sandy loam soil at Coimbatore, under irrigated condition noticed significant effect on formation of soil aggregates by mere incorporation of maize stalks and farmyard manure than fertilizer alone.

Incorporation of organic sources, decrease the bulk density, increase the water holding capacity and air porosity which found to improve soil-water relationship.

Biswas *et al.* (1964) in an alluvial sandy loam soil at Bhubaneshwar noticed highest bulk density in plots where

chemical fertilizer applied alone. Wherein the plots receiving organic matter in the form of farmyard manure, rapeseed cake and green manure in combination with superphosphate were having lower bulk density.

Ganal and Singh (1988) observed significant decrease in bulk density with farmyard manure application over control. Badanur *et al.* (1990) noticed significant reduction in bulk density in vertisols when sorghum and safflower crop residues were incorporated into the soil at the rate of 5 t/ha. Sarkar and Rathod (1992) reported that bulk density value decreased by 1.42 per cent due to incorporation of crop residue over control.

Havanagi and Mann (1970) reported that no appreciable variation in the maximum water holding capacity due to incorporation of green manure or farmyard manure over control. Lavti (1990) observed the higher percentage of water holding capacity in Alfisols of Udaipur due to incorporation of organic materials, like farmyard manure, rice straw, groundnut shell, wheat straw over control. Aziz Quereshi (1991) noticed maximum water holding capacity of soil with redgram incorporated in black soils.

Sharma *et al.* (1987) also noticed increased cumulative infiltration of water, when farmyard manure and plant residues incorporated into soils. The highest cumulative infiltration of water recorded with farmyard manure treated plot (Ganal and Singh, 1988).

2.5.2 Chemical properties

Incorporation of organic sources, profoundly influences many chemical properties of soil. Soil reaction is one of the important factors influencing the nutrient availability.

Singh and Singh (1974) observed reduction in soil pH with the incorporation of sunhemp and farmyard manure when compared to control. Pandey *et al.* (1985) reported decrease in pH with incorporation of organic residues over fertilizer application in sandy loam soil.

Sureshlal and Mathur (1988) studied the effect of long term manuring and fertilization on physico-chemical properties of acidic red loam at Ranchi. They noticed increase in soil pH due to combined application of manures and fertilizers. Bharambe *et al.* (1990) noticed reduced pH when paddy straw, saw dust and farmyard manure incorporated in the soil.

Das *et al.* (1991) reported that addition of manures (farmyard manure, poultry manure and pig manure) increased the pH of soil at 12 days of incubation and declined thereafter. The reduction of pH was much pronounced in case of low organic matter status soil treated with higher dose of either poultry manure or pig manure at 36 days of incubation in acid alfisols.

Patiram and Singh (1993) noticed increased soil pH of acid soils, due to continuous application of manure. More

(1994) observed that application of farmyard manure, wheat straw and dried biogas slurry decreased the pH of sodic vertisols at Parbhani.

Organic carbon content of soil changed rapidly with addition of crop residues or organic manures Immobilization and mineralization of nutrients are two important processes that take place simulteneously in the soil on addition of organic residues. Kanwar and Prihar (1962b) observed that both organic manure and fertilizer application had increased organic carbon content of the soil. Helkaih *et al.* (1981) found that application of compost significantly increased (0.49%) organic carbon over control (0.32%) in black soils.

Sharma *et al.* (1984) in sandy loam soils at Ludhiana observed decline in organic carbon from 0.25 to 0.19 per cent after 10 years in control plot with maize - wheat sequence irrespective of phosphorus and potassium application. Organic carbon was significantly higher in plot where farmyard manure was applied.

Singh and Brar (1985) at Ludhiana noticed significant increase in organic carbon percentage after four years of farmyard manure and green manure application. Sharma *et al.* (1987) found that application of farmyard manure during both the crop seasons significantly increased, the organic carbon content of the soil over control. There had been a build up of organic carbon from the initial value with the application of organic wastes (Srivastav *et al.*, 1988 and Singh and Brar,

1985) noticed significant increase in the available nitrogen content of the soils after four years of farmyard manure and green manure application.

Chellamuthu *et al.* (1988) at Coimbatore observed that the total nitrogen increased by the increased application of nitrogen either as farmyard manure or as ammonium sulphate.

Udayasoorian *et al.* (1989) studied continuous addition of organic matter on chemical properties of alfisols. They found that addition of farmyard manure @ 25 t/ha per crop increased all the fractions of nitrogen in both surface and subsurface soils.

Somani and Sexana (1975) on clay loam soils observed the increased phosphorus with wheat crop residue and farmyard manure, while inorganic fertilizers were alone decreased when compared with initial content. Satyanarayana Rao (1987) recorded increase in available phosphorus content of the soil at the harvest due to incorporation of subabul, farm yard manure and recommended dose of fertilizer when compared with control in black soils of Bijapur (Karnataka). Bhriguvanshi (1988) reported that continuous application of farmyard manure increased the available phosphorus content.

Das *et al.* (1991) found increase in available phosphorus status of alfisol with application of organic manure after 12 days of incubation, which drastically decreased afterwards. Patiram and Singh (1993) noticed that continuous application of

farmyard manure increased the available phosphorus content of the soil.

Pandey *et al.* (1985) reported that application of fly ash considerably improved the available potassium status of the sandy loam soil at Kanpur , during *kharif* season. Chellamuthu *et al.* (1988) noticed increased available potassium status of soil when farmyard manure was incorporated in to the soil.

Lavanya and Manickam (1991) reported that 100 per cent NPK fertilizer along with organic materials resulted in higher availability of potassium. More (1994) noticed higher amount of available potassium where farmyard manure, wheat straw , press mud and biogas slurry incorporated into the sodic vertisols at Parbhani.

Somalkar *et al.* (1997) noticed that addition of 18.5 tonnes farmyard manure per ha once in two years along with 50 kg nitrogen per hectare to cotton and 50 kg nitrogen and 25 kg potassium per ha to sorghum has been found to favourably influence the available nitrogen, phosphorus and potassium content of the soil in cotton-sorghum rotation in vertisols at Nagpur .

Jagadev Singh *et al.* (1998) reported from Hisar , that application of farmyard manure 10 t/ha significantly improved the nitrogen and phosphorus contents in seed and stalk of sunflower in both the years (1992-93) and potassium content in the second year only.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

A field experiment was conducted at Main Research Station, Dharwad (Karnataka) in vertisols during *kharif* season of 1998-99, to study the effect of integrated nutrient management in sunflower - pigeonpea intercropping system. The material used and techniques adopted during the course of investigation are described in this chapter.

3.1 Experimental site

The experiment was conducted at the Agricultural College Farm, Dharwad, in Plot No. 152 of "F" block during *kharif* season, 1998-99.

3.2 Soil and its characteristics

The experiment was laid out in vertisol. A composite soil sample was collected from 0 to 30 cm depth in experimental plot before sowing and analysed for physical and chemical characteristics. The results of soil analysis along with methods followed are furnished in Table 1.

3.3 Climatic conditions

The Agricultural College Farm, Dharwad is situated in the transitional tract of Karnataka state on 15°26' N latitude, 75°07' E longitude and has an altitude of 678 meters above the mean sea level. The Agricultural College Farm is situated in the central transitional tract of Karnataka state and receives a

Table 1. Physical and chemical characteristics of the soil in the experimental site

Particulars	Values obtained	Method adopted
I. Physical properties		
i. Mechanical analysis		International Pippette Method (Piper, 1966)
Coarse sand (%)	5.46	
Fine sand (%)	14.12	
Silt (%)	29.20	
Clay (%)	51.22	
ii. B.D. (g/cc)	1.35	Core Sampler method (Dastane, 1961)
II. Chemical properties		
Organic carbon (%)	0.61	Walkley's and Black's method (Jackson, 1967)
Soil pH (1:2.5)	7.70	Jackson, 1967
Electrical conductivity (dS/m)	0.28	Electrical conductivity bridge
Available nitrogen (kg/ha)	150.50	Subbaiah and Asija (1956)
Available phosphorus (kg/ha)	29.16	Olson's Method (Jackson, 1967)
Available potassium (kg/ha)	312.80	Jackson, 1967

fairly well distributed mean annual rainfall of 790.2 mm. April and May are the months of maximum temperature ranging from 35.8°C to 38.3°C . December and January are the months of minimum temperature ranging from 27.5°C to 30.5°C . The relative humidity fluctuates between 58 to 93 per cent. The meteorological data for the year 1998-99 and the mean of 48 years recorded at the meteorological observatory , Agricultural College Farm, Dharwad, are presented in Table 2.

The rainfall during the cropping period (July 1998 to January 1999) of the experiment was 486.6 mm which was higher than the average rainfall for the past 40 years. The maximum and minimum temperature during the cropping period were 30.17°C and 27.05°C in the month of October 1998 and July 1998 respectively . The distribution of rainfall, maximum and minimum temperature in different months are shown in Fig. 1.

3.4 Previous crop in the experimental plot

General crop of maize was taken during *kharif* season of 1997-98 and kept fallow during *rabi* season.

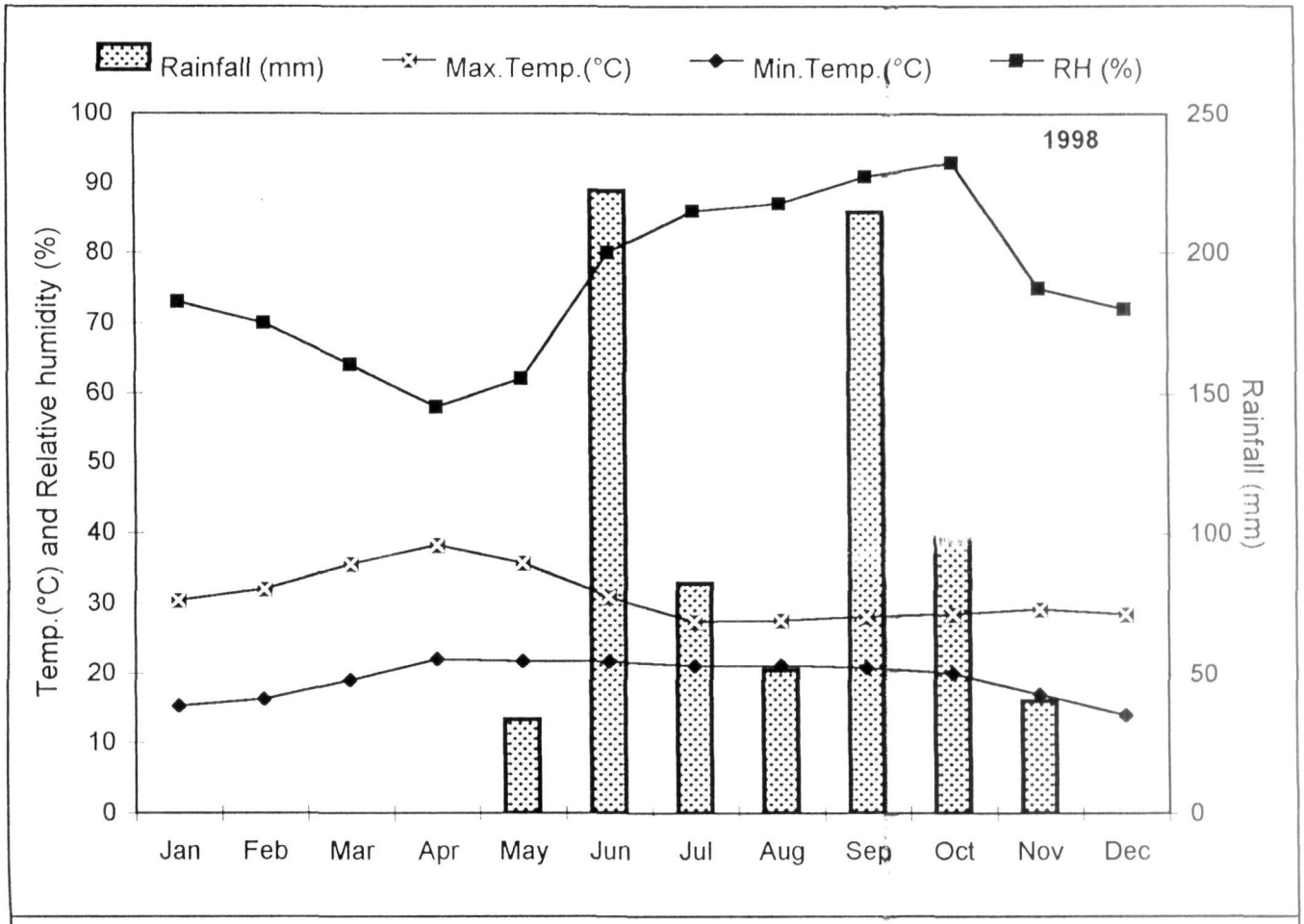
3.5 Experimental details

3.5.1 Design and layout

The field experiment was laid out in a randomised block design (Factorial) with 15 treatment combinations comprising three organic sources and five fertilizer levels and replicated three times. The plan of layout of the experiment is given in Fig. 2.

Table 2. Monthly meteorological data for the year 1998-99 and average of past 48 years (1950-1998) of Main Research Station, University of Agricultural Sciences, Dharwad

Months	Rainfall (mm)		Mean temperature (° C)				Mean Relative Humidity (%)	
	1998	1950-1997	Maximum		Minimum		1998	1950-1998
			1998	1950-1997	1998	1950-1997		
January	-	0.11	30.5	29.15	15.3	14.11	73	62.88
February	-	0.00	32.1	34.76	16.3	15.94	70	50.82
March	-	7.77	35.7	35.76	19.0	18.76	64	56.48
April	-	49.51	38.3	37.09	22.1	21.37	58	79.10
May	33.2	87.62	35.8	36.75	21.8	21.45	62	67.10
June	222.4	112.96	31.0	29.47	21.8	21.20	80	81.77
July	82.5	156.03	27.5	27.05	21.2	20.96	86	88.37
August	51.4	102.37	27.7	27.10	21.3	20.64	87	86.83
September	214.4	104.13	28.2	28.75	20.9	20.16	91	83.24
October	98.1	136.62	28.6	30.17	20.1	19.22	93	76.26
November	40.2	35.04	29.3	29.37	17.1	15.33	75	68.44
December	-	6.08	28.6	29.17	14.0	13.41	72	64.69
Total Rainfall	742.2	798.24	-	-	-	-	-	-
Mean Temperature	-	-	31.11	31.22	19.24	18.55	-	-
Mean RH %	-	-	-	-	-	-	75.92	72.17



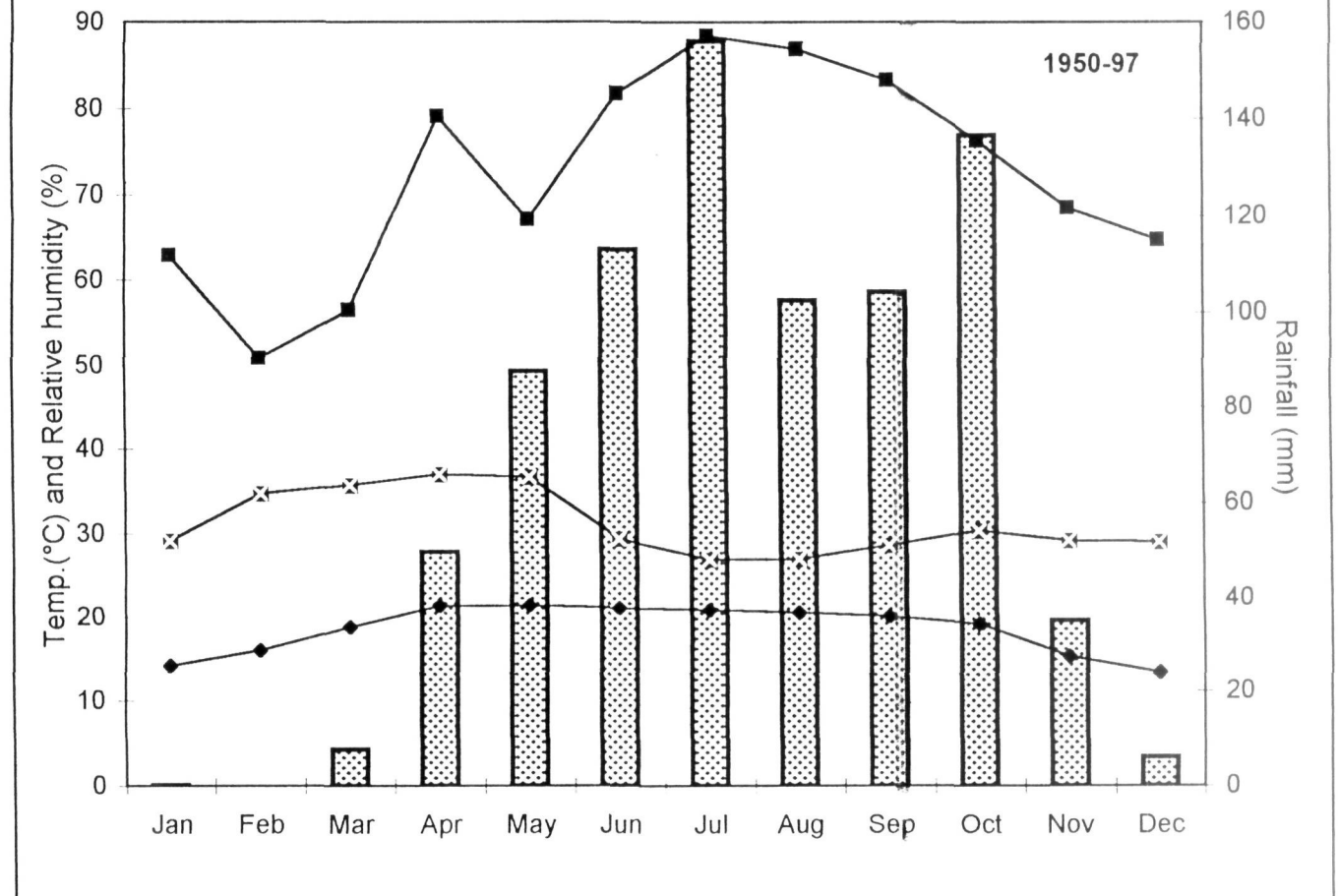


Fig. 1 Monthly meteorological data for the year 1998 and the average of 48 years (1950-97) recorded at the meteorological observatory of the Agricultural College Farm, Dharwad

LEGEND

T_1 = FYM + 100% RDF for both SF and PP

T_2 = FYM + 100% RDF for SF and 75% RDF for PP

T_3 = FYM + 100% RDF for SF and 50% RDF for PP

T_4 = FYM + 100% RDF for SF and 25% RDF for PP

T_5 = FYM + 100% RDF for SF and No RDF for PP

T_6 = Vermicompost + 100% RDF for both SF and PP

T_7 = Vermicompost + 100% RDF for SF and 75% RDF for PP

T_8 = Vermicompost + 100% RDF for SF and 50% RDF for PP

T_9 = Vermicompost + 100% RDF for SF and 25% RDF for PP

T_{10} = Vermicompost + 100% RDF for SF and No RDF for PP

T_{11} = Poultry manure + 100 RDF for both SF and PP

T_{12} = Poultry manure + 100 RDF for SF and 75% RDF for PP

T_{13} = Poultry manure + 100 RDF for SF and 50% RDF for PP

T_{14} = Poultry manure + 100 RDF for SF and 25% RDF for PP

T_{15} = Poultry manure + 100 RDF for SF and No RDF for PP

FYM @ 7.5 t/ha

Vermicompost @ 4.7 t/ha

Poultry manure @ 2.7 t/ha

RDF = Recommended dose of fertilizer

SF = Sunflower

PP = Pigeonpea

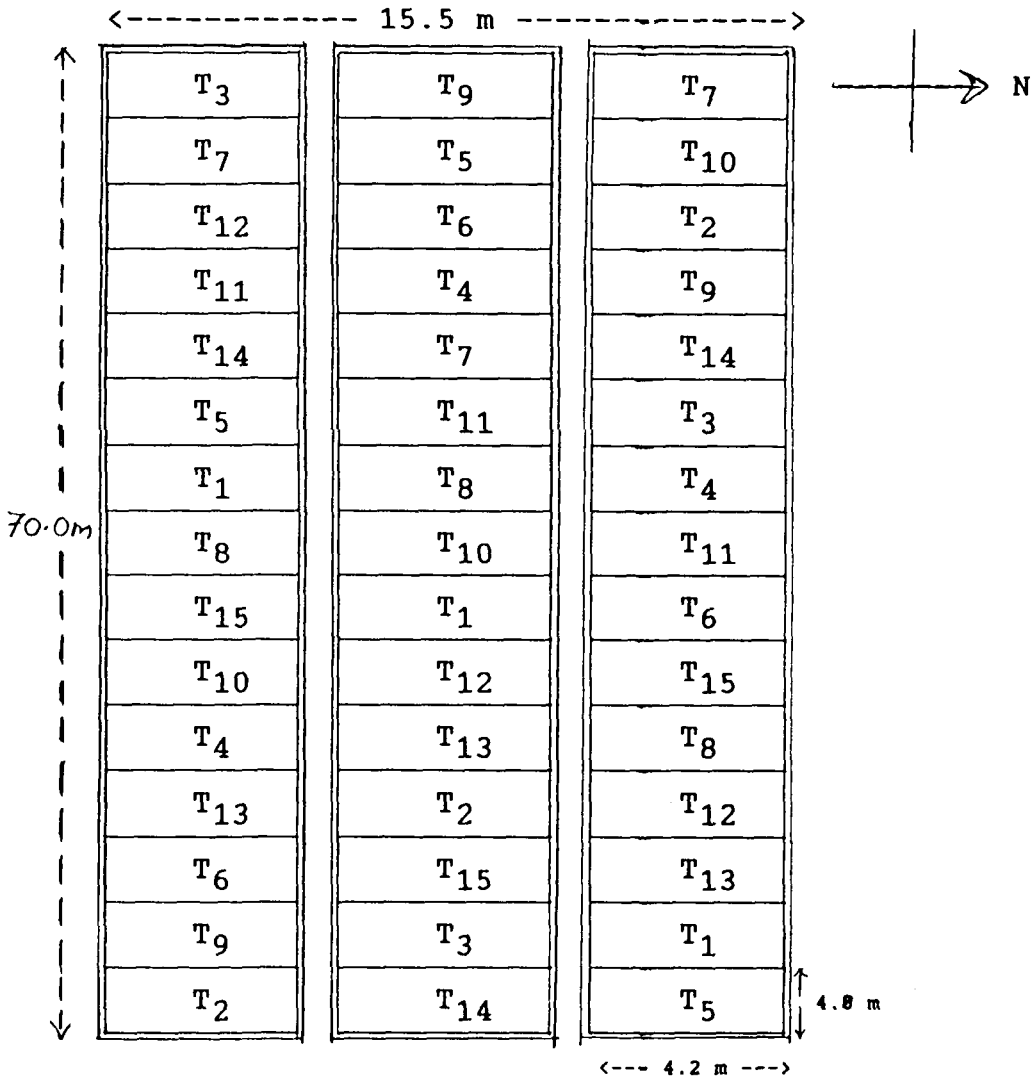


Fig. 2. PLAN OF LAYOUT

Treatments :

I. **Organic sources**

i. FYM @ 7.5 t/ha
ii. Vermicompost @ 4.7 t/ha
iii. Poultry manure @ 2.7 t/ha

II. **Fertilizer levels**

i. 100% RDF for both sunflower and pigeonpea crops
ii. 100% RDF for sunflower and 75% RDF for pigeonpea
iii. 100% RDF for sunflower and 50% RDF for pigeonpea
iv. 100% RDF for sunflower and 25% RDF for pigeonpea
v. 100% RDF for sunflower and No RDF for pigeonpea

* RDF = Recommended dose of fertilizers

3.5.2 Treatments

I. Organic manures

i) FYM @ 7.5 tonnes/ha
ii) Vermicompost @ 4.7 tonnes/ha
iii) Poultry manure @ 2.7 tonnes/ha

II. Inorganic fertilizers

i) 100% RDF for both sunflower and pigeonpea crops
ii) 100% RDF for sunflower and 75% RDF for pigeonpea
iii) 100% RDF for sunflower and 50% RDF for pigeonpea
iv) 100% RDF for sunflower and 25% RDF for pigeonpea
v) 100% RDF for sunflower and No RDF for pigeonpea

3.5.3 Plot size

Gross plot = 4.8 m x 4.2 m
Net plot = 3.6 m x 3.0 m

3.6 Incorporation of organic manures

The organic sources used in the investigation were farmyard manure, vermicompost and poultry manure. They were incorporated in to the soil at 10 - 15 cm depth a week prior to sowing.

3.7 Crops and genotypes

The cultivars used in the experiment were KBSH-1 of sunflower and S-1 of pigeonpea with row proportion 2:1 (SF:PP) and spacing followed is 60 cm x 30 cm.

3.8 Cultural operations

3.8.1 Land preparation

Land was ploughed with wooden plough after the receipt of pre monsoon showers. Soil was brought to a fine tilth by harrowing two times. Plots were laid out as per the plan (Fig. 2).

3.8.2 Application of fertilizer

In intercropping treatments fertilizers were applied based on plant population. The recommended doses for sunflower and pigeonpea were 35:50:35 and 25:50:0 N, P_2O_5, K_2O kg per ha respectively . The sources of fertilizer for nitrogen, phosphorus and potassium were in the form of urea, single super phosphate and muriate of potash respectively . Fertilizer was applied at five cm away from seed line to a depth of five centimeters at the time of sowing.

Treatments	Fertilizers	$N:P_2O_5:K_2O$ (kg/ha)
	SF	PP
i. 100% RDF for both SF and PP	35:50:35	25:50:0
ii. 100% RDF for SF and 75% RDF for PP	35:50:35	18.50:37.50:0
iii. 100% RDF for SF and 50% RDF for PP	35:50:35	12.50:25:0
iv. 100% RDF for SF and 25% RDF for PP	35:50:35	6.25:12.50:0
v. 100% RDF for SF and No RDF for PP	35:50:35	0:0:0

3.8.3 Seeds and sowing

Bold and healthy seeds of sunflower and pigeonpea were selected and treated with cerosan at the rate of two grams per kg of seed. Sunflower and pigeonpea were sown on sixth July 1998 by providing required inter and intra row spacing (60 cm x 30 cm). At each spot two seeds were dibbled in sunflower and pigeonpea. After 15 days, seedlings were thinned out to maintain only one plant per hill.

3.8.4 After care

To keep the crop free of weeds, two hoeings and two hand weedings were carried out. Even-though, there were no disease and pest incidence in the early stage of crop as a preventive measure, monocrotophos spray was given at 30 days after sowing. Pigeonpea crop was drenched with endosulphon at the rate of 36 ml in 18 liters of water to prevent stem gall weevil at 45 days after sowing. Pigeonpea crop was sprayed with monocrotophos at the rate of 15 ml in 36 liters of water

and Bavistin along with Dithane-M-45 at 90, 100 and 125 days after sowing to control the pod borer and powdery mildew disease.

3.8.5 Harvesting and threshing

Sunflower was harvested on 26th October 1998. The crop maturity was judged when the back of the capitulam turned to lemon yellow colour. The heads from the net plot were cut at their base and sun dried. The seeds were separated by hand threshing. The produce was cleaned and seed yield per net plot was recorded after complete drying. The stalk yield from each net plot was recorded after sun drying.

Pigeonpea was harvested on 29th January 1999. The plants were cut at the base close to the ground level. The plants were heaped and left for drying. The dried plants were threshed with a bamboo stick to separate the seeds from pods. After threshing, the produce was winnowed, cleaned and weighed. The stalk weight from each net plot was recorded after sundrying.

3.9 Collection of experimental data

3.9.1 Sunflower growth components

For recording various biometric observations five plants were selected at random from each net plot and observations were recorded at 30, 60, 90 days after sowing and at harvest.

3.9.2 Plant height (cm)

The height of five plants was measured from the base of the plant to the growing tip of the plant at 30 days after sowing and to the capitulam at 60, 90 days after sowing and at harvest. The mean plant height (cm) was computed.

3.9.3 Number of green leaves per plant

Total number of fully opened green leaves present in each of the five plants were counted and their mean was taken as the number of leaves per plant.

3.9.4 Leaf area per plant

Length and breadth of all fully opened green leaves per plant were measured (cm). Leaf length was measured from the base to the tip of the lamina and breadth was taken at the widest point of the lamina. From this mean length and breadth of leaf were worked out. The leaf area was calculated as per the formula given by Schneiter, 1978.

$$LA = ((L \times W) \times 0.6683) - 2.45$$

Where, LA = Leaf area in dm^2

L = Length of leaf in cm

W = Breadth of leaf in cm

The number of leaves per plant was multiplied by LA to get leaf area per plant.

3.9.5 Dry matter production and accumulation in different parts

The randomly selected three plants were partitioned into different plant parts namely , stem, leaves, petiole and capitulam and oven dried at 70°C to constant weight. The sum of the dry weights of all the plant parts was taken as the dry matter production per plant.

3.9.6 Sunflower yield and yield components

At the time of harvesting, five plants were selected randomly for recording yield and yield components.

3.9.6.1 Diameter of the head

The distance between the two diagonally opposite edges of the head was recorded as head diameter (cm) from five randomly selected plants from each net plot. Mean of five plants was taken as diameter of the head.

3.9.6.2 Number of seeds per head

The seeds obtained from each head of five sample plants were cleaned and counted. From this mean number of seeds per head was calculated.

3.9.6.3 Seed yield per plant

The seeds from the heads of five randomly selected plants were separated and the seed yield was recorded. The

mean weight of seed of the five heads was taken as the seed yield per plant.

3.9.6.4 1000-seed weight

From the seed yield of each net plot, 1000-seeds were randomly collected and their weight was recorded in grams.

3.9.6.5 Per cent chaffyness

It was calculated by using the following formula.

$$\text{Per cent chaffyness} = \frac{\text{Number of unfilled seeds per head}}{\text{Total number of seeds}} \times 100$$

3.9.6.6 Harvest Index

It was calculated by using the formula given by Donald (1962).

$$\text{Harvest Index} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} = \frac{\text{Seed yield (kg/ha)}}{\text{Seed and stalk yield (kg/ha)}}$$

3.9.6.7 Stalk yield

The weight of the stalks in the net plot was recorded after complete sun drying and the stalk yield per hectare was calculated.

3.9.6.8 Seed yield

The sun dried heads from each net plot were hand threshed, cleaned and the weight of the seeds was recorded. From the seed yield of net plot, seed yield per hectare was calculated.

3.9.7 Quality parameter

3.9.7.1 Oil content

The oil content of the seeds was estimated from the sample of seeds drawn from the net plot yield of each treatment by Nuclear magnetic resonance spectrometer and was expressed in percentage.

3.9.7.2 Oil yield

The oil yield per hectare was worked out on the basis of seed oil content and seed yield.

3.9.8 Pigeonpea growth components

For recording observations as detailed below, five plants from each net plot were selected at random and observations were recorded at 30, 60, 90, 120, 150, 180 days after sowing and at harvest.

3.9.8.1 Plant height (cm)

Plant height from the ground level to the growing tip of the plant was recorded and mean plant height was worked out.

3.9.8.2 Number of leaves per plant

Total number of fully opened green trifoliate leaves produced per plant were counted and mean was taken as number of leaves per plant.

3.9.8.3 Leaf area per plant

Leaf area per plant (dm^2) was worked out by Disc method on dry weight basis.

3.9.8.4 Number of primary branches per plant

Total number of branches arising from the main stem were counted and the mean was taken as number of primary branches per plant.

3.9.8.5 Number of secondary branches per plant

Total number of branches arising from the primary branches were counted and the mean was taken as number of secondary branches per plant.

3.9.8.6 Dry matter production and accumulation in different plant parts

The randomly selected three plants were partitioned into their component parts namely , stem, leaves, petiole and pods. These were dried in hot air oven at 70°C and their weights were recorded separately . The sum of the mean dry weight of all the plant parts was taken as the dry matter production per plant.

3.10 Yield and yield components

3.10.1 Number of pods per plant

The number of matured pods were counted and the mean number of pods per plant were calculated.

3.10.2 Number of seeds per pod

The seeds from ten representative matured pods were separated and counted and the mean number of seeds per pod were calculated by dividing the number of seeds by the number of pods.

3.10.3 Seed yield per plant

The seeds from the pods of five plants were separated by threshing and their mean weight was taken as seed yield per plant.

3.10.4 Hundred seed weight

From the seed yield of each net plot, 100-seeds were randomly collected and their weight was taken as hundred seed weight.

3.10.5 Seed yield per hectare

The pods from each net plot were threshed, cleaned and seed yield was recorded. From the seed yield from net plot, seed yield per hectare was computed.

3.10.6 Stalk yield per hectare

The plants in the net plot after threshing were dried and their weight was recorded. From this, stalk yield per hectare was calculated.

3.10.7 Harvest index (HI)

Harvest index was calculated by using the formula suggested by Donald (1962).

$$\text{Harvest index} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} = \frac{\text{Seed yield (kg/ha)}}{\text{Seed and stalk yield (kg/ha)}}$$

3.11 Sunflower seed equivalent yield (q/ha)

Sunflower seed equivalent yield was calculated by using the formula.

$$\text{Sunflower equivalent yield of grain pigeonpea (q/ha)} = \frac{\text{Yield of pigeonpea (q/ha)} \times \text{Price of the grain pigeonpea}}{\text{Price of the sunflower crop (Rs/ha)}}$$

$$\text{Sunflower equivalent yield (q/ha) of intercropping system} = \text{Sunflower yield (q/ha)} + \text{Sunflower equivalent yield of grain pigeonpea (q/ha)}$$

3.12 Soil analysis

3.12.1 Soil physical properties

3.12.1.1 Bulk density

Bulk density of soil in each treatment was estimated by core sampler method as described by Black (1965).

3.12.1.2 Infiltration rate

Infiltration rate of all the treatments was determined by double ring infiltrometer Dastane (1961).

3.12.1.3 Water stable aggregates

Water stable aggregates was estimated by wet sieving method as described by USD A Staff (1968).

3.12.1.4 Maximum water holding capacity

Maximum water holding capacity was determined by means of Keen-Racikowski cup method (Piper , 1966).

3.12.2 Chemical properties

Soil samples 0-20 cm depth were collected separately from each treatment in all the three replications before incorporation of organic manures and after harvest of both crops. The soil samples were chemically analysed for various characteristics.

3.12.2.1 Soil reaction

Soil reaction was determined by using pH meter by taking 1:2.5 ratio soil and water (Piper , 1966).

3.12.2.2 Electrical conductivity

Electrical conductivity was determined by using conductivity bridge and expressed as dS/m.

3.12.2.3 Organic carbon

Organic carbon was determined by Walkey's and Black wet oxidation method (Jackson, 1967).

3.12.2.4 Available nitrogen

It was estimated by alkaline permanganate oxidation method as outlined by Subbiah and Asija (1956).

3.12.2.5 Available phosphorus

Available phosphorus content of soil was determined by Olsen's method as described by Jackson (1967).

3.12.2.6 Available potash

It was determined by flame photometer after extracting with neutral normal ammonium acetate as described by Muhr *et al.* (1965).

3.13 Chemical analysis of organic sources

The samples of FYM, vermicompost and poultry manure were analysed for pH, EC, organic carbon and total nutrient content (NPK). The data are presented in Table 3. The pH of these three organic sources were near neutral but the electrical conductivity of poultry manure was higher (1.31 dSm^{-1}) compared to vermicompost (1.29 dSm^{-1}) and FYM (0.24 dSm^{-1}). The poultry manure was marginally superior to vermicompost and FYM in N and P content but low in K content.

3.14 Plant analysis for NPK contents (%)

Nitrogen content of stem and seeds at harvest was estimated by modified micro-kjeldhal's method as outlined by Jackson (1967) and expressed as percentage. Total phosphorus and potassium of stem and shoot were extracted by wet ashing method. P content was estimated by Vanedomolybdate phosphoric yellow colour method (Jackson, 1967) and K was determined by Flame photometer method (Jackson, 1967) and expressed in percentage.

Table 3. Nutrient composition of FYM, vermicompost and poultry manure

Particulars	FYM	Vermicompost	Poultry manure
pH (1:2.5)	7.23	7.15	7.08
EC (dS m^{-1})	0.24	1.29	1.31
Total nutrients (%)			
N	0.49	0.78	1.44
P	0.65	0.94	1.97
K	0.57	0.45	0.32
Organic carbon (%)	40.70	39.20	38.61

3.15 Nutrient uptake studies

The uptake of nitrogen, phosphorus and potassium was calculated by multiplying the oven dry weight at harvest of plant samples with their corresponding percentage of nitrogen, phosphorus and potassium and expressed as kg per ha from each plant parts. From these, the total uptake per ha was computed by mathematical addition of the uptake from different plant parts and of crops.

$$\text{Nutrient uptake} = \frac{\text{\% of nutrient concentration x Biomass kg/ha}}{100}$$

3.16 Chemical analysis of soil after harvest

Soil samples after harvest of the crops from 0-60 cm soil depth was collected from each treatment in all three replications. The soil samples were chemically analysed for available organic carbon, nitrogen, phosphorus and potassium of the soil.

Available soil nitrogen was estimated by alkaline permanganate oxidation method as out lined by Subbaiah and Asija (1956). Available phosphorus was determined by Olsen's method as out lined by Jackson (1967). Available potassium was extracted with nentral normal ammonium acetate and the content of K in the solution was estimated by flame photometer (Jackson, 1967). Organic carbon was determined by Walkely

and Black's wet oxidation method by oxidising organic matter as described by Jackson (1967).

3.17 Economics

The cost of the following items was considered for working out the cost of cultivation of different treatments..lh7

I. Labour charges (from land preparation to processing)
II. Seeds.
III. Fertilizers.
IV. Plant protection chemicals.
V. Miscellaneous (land rent, marketing charges, etc.,).

The prices of the inputs that were prevailing at the time of their use and prices of crop commodities at the time of marketing were taken to work out the cost of cultivation and gross return. The details of the cost of inputs and the values of produce considered in the calculation are given in Appendix-I.

The net profit per hectare was calculated by deducting the cost of cultivation per hectare from the gross income per hectare.

Benefit : Cost ratio was worked out as follows;

$$\text{Benefit : Cost ratio} = \frac{\text{Net profit in Rs./ha}}{\text{Cost of cultivation in Rs./ha}}$$

3.18 Statistical analysis and interpretation of data

Data recorded on various characters were subjected to Fisher's method of analysis of variance and interpretation of data was done as given by Phanse and Sukhatme (1967). The level of significance used in 'F' and 't' test were P = 0.05 critical difference values were calculated wherever the 'F' test was significant.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the experiment conducted during the *kharif* season of 1998-99 to study the effect of integrated nutrient management in sunflower - pigeonpea intercropping system are presented in this chapter.

4.1 Sunflower

4.1.1 Growth parameters

4.1.1.1 Plant height (cm)

The data on plant height of sunflower as influenced by integrated nutrient management at different stages of growth are presented in Table 4.

Integrated nutrient management did not influence the plant height significantly at any of the growth stages. The interaction effect of organics and inorganic fertilizers was also not significant. However, the plant height of sunflower varied from 190.45 to 197.26 cm under different treatments at harvest.

4.1.1.2 Number of green leaves per plant

The data on number of green leaves produced per plant as influenced by integrated nutrient management are presented in Table 5.

Integrated nutrient management in sunflower - pigeonpea intercropping system significantly influenced the number of leaves at 90 DAS. The number of leaves produced

Table 4. Plant height (cm) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	49.82	50.27	50.28	50.12	186.18	186.50	187.86	186.85	190.79	196.28	195.50	194.21	191.46	197.26	196.84	195.19
100% RDF + 75% RDF	49.08	49.93	50.92	49.98	186.17	186.42	187.04	186.54	190.85	194.99	195.25	193.70	190.75	196.12	196.19	194.35
100% RDF + 50% RDF	49.58	49.17	50.08	49.61	185.71	186.85	186.05	186.20	191.20	195.31	195.32	193.94	190.45	192.54	196.07	193.02
100% RDF + 25% RDF	48.67	49.45	49.87	49.33	185.42	185.76	185.78	185.65	190.87	193.97	195.17	193.34	191.08	194.86	195.54	193.83
100% RDF + No RDF	48.17	49.42	49.00	48.86	185.29	185.26	185.11	185.22	191.15	193.88	194.70	193.24	190.74	194.51	195.51	193.59
Mean	49.06	49.65	50.03	49.58	185.75	186.16	186.37	186.09	190.97	194.89	195.20	193.69	190.90	195.06	196.03	194.00

For comparing the means of

Sources	Org.	Inorg	Org. x Inorg.	Org.	Inorg.	Org. x Inorg.	Org.	Inorg.	Org. x Inorg	Org.	Inorg.	Org. x Inorg
S Em.±	0.93	1.20	2.09	3.37	4.35	7.53	3.47	4.48	7.75	3.71	4.78	8.28
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 5. Number of leaves per plant of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	11.32	11.69	11.61	11.54	21.11	20.80	21.28	21.06	4.78	5.39	5.45	5.21
100% RDF + 75% RDF	11.25	11.24	11.54	11.35	20.83	20.95	21.15	20.98	4.94	5.19	5.19	5.11
100% RDF + 50% RDF	10.96	10.95	11.14	11.01	20.45	20.89	21.19	20.84	4.53	5.38	5.03	4.98
100% RDF + 25% RDF	10.77	10.62	11.05	10.81	20.36	20.72	20.64	20.57	4.42	4.97	4.89	4.76
100% RDF + No RDF	10.05	10.25	11.35	10.55	20.17	20.42	20.24	20.28	4.00	4.84	4.73	4.52
Mean	10.87	10.95	11.34	11.05	20.59	20.76	20.90	20.75	4.53	5.16	5.06	4.92
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em ±	0.22	0.28	0.49		1.10	1.43	2.47		0.15	0.19	0.33	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		0.422	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Plate 1. General view of the experimental plot at 30 Days after sowing

Plate 2. General view of the experimental plot at flowering of sunflower (60 Days after sowing)

by sunflower at 30 DAS and 60 DAS were 11.05 and 20.75 per plant which was reduced to 4.92 per plant at 90 DAS and number of leaves per plant at harvest was nil.

Inorganic fertilizer did not have any significant influence on the number of leaves produced by sunflower at any of the stages of growth.

Organic sources had significant influence on the number of leaves produced by sunflower at 90 DAS. At 90 DAS, treatments receiving vermicompost produced significantly higher number of leaves (5.16/plant) when compared to that produced under FYM (4.53/plant) and it was on par with poultry manure (5.06/plant).

Interaction effect of organics and inorganic fertilizers was not significant with respect to the number of leaves produced by sunflower at any of the stages of growth.

4.1.1.3 Leaf area per plant (dm^2)

The data on leaf area (dm^2) per plant of sunflower as influenced by integrated nutrient management at different stages of growth are presented in Table 6.

Integrated nutrient management in sunflower – pigeonpea intercropping system significantly influences the leaf area (dm^2) per plant at 90 DAS. The leaf area (dm^2) produced by sunflower at 30 DAS and 60 DAS was 6.43 and 30.29 dm^2 per plant which was reduced to 12.99 dm^2 per plant at 90 DAS.

Table 6. Leaf area per plant (dm^2) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	6.25	6.92	7.03	6.73	30.05	31.82	31.92	31.26	12.12	15.01	14.69	13.94
100% RDF + 75% RDF	6.55	6.74	6.84	6.71	29.86	30.65	31.33	30.61	11.87	14.56	14.59	13.68
100% RDF + 50% RDF	6.34	6.49	6.49	6.44	29.52	30.50	31.10	30.37	11.43	13.47	13.42	12.77
100% RDF + 25% RDF	6.22	6.10	6.30	6.20	28.68	30.22	30.67	29.85	11.24	13.43	13.13	12.60
100% RDF + No RDF	5.98	6.02	6.14	6.05	28.15	29.84	30.12	29.37	10.24	12.86	12.78	11.96
Mean	6.27	6.45	6.56	6.43	29.29	30.61	31.03	30.29	11.38	13.87	13.72	12.99
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg	
S Em.±	0.15	0.20	0.34		1.23	1.58	2.74		0.69	0.89	1.54	
C D at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		1.99	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Inorganic fertilizer levels did not have any significant influence on the leaf area produced by sunflower at any of the stages of growth.

Organic sources had significant influence on the leaf area produced by sunflower at 90 DAS. At 90 DAS, plants under vermicompost recorded significantly higher leaf area (13.87 dm^2/plant) when compared to that produced under FYM (11.38 dm^2/plant) and it was on par with that of poultry manure (13.72 dm^2/plant).

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to the leaf area produced by sunflower at any of the stages of growth.

4.1.1.4 Dry matter production and its accumulation in different plant parts

4.1.1.4.1 Dry matter production (g/plant)

The data on dry matter produced by sunflower as influenced by organic sources and inorganic fertilizer levels at different growth stages are presented in Table 7.

Integrated nutrient management in sunflower - pigeonpea intercropping system had no significant influence on the dry matter production at all stages of growth except at 90 DAS. The dry matter produced by sunflower at 30 DAS, 60 DAS and 90 DAS was 8.32 g/plant, 85.68 g/plant and 103.36 g/plant which was reduced to 80.45 g/plant at harvest.

Table 7. Dry matter production (g/plant) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	8.65	9.54	9.21	9.13	86.45	91.45	95.25	91.05	102.85	104.62	106.80	104.76	78.67	88.94	87.82	85.14
100% RDF + 75% RDF	8.50	8.75	8.55	8.60	85.99	89.50	85.17	86.89	101.49	106.24	113.41	107.04	78.20	87.05	85.37	83.54
100% RDF + 50% RDF	8.32	8.12	8.32	8.25	85.05	85.38	88.15	86.19	99.83	108.25	105.50	104.52	75.87	83.37	81.41	80.21
100% RDF + 25% RDF	7.95	7.75	7.90	7.87	80.77	83.30	87.43	83.83	87.33	108.47	108.74	101.51	75.10	79.47	78.83	77.80
100% RDF + No RDF	7.70	7.81	7.72	7.74	80.35	80.70	80.25	80.43	100.17	99.42	97.31	98.97	74.27	76.78	75.62	75.55
Mean	8.22	8.39	8.34	8.32	83.72	86.07	87.25	85.68	98.33	105.40	106.35	103.36	76.42	83.12	81.81	80.45
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em.±	0.29	0.38	0.65		2.35	3.04	5.26		1.97	2.54	4.41		2.52	3.26	5.65	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		5.71	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Plate 5. Treatment showing Vermicompost + 100% RDF for sunflower and 75% RDF for Pigeonpea

Plate 6. Treatment showing FYM + 100% RDF for sunflower and No RDF for pigeonpea

Inorganic fertilizers did not have any significant influence on the dry matter produced by sunflower at any of the stages of growth.

Organic sources had significant influence on the dry matter produced by sunflower at 90 DAS. At 90 DAS, plants under poultry manure produced significantly higher dry matter production (106.35 g/plant) when compared to that produced under FYM (98.35 g/plant) and it was on par with that recorded under vermicompost (105.40 g/plant).

Interaction effect of organic sources and inorganic fertilizer levels had non-significant influence on the dry matter produced by sunflower at any of the stages of growth.

4.1.1.4.2 Dry matter accumulation in leaves (g/plant)

The data on dry matter accumulation in sunflower leaves at different growth stages as influenced by organic sources and inorganic fertilizer levels are presented in Table 8.

Integrated nutrient management in sunflower pigeonpea intercropping system had non-significant influence on the dry matter accumulation in leaves (g/plant) at all stages of growth.

Inorganic fertilizers did not have any significant influence on the dry matter accumulation in leaves (g/plant) of sunflower at any of the stages of growth.

Table 8. Dry matter accumulation (g/plant) in leaves of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS			
Organics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	4.87	4.99	4.98	4.95	27.10	28.59	29.19	28.29	20.17	24.18	24.65	23.00
100% RDF + 75% RDF	4.77	4.92	4.81	4.83	27.15	27.91	28.67	27.91	19.88	23.45	23.43	22.25
100% RDF + 50% RDF	4.60	4.55	4.50	4.57	26.45	27.49	28.64	27.53	19.85	22.69	22.62	21.72
100% RDF + 25% RDF	4.45	4.34	4.26	4.35	25.72	25.92	25.86	25.83	19.51	20.67	19.67	19.95
100% RDF + No RDF	4.34	4.45	4.19	4.32	25.45	25.67	25.43	25.52	18.77	20.79	19.92	19.82
Mean	4.62	4.65	4.55	4.61	26.37	27.12	27.56	27.02	19.63	22.36	22.06	21.35
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	0.19	0.24	0.42		0.79	1.01	1.75		1.06	1.37	2.37	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Organic sources also had non-significant influence on the dry matter accumulation in leaves (g/plant) of sunflower at any of the stages of growth.

Interaction effect of organic sources and inorganic fertilizer levels also had non-significant effect on the dry matter accumulation in leaves of sunflower at any of the stages of growth.

4.1.1.4.3 Dry matter accumulation in stem (g/plant)

The data on drymatter accumulation in stem as influenced by organics and inorganics at different growth stages are presented in Table 9.

Integrated nutrient management in sunflower - pigeonpea intercropping system had non-significant influence on dry matter accumulation in stem (g/plant) at all stages of growth except at 90 DAS. The dry matter accumulation in stem (g/plant) of sunflower at 30 DAS, 60 DAS and 90 DAS was 3.08 g/plant, 32.34 g/plant and 39.93 g/plant which was reduced to 36.43 g/plant at harvest.

Inorganic fertilizers did not have any significant influence on the dry matter accumulation in stem (g/plant) of sunflower at any of the stages of growth.

Organic sources had significant influence on the dry matter accumulation in stem (g/plant) of sunflower at 90 DAS. At 90 DAS, plants under vermicompost produced significantly

Table 9. Dry matter accumulation in stem (g/plant) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	3.15	3.43	3.46	3.35	33.42	35.43	38.00	35.62	38.73	42.33	41.92	40.99	34.83	43.85	41.10	39.93
100% RDF + 75% RDF	3.07	3.29	3.25	3.21	33.21	34.24	33.58	33.68	38.67	42.92	42.77	41.45	33.75	41.95	39.82	38.50
100% RDF + 50% RDF	2.79	3.27	3.10	3.05	32.17	30.35	33.49	32.00	38.95	41.69	40.96	40.53	33.67	39.00	37.67	36.78
100% RDF + 25% RDF	2.73	3.12	3.01	2.96	29.85	30.33	32.25	30.81	37.20	40.77	39.01	38.99	33.33	34.67	34.28	34.09
100% RDF + No RDF	2.71	2.85	2.99	2.85	29.33	29.77	29.67	29.59	37.00	37.67	38.33	37.67	33.00	33.42	32.16	32.86
Mean	2.89	3.19	3.16	3.08	31.60	32.03	33.40	32.34	38.11	41.07	40.60	39.93	33.72	38.58	37.01	36.43
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S Em.±	0.15	0.20	0.34		1.36	1.76	3.05		0.805	1.04	1.80		1.47	1.90	3.29	
C.D at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		2.33	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

higher dry matter accumulation in stem (41.07 g/plant) when compared to that accumulated under FYM (38.11 g/plant) and it was on par with poultry manure (40.60 g/plant).

Interaction effect of organics and inorganics had non-significant influence on the dry matter accumulation in stem (g/plant) of sunflower at any of the stages of growth.

4.1.1.4.4 Dry matter accumulation in petiole (g/plant)

The data on dry matter accumulation in petiole of sunflower as influenced by organics and inorganics at different growth stages are presented in Table 10.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the dry matter accumulation in sunflower petioles at any of the growth stages.

Inorganic fertilizers did not have any significant influence on the dry matter accumulation in petiole (g/plant) of sunflower at any of the stages of growth.

Organic sources also did not bring any significant difference in the dry matter accumulation in sunflower petioles at any of the stages of growth.

Interaction effect of organics and inorganics had non-significant influence on the dry matter accumulation in petioles (g/plant) of sunflower at any of the stages of growth.

Table 10. Dry matter accumulation in petiole (g/plant) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS			
Organic Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	0.60	0.61	0.62	0.61	5.54	6.25	6.27	6.02	3.79	4.10	4.33	4.07
100% RDF + 75% RDF	0.59	0.60	0.61	0.60	5.30	6.07	5.98	5.78	3.60	4.02	3.95	3.85
100% RDF + 50% RDF	0.59	0.59	0.60	0.59	5.22	5.56	5.77	5.51	3.43	3.83	3.93	3.73
100% RDF + 25% RDF	0.59	0.59	0.59	0.59	5.18	5.51	5.65	5.44	3.28	3.77	3.51	3.52
100% RDF + No RDF	0.57	0.58	0.58	0.58	5.03	5.41	5.42	5.29	3.00	3.43	3.42	3.28
Mean	0.59	0.59	0.60	0.59	5.25	5.76	5.82	5.61	3.42	3.83	3.83	3.69
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S Em ±	0.012	0.015	0.026		0.19	0.25	0.43		0.16	0.21	0.36	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

4.1.1.4.5 Dry matter accumulation in head (g/plant)

The data on dry matter accumulation in sunflower head as influenced by organics and inorganics are presented in Table 11.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the drymatter accumulation in head at any of the growth stages.

Inorganic fertilizers did not have any significant influence on the dry matter accumulation in head (g/plant) of sunflower at any of the stages of growth.

Organic sources also had non-significant influence on the drymatter accumulation in head (g/plant) of sunflower at any of the stages of growth.

Interaction effect of organics and inorganics had non-significant influence on the dry matter accumulation in head (g/plant) of sunflower at any of the stages of growth.

4.1.2 Yield and yield components

4.1.2.1 Head diameter (cm)

The data pertaining to head diameter as influenced by organics and inorganics at different growth stages are presented in Table 12.

Table 11. Drymatter accumulation in head (g/plant) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	19.36	20.17	20.77	20.10	38.15	38.88	38.93	38.65	42.25	42.81	43.13	42.73
100% RDF + 75% RDF	19.29	20.08	20.57	19.98	37.32	38.30	38.53	38.05	42.39	42.79	42.86	42.68
100% RDF + 50% RDF	19.20	19.98	20.19	19.79	36.48	37.75	37.85	37.36	42.17	42.50	42.84	42.17
100% RDF + 25% RDF	19.00	19.52	18.86	19.12	36.02	37.33	37.47	36.94	41.87	42.04	42.13	42.01
100% RDF + No RDF	18.51	18.83	18.72	18.69	35.83	36.94	37.15	36.64	41.45	41.82	41.54	41.60
Mean	19.07	19.72	19.82	19.54	36.76	37.84	37.99	37.53	42.03	42.39	42.30	42.24
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	0.57	0.73	1.27		0.91	1.17	2.03		1.33	1.71	2.96	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Plate 7. Treatment showing Poultry manure + 100% RDF for sunflower and 25% RDF for pigeonpea

Plate 8. Treatment showing FYM + 100% RDF for sunflower and 50% RDF for pigeonpea

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the head diameter (cm) of sunflower at any of the growth stages.

Inorganic fertilizers did not have any significant influence on the head diameter of sunflower at any of the stages of growth.

Organic sources also did not bring any significant difference in the head diameter of sunflower at any of the stages of growth.

Interaction effect of organics and inorganics had non-significant influence on the head diameter of sunflower at any of the growth stages.

4.1.2.2 Number of seeds per head

The data pertaining to number of sunflower seeds produced per head as influenced by organics and inorganic fertilizer levels are presented in Table 13.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the number of seeds per head of sunflower at any of the growth stages. The number of seeds per head of sunflower at harvest was 940.40. However, the number of sunflower seeds produced per head under vermicompost was higher (954.07) than that produced under FYM (920.00) and poultry manure (947.13).

Table 12. Head diameter (cm) of sunflower as influenced by integrated nutrient management at different growth stages

Stages	60 DAS				90 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	8.02	8.50	8.13	8.22	11.68	12.50	12.78	12.32	12.67	13.00	13.26	12.97
100% RDF + 75% RDF	7.65	8.43	8.08	8.05	10.96	12.32	12.46	11.91	12.54	13.25	13.10	12.96
100% RDF + 50% RDF	7.26	8.04	7.69	7.66	10.64	11.92	11.69	11.42	12.55	12.82	12.83	12.73
100% RDF + 25% RDF	7.17	7.72	7.65	7.51	10.77	11.45	11.21	11.14	12.19	12.55	12.40	12.38
100% RDF + No RDF	6.95	7.00	7.37	7.10	10.65	11.17	11.05	10.95	11.79	12.12	12.13	12.01
Mean	7.41	7.94	7.79	7.71	10.94	11.87	11.84	11.55	12.35	12.75	12.74	12.61
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S Em +	0.28	0.36	0.62		0.35	0.45	0.77		0.21	0.28	0.48	
C D at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N S - Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Inorganic fertilizers did not bring any significant difference in the number of sunflower seeds produced per head. However, the number of sunflower seeds produced under vermicompost with 100% RDF was higher (954.07) than that produced under FYM with 100 per cent RDF (920.00) and poultry manure with 100 per cent RDF (947.13).

Interaction effect of organics and inorganics was not significant with respect to the number of sunflower seeds produced per head.

4.1.2.3 Seed yield per plant (g)

The data on seed yield per plant as influenced by integrated nutrient management is presented in Table 13.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the sunflower seed yield produced per plant. However, the mean seed yield (g) produced per plant was 27.58 g/plant.

Inorganic fertilizer levels to sunflower did not have any significant influence on the seed yield produced per plant (g). However, sunflower grown under vermicompost with 100 per cent RDF recorded higher seed yield 28.71 g/plant than that recorded under FYM with 100 per cent RDF 25.78 g/plant and poultry manure with 100 per cent RDF 28.26 g/plant.

Interaction effect of organics and inorganics had non-significant influence on the seed yield of sunflower per plant.

4.1.2.4 Thousand seed weight (g)

The data on 1000-seed weight of sunflower as influenced by integrated nutrient management is presented in Table 13.

Effect of organics, inorganics and their interaction was not significant on the 1000-seed weight of sunflower. However, 1000-seed weight ranged from 31.72 to 33.21 g under different treatments.

4.1.2.5 Per cent chaffyness in sunflower seeds

The data pertaining to per cent chaffyness in sunflower seeds as influenced by integrated nutrient management are presented in Table 13.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the per cent chaffyness in sunflower seeds. However, the mean per cent chaffyness in sunflower seeds was 25.53.

Inorganic fertilizer levels did not have any significant influence on the per cent chaffyness in sunflower seeds. However, the sunflower grown under vermicompost with 100 per cent RDF recorded lower per cent of chaffyness (24.65%) than that recorded under FYM with 100 per cent RDF (26.64%) and poultry manure with 100 per cent RDF (25.32%).

Table 13. Yield components of sunflower as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	No. of seeds per head				Seed yield per plant (g)				1000-seed weight (g)				Chaffyness (%)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	946.67	975.33	972.00	964.67	27.45	29.81	29.71	28.99	32.65	33.18	33.08	32.97	24.77	24.28	25.12	24.72
100% RDF + 75% RDF	932.67	972.67	960.67	955.33	26.37	29.52	29.18	28.36	31.75	33.21	32.91	32.62	26.52	23.25	25.02	24.93
100% RDF + 50% RDF	921.33	951.33	943.00	938.56	25.75	28.85	28.45	27.68	32.00	32.86	31.94	32.27	27.20	25.20	24.55	25.65
100% RDF + 25% RDF	909.00	936.67	934.33	926.67	25.07	28.17	27.52	26.92	31.95	32.72	32.34	32.34	26.52	24.63	25.68	25.61
100% RDF + No RDF	890.33	934.33	925.66	916.78	24.25	27.20	26.42	25.95	31.72	32.74	31.98	32.15	28.20	25.86	26.21	26.76
Mean	920.00	954.07	947.13	940.40	25.78	28.71	28.26	27.58	32.01	32.94	32.45	32.47	26.64	24.65	25.32	25.53
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org	Inorg	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S Em.±	15.14	19.55	33.86		1.07	1.38	2.39		1.26	1.63	2.82		0.68	0.88	1.52	
C D at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Plate 3. Sunflower heads showing T_5, T_{14} and T_7 treatments

Plate 4. Sunflower heads showing T_3, T_{14} and T_7 treatments

Interaction effect of organics and inorganics had non-significant influence on the per cent chaffyness in sunflower seeds.

4.1.2.6 Seed oil content (%)

The data on seed oil content of sunflower as influenced by integrated nutrient management is presented in Table 14.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not bring any influence on the seed oil content (%). However, the mean seed oil content in sunflower was 40.60 per cent.

Inorganics, organics and their interaction did not influence the seed oil content of sunflower significantly. However, the seed oil content ranged from 38.25 to 42.34 per cent in different treatments.

4.1.2.7 Seed yield (q/ha)

The data pertaining to influence of integrated nutrient management on seed yield of sunflower are presented in Table 15.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the seed yield (q/ha). However, the sunflower grown under vermicompost with 100% RDF recorded higher seed yield 13.24 q/ha than that recorded under FYM with 100 per cent RDF

Table 14. Oil content (%) and oil yield (q/ha) of sunflower as influenced by integrated nutrient management

Organic Sunflower – Pigeonpea	Oil content (%)				Oil yield (q/ha)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	40.62	41.08	42.34	41.35	4.99	5.82	5.88	5.56
100% RDF + 75%RDF	39.98	42.08	41.89	41.32	4.92	5.91	5.86	5.56
100% RDF + 50% RDF	39.78	41.05	41.86	40.90	4.70	5.68	5.51	5.30
100% RDF + 25% RDF	39.00	40.26	40.90	40.05	4.62	4.94	5.01	4.86
100% RDF + No RDF	38.25	39.86	40.05	39.39	4.29	4.54	4.55	4.46
Mean	39.53	40.87	41.41	40.60	4.71	5.38	5.36	5.15
For comparing the means of								
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S Em.±	1.52	1.96	3.40		0.27	0.35	0.61	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

(11.83 q/ha) and poultry manure with 100 per cent RDF (12.68 q/ha).

Interaction effect of organics and inorganics had non-significant influence on the seed yield (q/ha) in sunflower.

4.1.2.8 Oil yield (q/ha)

The data on oil yield of sunflower as influenced by integrated nutrient management is presented in Table 14.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not have any influence on oil yield (q/ha). However, the sunflower grown under vermicompost with 100% RDF recorded higher oil yield 5.38 q/ha than that recorded under FYM with 100 per cent RDF (4.71 q/ha) and poultry manure 100 per cent RDF (5.36 q/ha).

Inorganics, organics and their interaction did not influence the oil yield (q/ha) of sunflower significantly.

4.1.2.9 Stalk yield (q/ha)

The data pertaining to influence of integrated nutrient management on stalk yield of sunflower is presented in Table 15.

Integrated nutrient management in sunflower - pigeonpea intercropping system did not influence the stalk yield (q/ha). However, the sunflower grown under vermicompost with 100 per cent RDF recorded higher stalk

Table 15. Seed yield (q/ha), stalk yield (q/ha) and harvest index of sunflower as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	Seed yield (q/ha)				Stalk yield (q/ha)				Harvest index			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	12.42	14.25	13.81	13.49	37.51	39.93	39.17	38.87	0.27	0.26	0.26	0.27
100% RDF + 75% RDF	12.15	14.15	13.55	13.28	37.00	39.88	39.18	38.69	0.25	0.26	0.26	0.26
100% RDF + 50% RDF	11.75	13.84	12.52	12.70	36.45	38.21	37.53	37.40	0.24	0.27	0.25	0.25
100% RDF + 25% RDF	11.69	12.48	11.92	12.03	35.78	37.19	36.88	36.62	0.25	0.25	0.24	0.25
100% RDF + No RDF	11.12	11.48	11.57	11.39	33.73	36.56	36.21	35.50	0.25	0.24	0.24	0.24
Mean	11.83	13.24	12.68	12.58	36.10	38.35	37.79	37.42	0.25	0.26	0.25	0.25
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	0.43	0.55	0.95		1.46	1.89	3.27		0.004	0.005	0.010	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

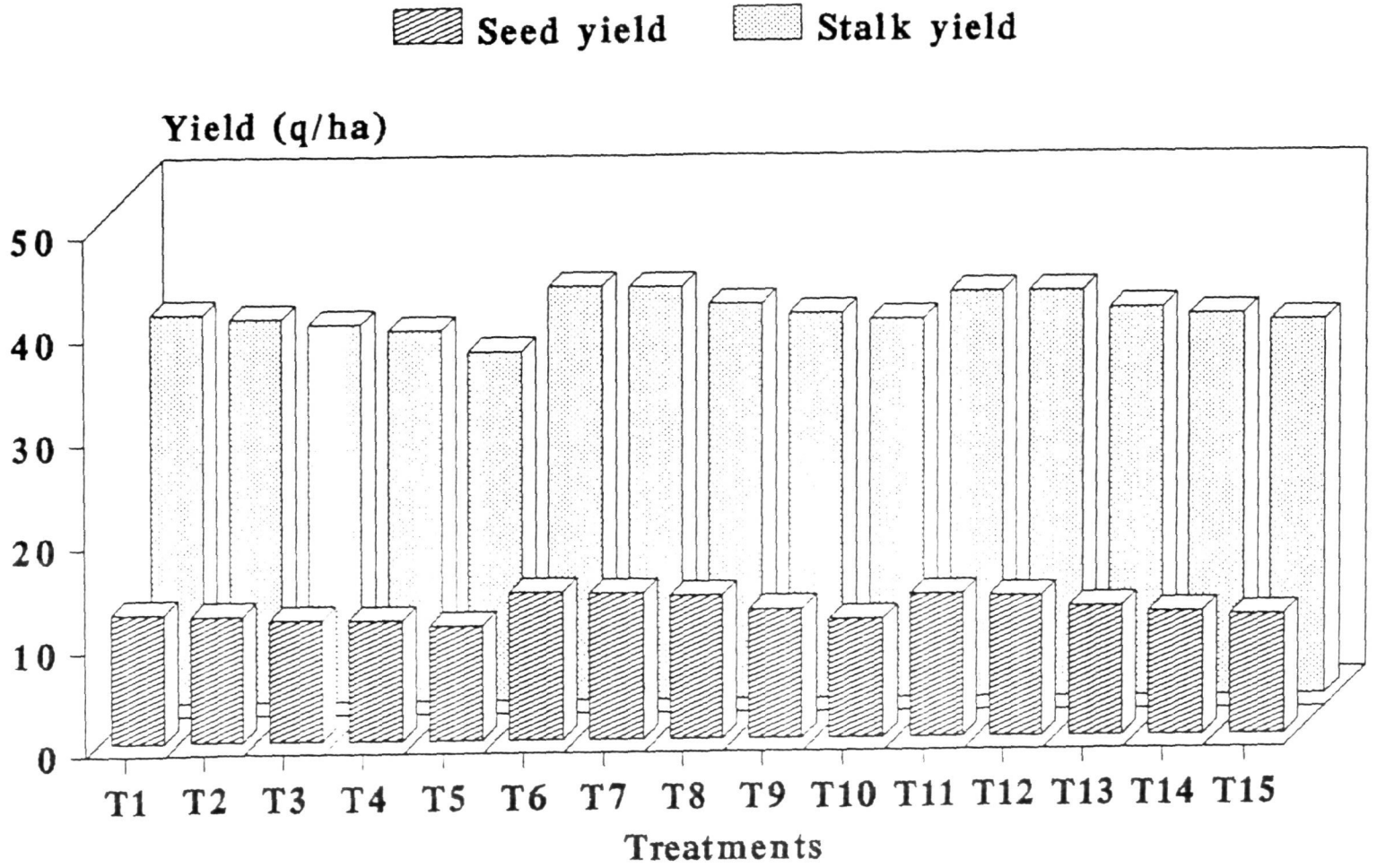


Fig. 3. Seed and stalk (q/ha) yield of sunflower as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system

yield 38.35 q/ha than that recorded under FYM with 100 per cent RDF (36.10 q/ha) and poultry manure with 100 per cent RDF (37.79 q/ha).

Inorganics, organics and their interaction has non-significant influence on the stalk yield (q/ha) in sunflower.

4.1.2.10 Harvest index (HI)

Differences in the harvest index of sunflower due to integrated nutrient management i.e., organics, inorganics and their interactions were non-significant on harvest index. However, the harvest index recorded in sunflower varies from 0.24 to 0.27 in different treatments (Table 15).

4.2 Pigeonpea

4.2.1 Growth parameters

4.2.1.1 Plant height

The data on plant height of pigeonpea as influenced by integrated nutrient management at different growth stages are presented in Table 16a and b.

Integrated nutrient management in sunflower - pigeonpea intercropping system had non-significant influence on the plant height (cm) at all the stages of growth except at 120 DAS and 150 DAS. The plant height at 30 DAS, 60 DAS, 90 DAS, 180 DAS and at harvest were 18.17 cm, 88.10 cm, 134.86 cm, 181.17 cm and 184.29 cm, respectively.

Table 16a. Plant height (cm) of pigeonpea as influenced by integreated nutrient management at different growth stages

Stages / Organics Sunflower – Pigeonpea	30 DAS				60 DAS				90 DAS				120 DAS			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF – 100% RDF	18.80	19.50	19.00	19.10	90.86	89.89	91.00	90.58	136.92	140.91	139.76	139.19	159.10	171.79	169.66	166.85
100% RDF – 75% RDF	18.41	18.92	18.72	18.68	89.61	89.52	90.00	89.71	136.11	140.59	140.33	139.01	156.20	169.82	167.85	164.62
100% RDF – 50% RDF	18.15	17.98	18.53	18.22	89.00	88.85	86.78	88.21	136.85	133.15	134.19	134.73	155.20	157.11	166.42	159.58
100% RDF – 25% RDF	17.65	17.62	17.99	17.75	87.00	86.87	86.79	86.89	135.08	130.33	131.53	132.32	152.15	150.98	157.11	153.41
100% RDF – No RDF	16.84	17.33	17.15	17.11	82.12	86.45	86.59	85.12	127.01	129.41	130.69	129.04	150.67	149.82	154.38	151.62
Mean	17.97	18.27	18.28	18.17	87.72	88.36	88.23	88.10	134.39	134.88	135.30	134.86	154.66	159.90	163.08	159.22

For comparing the means of

Sources	Org.	Inorg.	Org. x Inorg.	Org.	Inorg.	Org. x Inorg.	Org.	Inorg.	Org. x Inorg.	Org.	Inorg.	Org. x Inorg.
S.Em ±	0.47	0.60	1.05	1.77	2.29	3.96	2.57	3.32	5.75	3.04	3.92	6.79
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	11.36	N.S.

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 16b. Plant height (cm) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organic Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	169.61	185.21	185.72	180.18	185.98	188.98	190.18	188.38	187.21	191.23	192.91	190.45
100% RDF + 75% RDF	164.38	175.04	173.25	170.89	181.71	187.07	186.24	185.00	185.82	191.81	189.46	189.03
100% RDF + 50% RDF	162.42	163.13	172.61	166.06	178.67	180.00	183.72	180.80	182.35	186.54	185.39	184.76
100% RDF + 25% RDF	160.36	158.41	163.72	160.85	177.12	175.28	181.11	177.84	180.61	181.60	180.23	180.82
100% RDF + No RDF	156.56	157.10	160.21	157.96	168.88	173.91	178.67	173.82	177.09	177.09	174.94	176.37
Mean	162.67	167.78	171.11	167.19	178.47	181.05	183.98	181.17	182.62	185.65	184.59	184.29
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S Em ±	3.82	4.94	8.55		3.12	4.03	6.96		2.88	3.72	6.45	
C.D at 5%	N.S.	14.31	N.S		N.S.	N.S.	N.S		N.S.	N.S.	N.S.	

N.S = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Organic sources did not have any significant influence on the plant height (cm) of pigeonpea at any of the stages of growth. However, at harvest vermicompost recorded higher plant height (185.65 cm) than recorded under FYM (182.62 cm) and poultry manure (184.59 cm).

Inorganic fertilizer levels had significant influence on the plant height (cm) of pigeonpea at 120 DAS and 150 DAS. The pigeonpea grown under 100 per cent RDF recorded significantly higher plant height at 120 DAS (166.85 cm) and at 150 DAS (180.18 cm) when compared to that recorded under No RDF (151.62 cm and 157.96 cm).

Interaction effect of organics and inorganics also had non-significant influence on the plant height (cm) of pigeonpea at any of the stages of growth.

4.2.1.2 Number of primary branches per plant

The data on number of primary branches per plant of pigeonpea as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system at different growth stages are presented in Table 17a and b.

Integrated nutrient management in sunflower - pigeonpea intercropping has significant influence on the number of primary branches per plant at all the stages of growth except at 60 DAS.

Organic sources didnot have any significant influence on the number of primary branches per plant at all the stages except at 120 DAS. At 120 DAS, FYM applied treatments significantly reduced the number of primary branches produced by pigeonpea when compared to treatments received poultry manure. The number of primary branches produced in FYM applied pigeonpea at 120 DAS was 8.93 per plant and it was significantly increased to 10.03 per plant under vermicompost applied pigeonpea.

Inorganic fertilizer levels had significant influence on the number of primary branches produced per plant at all the stages of growth except at 60 DAS. The number of primary branches produced in 100 per cent RDF applied pigeonpea at 90 DAS was 7.94 per plant and it was significantly reduced to 6.70 per plant under No RDF level. A similar trend was followed at 120 DAS, 150 DAS, 180 DAS and at harvest. At the time of harvesting, the number of primary branches produced by pigeonpea under 100 per cent RDF level (14.85/plant) was 25 per cent higher than that produced under No RDF (11.18/plant).

Interaction effect of organics and inorganics also had non-significant influence on the number of primary branches produced per plant of pigeonpea at any of the stages of growth.

Table 17a. Number of primary branches per plant of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	60 DAS				90 DAS				120 DAS				150 DAS			
Orgganics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF – 100% RDF	3.23	3.50	3.91	3.55	7.76	7.95	8.10	7.94	10.08	11.08	10.98	10.71	11.68	13.50	13.70	12.96
100% RDF – 75% RDF	3.12	3.50	3.77	3.46	7.60	7.88	7.85	7.78	9.54	10.50	11.05	10.37	10.69	12.03	12.69	11.81
100% RDF – 50% RDF	2.79	3.22	3.46	3.16	7.22	7.59	7.55	7.45	9.63	10.43	10.29	10.12	10.05	11.43	11.70	11.06
100% RDF – 25% RDF	2.85	3.21	3.07	3.04	6.93	7.22	7.22	7.12	8.28	9.55	9.15	8.99	9.40	10.40	10.37	10.06
100% RDF – No RDF	2.59	2.99	2.79	2.79	6.55	6.88	6.68	6.70	7.10	8.68	8.18	7.96	9.04	6.39	9.71	8.38
Mean	2.92	3.28	3.40	3.20	7.21	7.51	7.48	7.40	8.93	10.03	9.93	9.63	10.17	10.75	11.64	10.85
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S Em ±	0.15	0.20	0.34		0.16	0.20	0.35		0.32	0.42	0.72		0.59	0.77	1.32	
C D at 5%	N.S.	N.S.	N.S.		N.S.	0.59	N.S.		0.93	1.21	N.S		N.S.	2.22	N.S.	

N.S = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 17b. Number of primary branches per plant of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	180 DAS				Hervest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	13.09	14.17	14.65	13.97	13.91	15.44	15.20	14.85
100% RDF + 75%RDF	12.60	13.30	13.38	13.09	13.02	14.03	14.05	13.70
100% RDF + 50% RDF	11.98	12.72	12.70	12.47	12.34	13.35	13.42	13.04
100% RDF + 25% RDF	10.71	11.54	11.70	11.32	11.70	12.02	12.10	11.94
100% RDF + No RDF	9.85	10.66	10.70	10.40	11.05	11.04	11.45	11.18
Mean	11.65	12.48	12.63	12.25	12.41	13.18	13.24	12.94
For comparing the means of								
Sources	Org.	Inorg.	Org. x Inorg.		Org	Inorg.	Org. x Inorg.	
S.Em.±	0.34	0.44	0.76		0.55	0.71	1.23	
C.D. at 5%	N.S.	1.26	N.S.		N.S.	2.05	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

4.2.1.3 Number of secondary branches per plant

The data on number of secondary branches per plant of pigeonpea as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 18a and b.

Integrated nutrient management in sunflower - pigeonpea intercropping system has significant influence on the number of secondary branches per plant at all the stages of growth.

Organic sources did not have any significant influence on the number of secondary branches per plant at all the stages except at 150 DAS and 180 DAS. At 150 DAS, poultry manure applied treatments significantly increased the number of secondary branches produced by pigeonpea when compared to treatments received FYM. A similar trend was followed at 180 DAS. The number of secondary branches produced in poultry manure applied pigeonpea at 150 DAS and 180 DAS were 13.68 per plant and 15.05 per plant and these were significantly reduced to 12.28 per plant and 13.31 per plant under FYM applied pigeonpea.

Inorganic fertilizer levels also had significant influence on the number of secondary branches produced per plant at all the stages of growth. The number of secondary branches produced in 100 per cent RDF applied pigeonpea at 90 DAS was 6.01 per plant and it was significantly reduced to 3.89 per

Table 18a. Number of secondary branches per plant of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	90 DAS				120 DAS				150 DAS			
Organics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF – 100% RDF	5.63	5.92	6.50	6.01	11.23	11.99	12.22	11.81	14.09	15.09	15.44	14.87
100% RDF – 75% RDF	5.35	5.77	6.31	5.81	10.01	11.23	11.41	10.88	12.92	14.15	14.47	13.84
100% RDF – 50% RDF	4.28	5.39	4.91	4.86	9.41	10.65	10.31	10.12	12.31	13.26	13.86	13.14
100% RDF – 25% RDF	3.84	4.13	4.64	4.20	8.98	9.69	9.79	9.49	11.42	12.48	12.95	12.28
100% RDF – No RDF	3.28	3.99	4.40	3.89	8.59	9.15	9.81	9.19	10.65	11.75	11.67	11.36
Mean	4.74	5.04	5.35	4.96	9.65	10.54	10.71	10.30	12.28	13.35	13.68	13.10
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	0.26	0.33	0.58		0.38	0.48	0.84		0.36	0.47	0.81	
C.D. at 5%	N.S.	0.97	N.S.		N.S.	1.402	N.S.		1.05	1.36	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 18b. Number of secondary branches per plant of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	180 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	15.11	16.24	16.92	16.09	14.46	14.94	15.42	14.94
100% RDF + 75%RDF	14.41	15.65	15.98	15.35	13.58	14.70	14.91	14.41
100% RDF + 50% RDF	13.59	14.32	14.68	14.19	12.54	13.72	13.98	13.41
100% RDF + 25% RDF	12.33	13.77	14.25	13.45	11.66	13.25	12.77	12.56
100% RDF + No RDF	11.08	13.18	13.41	12.56	10.94	11.95	12.51	11.80
Mean	13.31	14.63	15.05	14.33	12.64	13.72	13.92	13.43
For comparing the means of								
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em ±	0.46	0.59	1.02		0.39	0.51	0.88	
C.D. at 5%	1.32	1.71	N.S.		N.S.	1.470	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

plant under No RDF. A similar trend was followed at 120 DAS, 150 DAS, 180 DAS and at harvest. At the time of harvesting, the number of secondary branches produced by pigeonpea under 100 per cent RDF level (14.94/plant) was 21 per cent higher than that produced under No RDF (11.80/plant).

Interaction effect of organics and inorganics also had non-significant influence on the number of secondary branches produced per plant of pigeonpea at any of the stages of growth.

4.2.1.4 Number of leaves per plant

The data pertaining to the influence of integrated nutrient management in sunflower - pigeonpea intercropping system on number of leaves per plant at different growth stages are presented in Table 19a and b.

Integrated nutrient management in sunflower - pigeonpea intercropping system has significant influence on the number of leaves per plant at all the stages of growht except at 30 DAS.

Organic sources had significant influence on the number of leaves per plant only at 90 DAS, 120 DAS, 150 DAS and 180 DAS. At 90 DAS, vermicompost applied treatments significantly increased the number of leaves produced by pigeonpea when compared to treatments applied with FYM. A similar trend was followed at 120 DAS and 150 DAS. But at 180 DAS, the number of leaves produced under poultry manure

Table 19a. Number of trifotiare leaves per plant of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				120 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	13.77	14.15	14.13	14.02	49.95	52.51	53.24	51.90	139.79	159.76	162.94	154.16	200.69	215.25	219.13	211.69
100% RDF + 75% RDF	13.18	13.64	14.33	13.72	48.65	50.29	51.75	50.23	134.41	156.29	156.77	149.16	192.48	210.15	209.82	204.15
100% RDF + 50% RDF	13.02	13.04	13.35	13.14	46.65	49.12	50.72	48.83	132.48	148.05	141.92	140.82	184.46	196.13	203.39	194.66
100% RDF + 25% RDF	12.55	12.81	12.20	12.52	44.67	47.08	47.43	46.39	128.44	136.61	133.09	132.71	172.88	187.41	186.98	182.42
100% RDF + No RDF	11.64	12.01	11.23	11.63	42.24	44.43	43.30	43.33	124.23	128.91	123.31	125.48	146.15	178.37	164.34	162.96
Mean	12.83	13.13	13.05	13.00	46.43	48.69	49.29	48.14	131.87	145.92	143.61	140.47	179.33	197.46	196.73	191.18
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em.±	0.50	0.64	1.11		1.42	1.84	3.184		2.17	2.80	4.85		3.01	3.90	6.75	
C.D at 5%	N.S.	N.S.	N.S.		N.S.	5.33	N.S.		6.28	8.11	N.S.		8.75	11.30	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 19b. Number of trifoliate leaves per plant of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	190.98	210.64	215.57	205.73	89.64	95.64	95.21	93.50	41.51	45.58	49.33	45.48
100% RDF + 75% RDF	182.97	200.98	206.70	196.89	82.01	86.08	91.74	86.61	40.15	42.76	47.11	43.34
100% RDF + 50% RDF	179.43	186.90	190.79	185.71	76.36	83.08	82.66	80.70	37.57	39.76	41.13	39.48
100% RDF + 25% RDF	164.09	181.88	183.65	176.54	73.74	78.93	78.61	77.09	36.13	37.65	36.18	36.65
100% RDF + No RDF	145.68	177.63	160.73	161.35	69.81	74.97	76.24	73.68	33.57	35.58	35.28	34.81
Mean	172.63	191.61	191.49	185.24	78.31	83.74	84.89	82.32	37.79	40.27	41.80	39.95
For comparing the means of												
Source	Org.	Inorg.	Org x Inorg.		Org.	Inorg	Org. x Inorg.		Org.	Inorg.	Org. x Inorg	
S.Em.±	2.46	3.17	5.50		1.72	2.23	3.86		1.42	1.83	3.17	
C.D. at 5%	7.13	9.20	N.S.		5.00	6.46	N.S.		N.S.	5.30	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

applied pigeonpea was 84.89 per plant and it was significantly decreased to 78.31 per plant recorded in FYM applied pigeonpea.

Inorganic fertilizer levels had significant influence on the number of leaves produced per plant at all the stages of growth except at 30 DAS. The pigeonpea grown under 100 per cent RDF produced significantly higher number of leaves at 60 DAS (51.90/plant), 90 DAS (154.16/plant), 120 DAS (211.69/plant), 150 DAS (205.73/plant), 180 DAS (93.50/plant) and at harvest (45.48/plant). When compared to that produced under No RDF (43.33, 125.48, 162.96, 161.35, 73.68 and 34.81/plant).

Interaction effect of organics and inorganics did not have any significant influence on the number of leaves produced per plant of pigeonpea at any of the stages of growth.

4.2.1.5 Leaf area per plant (dm^2)

The data pertaining to leaf area per plant of pigeonpea as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 20a and b.

Integrated nutrient management in sunflower - pigeonpea intercropping system has significant influence on the leaf area of pigeonpea at all the stages of growth except 30 DAS.

Organic sources had significant influence on the leaf area of pigeonpea only at 90 DAS, 120 DAS, 150 DAS and 180 DAS. The pigeonpea grown under poultry manure recorded significantly higher leaf area at 90 DAS (24.03 dm^2/plant) and 180 DAS (24.79 dm^2/plant) when compared to that recorded under FYM (20.33 and 20.75 dm^2/plant) and these are on par with that recorded under vermicompost (23.35 and 23.75 dm^2/plant). However, during 120 DAS and 150 DAS pigeonpea grown under vermicompost recorded significantly higher leaf area (49.84 and 44.83 dm^2/plant) when compared to that recorded under FYM (45.61 and 38.80 dm^2/plant) and these are on par with that recorded under poultry manure (49.66 and 44.53 dm^2/plant).

Inorganic fertilizer levels also had significant influence on the leaf area of pigeonpea at all the stages of growth except at 30 DAS. At 60 DAS, plants under 100 per cent RDF recorded significantly higher, leaf area (15.89 dm^2/plant) when compared to that recorded under No RDF (12.46 dm^2/plant) and 25 per cent RDF (13.09 dm^2/plant). At 90 DAS, 120 DAS, 150 DAS, 180 DAS and at harvest similar trend was followed. At the time of harvesting, plants under 100 per cent RDF recorded significantly higher leaf area (8.69 dm^2/plant) and it was 37 per cent higher than that recorded under No RDF level (5.47 dm^2/plant).

Table 20a. Leaf area per plant (dm^2) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				120 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	1.96	1.99	1.99	1.98	15.01	15.95	16.72	15.89	23.01	28.82	27.98	26.60	48.26	56.75	55.49	53.50
100% RDF + 75% RDF	1.87	1.93	1.93	1.91	14.45	15.17	15.95	15.19	21.92	25.32	27.01	24.75	46.95	54.01	54.07	51.68
100% RDF + 50% RDF	1.85	1.90	1.90	1.88	13.04	14.21	14.98	14.08	20.81	23.41	23.24	22.49	46.24	46.96	49.85	47.68
100% RDF + 25% RDF	1.81	1.87	1.84	1.84	12.55	13.01	13.72	13.09	18.23	20.21	21.21	19.88	44.41	46.00	45.73	45.38
100% RDF + No RDF	1.79	1.82	1.81	1.80	11.69	12.37	13.33	12.46	17.65	19.01	20.71	19.12	42.18	45.45	43.17	43.60
Mean	1.86	1.90	1.89	1.88	13.35	14.14	14.94	14.14	20.33	23.35	24.03	22.57	45.61	49.84	49.66	48.37
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em ±	0.04	0.05	0.09		0.58	0.75	1.30		0.55	0.71	1.22		0.83	1.07	1.85	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	2.17	N.S.		1.58	2.05	N.S.		2.40	3.09	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 20b. Leaf area per plant (dm^2) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	49.48	55.38	53.75	50.87	24.14	28.35	29.55	27.35	7.98	9.08	9.00	8.69
100% RDF + 75% RDF	44.85	53.41	49.44	49.23	22.11	23.73	28.11	24.65	7.39	8.99	8.67	8.35
100% RDF + 50% RDF	37.09	39.74	44.85	40.56	20.81	23.48	24.89	23.06	6.05	5.45	7.02	6.17
100% RDF + 25% RDF	32.15	38.45	40.52	37.04	18.32	22.10	21.51	20.64	5.88	5.51	6.42	5.94
100% RDF + No RDF	30.43	37.18	34.08	33.90	18.36	21.08	19.87	19.77	5.59	5.40	5.41	5.47
Mean	38.80	44.83	44.53	42.72	20.75	23.75	24.79	23.10	6.58	6.89	7.30	6.92
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	1.12	1.44	2.50		1.06	1.37	2.38		0.35	0.45	0.78	
C.D. at 5%	3.24	4.18	N.S.		3.08	3.97	N.S.		N.S	1.31	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to leaf area per plant of pigeonpea at all the stages of growth.

4.2.1.6 Dry matter production and its accumulation in different parts

4.2.1.6.1 Dry matter production (g/plant)

The data on dry matter produced by pigeonpea as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system at different stages of growth are presented in Table 21a and b.

Integrated nutrient management in sunflower-pigeonpea intercropping system had significant effect on the dry matter produced by pigeonpea at all the stages of growth except at 30 DAS and 60 DAS. The dry matter production at 30 DAS and 60 DAS were 4.79 g/plant and 44.77 g/plant.

Organic sources did not have any significant influence on the dry matter produced by pigeonpea at all the stages of growth except at 120 DAS and 150 DAS. At 120 DAS, poultry manure applied treatments significantly increased the dry matter produced by pigeonpea when compared to treatments received FYM. A similar trend was followed at 150 DAS. The dry matter produced in poultry manure applied pigeonpea at 120 DAS and 150 DAS were 116.20 g/plant and 156.01 g/plant and these were significantly reduced to 102.02 g/plant and 138.99 g/plant under FYM applied pigeonpea.

Table 21a. Dry matter production (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages / Organics Sunflower – Pigeonpea	30 DAS				60 DAS				90 DAS				120 DAS			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF – 100% RDF	4.87	5.01	5.08	4.99	48.60	50.61	51.98	50.40	109.42	115.96	116.94	114.11	114.13	123.31	131.99	123.14
100% RDF + 75% RDF	4.80	4.84	4.94	4.86	44.49	47.00	48.22	46.57	98.80	106.84	105.70	103.78	106.43	116.07	122.78	115.09
100% RDF + 50% RDF	4.69	4.79	4.84	4.77	43.00	42.72	46.50	44.07	95.58	104.00	103.91	101.16	99.99	109.45	115.76	108.40
100% RDF + 25% RDF	4.62	4.72	4.80	4.71	40.54	42.71	43.34	42.20	91.18	98.71	100.62	96.84	97.96	105.85	109.35	104.39
100% RDF + No RDF	4.54	4.64	4.72	4.63	38.87	41.67	41.25	40.60	90.21	93.72	97.50	93.81	91.61	98.79	101.13	97.18
Mean	4.70	4.80	4.88	4.79	43.10	44.94	46.26	44.77	97.04	103.85	104.93	101.94	102.02	110.69	116.20	109.64
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S Em ±	0.08	0.10	0.17		2.14	2.77	4.79		3.51	4.53	7.85		2.47	3.19	5.53	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	13.13	N.S.		7.16	9.25	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 21b. Dry matter production (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	158.83	179.04	183.98	173.95	168.61	172.68	175.95	172.41	151.98	167.21	178.13	165.77
100% RDF + 75% RDF	145.85	160.95	166.99	157.93	159.02	161.32	166.63	162.32	141.17	149.15	161.99	150.77
100% RDF + 50% RDF	135.73	152.07	155.44	147.75	148.72	154.07	157.50	153.43	135.89	139.95	149.24	141.69
100% RDF + 25% RDF	130.22	136.65	141.57	136.14	136.74	142.37	150.41	143.17	128.83	130.52	142.63	133.99
100% RDF + No RDF	124.38	132.40	132.05	129.61	126.18	135.98	136.36	132.84	126.89	126.88	134.26	129.34
Mean	138.99	152.22	156.01	149.08	147.85	153.28	157.37	152.84	136.95	142.74	153.25	144.31
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org	Inorg.	Org. x Inorg.	
S.Em ±	4.01	5.18	8.97		4.08	5.27	9.13		4.73	6.11	10.58	
C.D. at 5%	11.63	15.01	N.S.		N.S.	15.27	N.S.		N.S.	17.71	N.S.	

N.S. = Non-significant

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Inorganic fertilizer levels also had significant influence on the drymatter produced by pigeonpea at all the stages of growth except at 30 DAS and 60 DAS. At 90 DAS plants under 100 per cent RDF recorded significantly higher dry matter production (114.11 g/plant) when compared to that recorded under No RDF (93.81 g/plant) and 25 per cent RDF (96.84 g/plant). At 120 DAS, 150 DAS, 180 DAS and at harvest similar trend was followed. At the time of harvest plants under 100 per cent RDF recorded significantly higher dry matter production (165.77 g/plant) and it was 22 per cent higher than that recorded under No RDF level (129.34 g/plant).

Interaction effect of organics and inorganics was not significant with respect to the dry matter produced by pigeonpea at any of the stages of growth.

4.2.1.6.2 Dry matter accumulation in leaves (g/plant)

The data on dry matter accumulation in leaves of pigeonpea as influenced by integrated nutrient management at different stages of growth are presented in Table 22a and 22b.

Integrated nutrient management in sunflower - pigeonpea intercropping system had significant effect on the dry matter accumulation in the leaves of pigeonpea at all the stages of growth except at 30 DAS.

Organic sources did not have any significant influence on the dry matter accumulation in the leaves of pigeonpea at

all the stages of growth except at 120 DAS and 150 DAS. At 120 DAS, poultry manure received treatments significantly increased the dry matter accumulation in the leaves of pigeonpea when compared to treatments which received FYM. A similar trend was followed at 150 DAS. The drymatter accumulation in the leaves of pigeonpea in poultry manure received treatments at 120 DAS and 150 DAS were 30.77 g/plant and 27.78 g/plant and these were significantly reduced to 24.97 g/plant and 21.96 g/plant under FYM received treatments.

Inorganic fertilizer levels significantly reduced the dry matter accumulation in leaves of pigeonpea at all the stages of growth except at 30 DAS. At 60 DAS, the dry matter accumulated in pigeonpea leaves under 100 per cent RDF level was significantly higher (18.43 g/plant) than the dry matter accumulated in leaves of pigeonpea under no RDF level (13.14 g/plant). At 90 DAS, 120 DAS, 150 DAS, 180 DAS and at harvest similar trend was followed. At the time of harvesting the dry matter accumulated in leaves of pigeonpea under 100 per cent RDF level (6.12 g/plant) was 21 per cent higher than that accumulated under No RDF level (4.82 g/plant).

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to the dry matter accumulation in the leaves of pigeonpea at all the stages of growth.

Table 22a. Dry matter accumulation in leaves (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				120 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	2.89	3.01	3.07	2.99	17.77	18.40	19.11	18.43	23.51	27.85	28.79	26.72	28.60	33.51	36.55	32.89
100% RDF + 75% RDF	2.84	2.88	2.95	2.89	14.89	15.60	16.54	15.68	21.24	26.17	26.43	24.62	25.95	31.75	33.29	30.33
100% RDF + 50% RDF	2.79	2.85	2.88	2.84	13.82	14.54	15.37	14.58	20.02	24.65	24.70	23.12	23.91	29.43	31.19	28.18
100% RDF + 25% RDF	2.76	2.82	2.87	2.82	12.67	13.49	14.25	13.47	18.25	21.72	23.01	20.99	24.06	28.68	28.22	26.99
100% RDF + No RDF	2.72	2.77	2.80	2.76	12.15	13.69	13.58	13.14	17.17	18.98	21.08	19.08	22.35	25.69	24.58	24.21
Mean	2.80	2.87	2.91	2.86	14.26	15.15	15.77	15.06	20.04	23.87	24.80	22.91	24.97	29.81	30.77	28.52
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em ±	0.05	0.07	0.12		0.57	0.74	1.28		0.79	1.03	1.78		1.23	1.59	2.76	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	2.15	N.S.		N.S.	2.97	N.S.		3.57	4.61	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 22b. Dry matter accumulation in leaves (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	26.77	32.90	32.41	30.69	20.02	21.72	22.63	21.46	6.06	6.16	6.13	6.12
100% RDF + 75% RDF	22.98	28.91	29.96	27.28	17.67	19.01	20.35	19.01	5.08	5.73	6.08	5.63
100% RDF + 50% RDF	21.39	27.63	28.07	25.70	14.95	16.69	19.42	17.02	4.99	5.21	5.33	5.18
100% RDF + 25% RDF	19.71	24.77	25.10	23.19	13.25	15.10	17.43	15.26	4.81	5.28	5.04	5.04
100% RDF + No RDF	18.94	22.95	23.34	21.74	11.26	14.21	15.31	13.59	4.68	5.00	4.79	4.82
Mean	21.96	27.43	27.78	25.72	15.43	17.35	19.03	17.27	5.12	5.48	5.48	5.36
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	1.34	1.73	3.00		0.79	1.02	1.77		0.15	0.20	0.34	
C.D. at 5%	3.89	5.02	N.S.		N.S.	2.97	N.S.		N.S.	0.574	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

4.2.1.6.3 Dry matter accumulation in stem (g/plant)

The data pertaining to dry matter accumulation in stem as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system are presented in Table 23a and b.

Integrated nutrient management in sunflower - pigeonpea intercropping system had significant effect on the dry matter accumulation in pigeonpea stem at all the stages of growth except 30 DAS and 60 DAS.

Organic sources did not have any significant influence on the dry matter accumulation in the stem of pigeonpea at all the stages of growth except at 120 DAS and 150 DAS. At 120 DAS, poultry manure received treatments significantly increased the dry matter accumulation in the stem of pigeonpea when compared to the treatments which received FYM. A similar trend was followed at 150 DAS. The dry matter accumulation in the stem of pigeonpea in poultry manure received treatments at 120 DAS and 150 DAS are 82.32 g/plant and 85.08 g/plant and these were significantly reduced to 73.52 g/plant and 74.81 g/plant under FYM received treatments.

Inorganic fertilizer levels significantly reduced the dry matter accumulation in stem of pigeonpea at all the stages of growth except at 30 DAS and 60 DAS. At 90 DAS, the dry matter accumulated in pigeonpea stem under 100% RDF level was significantly higher (84.70 g/plant) than the dry matter

Table 23a. Dry matter accumulation in stem (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	30 DAS				60 DAS				90 DAS				120 DAS			
Organics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	1.98	2.00	2.01	2.00	29.65	31.02	31.67	30.78	83.62	85.25	85.24	84.70	81.61	86.39	91.63	86.54
100% RDF + 75% RDF	1.96	1.96	1.99	1.97	28.43	30.22	30.48	29.71	75.42	78.06	76.67	76.72	76.76	81.22	86.13	81.37
100% RDF + 50% RDF	1.90	1.94	1.96	1.93	28.02	29.28	29.94	29.08	73.45	76.94	76.81	75.74	72.53	77.28	71.45	77.09
100% RDF + 25% RDF	1.86	1.90	1.93	1.90	26.72	28.05	27.92	27.56	70.79	74.60	75.28	73.56	70.69	74.89	78.09	74.56
100% RDF + No RDF	1.82	1.87	1.92	1.87	25.57	26.81	26.51	26.29	70.94	72.73	74.34	72.67	66.01	71.01	74.31	70.44
Mean	1.90	1.94	1.96	1.93	27.68	29.08	29.30	28.69	74.85	77.52	77.67	76.68	73.52	78.16	82.32	78.00
For comparing the means of																
Sources	Org.	Inorg	Org. x Inorg.		Org	Inorg	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em ±	0.03	0.03	0.06		1.09	1.41	2.45		2.06	2.66	4.61		2.27	2.94	5.08	
C.D. at 5%	N.S.	N.S.	N.S.		N.S	N.S	N.S.		N.S.	7.72	N.S.		6.59	8.51	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 23b. Dry matter accumulation in stem (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower – Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	87.41	95.91	99.08	94.13	96.28	98.08	98.75	97.70	92.76	100.50	105.68	99.64
100% RDF + 75% RDF	76.18	85.15	88.68	83.34	90.58	91.51	90.58	90.89	87.43	90.92	96.58	91.64
100% RDF + 50% RDF	71.82	82.29	84.65	79.59	85.67	86.35	86.95	86.33	83.69	83.79	91.54	86.34
100% RDF + 25% RDF	71.26	77.68	79.79	76.24	80.75	80.88	80.43	80.69	80.67	78.00	88.08	82.25
100% RDF + No RDF	67.36	75.74	73.20	72.10	78.01	76.53	75.94	76.83	79.85	78.85	81.72	80.14
Mean	74.81	83.36	85.08	81.08	86.26	86.67	86.53	86.49	82.88	86.41	92.72	90.67
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	2.72	3.51	6.09		2.52	3.26	5.65		4.70	6.07	10.52	
C.D. at 5%	7.89	10.19	N.S.		N.S.	9.44	N.S.		N.S.	17.60	N.S.	

N.S. = Non-significant

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

accumulated in pigeonpea stem under No RDF level (72.67 g/plant). At 120 DAS, 150 DAS, 180 DAS and at harvest similar trend was followed. At the time of harvesting, the dry matter accumulated in stem of pigeonpea under 100 per cent RDF level (99.64 g/plant) was 20 per cent higher than that accumulated under no RDF level (80.14 g/plant).

There were no significant differences in the dry matter accumulation in stem of pigeonpea due to interaction effect of organic sources and inorganic fertilizer levels at any of the stages of growth.

4.2.1.6.4 Dry matter accumulation in petioles (g/plant)

The data pertaining to dry matter accumulation in petioles of pigeonpea as influenced by integrated nutrient management at different stages of growth are presented in Table 24a and b.

Integrated nutrient management in sunflower – pigeonpea intercropping system had significant effect on the dry matter accumulation in petioles of pigeonpea at all the stages of growth except at 60 DAS.

Organic sources have non-significant influence on the dry matter accumulation in the petioles of pigeonpea at all the stages of growth except at 120 DAS, 150 DAS and 180 DAS. At 120 DAS, poultry manure received pigeonpea significantly increased the dry matter accumulation in the petioles when

compared to pigeonpea which received FYM. A similar trend was followed at 150 DAS. But, the dry matter accumulation in the petioles of pigeonpea in vermicompost received treatments at 180 DAS recorded significantly higher (1.76 g/plant) than the dry matter accumulated in petioles of pigeonpea under FYM received treatments (1.50 g/plant).

Inorganic fertilizer levels significantly reduced the dry matter accumulation in petioles of pigeonpea at all the stages of growth except at 60 DAS. At 90 DAS, the dry matter accumulated in petioles of pigeonpea under 100 per cent RDF level was significantly higher (2.69 g/plant) than the dry matter accumulation in petioles of pigeonpea under No RDF level (2.06 g/plant). At 120 DAS, 150 DAS, 180 DAS and at harvest similar trend was followed. At the time of harvesting, the dry matter accumulation in petioles of pigeonpea under 100 per cent RDF level (1.58 g/plant) was 27 per cent higher than that accumulated under No RDF level (1.16 g/plant).

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to dry matter accumulated in pigeonpea petioles at any of the stages of growth.

4.2.1.6.5 Dry matter accumulation in pods (g/plant)

The data pertaining to influence of integrated nutrient management on the dry matter accumulation in pods at 150 DAS, 180 DAS and at harvest are presented in Table 25.

Table 24a. Dry matter accumulation in petiole (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	60 DAS				90 DAS				120 DAS			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	1.18	1.19	1.20	1.19	2.29	2.86	2.91	2.69	3.25	3.41	3.81	3.49
100% RDF + 75% RDF	1.16	1.18	1.20	1.18	2.14	2.61	2.60	2.45	3.05	3.43	3.36	3.28
100% RDF + 50% RDF	1.16	1.18	1.19	1.18	2.11	2.41	2.40	2.31	2.88	2.74	3.12	2.91
100% RDF + 25% RDF	1.15	1.17	1.17	1.17	2.14	2.39	2.33	2.28	2.54	2.28	3.03	2.62
100% RDF + No RDF	1.15	1.17	1.16	1.16	2.10	2.01	2.08	2.06	2.25	2.09	2.24	2.19
Mean	1.16	1.18	1.19	1.17	2.15	2.46	2.46	2.36	2.80	2.79	3.11	2.90
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em ±	0.02	0.03	0.05		0.10	0.13	0.22		0.10	0.13	0.22	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	0.37	N.S.		0.29	0.38	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 24b. Dry matter accumulation in petiole (g/plant) of pigeonpea as influenced by integrated nutrient management at different growth stages

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower - Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	2.76	3.49	3.84	3.63	1.79	1.95	2.17	1.97	1.53	1.57	1.63	1.58
100% RDF + 75% RDF	2.78	3.44	3.32	3.18	1.62	1.98	1.75	1.78	1.25	1.29	1.41	1.32
100% RDF + 50% RDF	2.75	2.66	3.11	2.84	1.52	1.83	1.66	1.67	1.11	1.42	1.28	1.27
100% RDF + 25% RDF	2.61	2.51	2.70	2.61	1.49	1.68	1.67	1.61	1.09	1.29	1.20	1.19
100% RDF + No RDF	2.11	2.30	2.49	2.30	1.07	1.35	1.17	1.20	1.18	1.19	1.10	1.16
Mean	2.60	2.88	3.09	2.86	1.50	1.76	1.68	1.65	1.23	1.35	1.32	1.30
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org	Inorg.	Org. x Inorg.	
S Em±	0.12	0.16	0.27		0.06	0.08	0.14		0.06	0.08	0.14	
C.D. at 5%	0.36	0.46	N.S.		0.19	0.24	N.S.		N.S.	0.23	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Integrated nutrient management in sunflower - pigeonpea intercropping system had significant influence on the dry matter accumulation in pods at 150 DAS, 180 DAS and at harvest.

Organic sources significantly reduced the dry matter accumulation in pigeonpea pods at 150 DAS, 180 DAS and at harvest. The dry matter accumulated in pods at 150 DAS, 180 DAS and at harvest under poultry manure treated pigeonpea were 40.06, 50.12 and 53.86 g per plant and these were respectively reduced to 34.89, 44.67 and 44.98 g per plant under FYM treated pigeonpea. The reduction in dry matter accumulated in pods of FYM treated pigeonpea were 13, 11 and 16 per cent when compared to the poultry manure treated pigeonpea at 150 DAS, 180 DAS and at harvest respectively.

Inorganic fertilizer levels had significant influence on the dry matter accumulation in pods at 150 DAS, 180 DAS and at harvest. Under 100 per cent RDF level, pigeonpea accumulated significantly higher dry matter in pods at 150 DAS (45.52 g/plant), 180 DAS (51.28 g/plant) and at harvest (58.21 g/plant) when compared to the dry matter accumulated in pods under 100 per cent RDF level was 22 and 26 per cent higher than that accumulated under 25 per cent RDF and No RDF levels, respectively.

The dry matter accumulation in pigeonpea pods was not influenced by the interaction effect of organic sources and

Table 25. Dry matter accumulation in pods (g/plant) of pigeonpea as influenced by integrated nutrient management at 150 DAS, 180 DAS and at Harvest

Stages	150 DAS				180 DAS				Harvest			
Organics Sunflower - Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF - 100% RDF	41.18	46.74	48.65	45.52	50.52	50.93	52.40	51.28	50.96	58.98	64.69	58.21
100% RDF - 75% RDF	39.24	43.45	46.03	42.57	49.15	48.82	53.95	50.64	46.74	51.21	57.92	51.96
100% RDF - 50% RDF	32.10	39.36	39.61	37.02	46.58	49.20	49.47	48.41	45.43	49.53	51.76	48.91
100% RDF - 25% RDF	31.97	31.68	33.98	32.54	41.25	44.71	50.88	45.61	41.59	45.95	48.31	45.28
100% RDF - No RDF	29.97	31.41	33.02	31.47	35.84	43.89	43.93	41.22	40.18	41.84	46.65	42.89
Mean	34.89	38.53	40.06	37.83	44.67	47.51	50.12	47.43	44.98	49.50	53.86	49.45
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em±	1.27	1.64	2.85		1.28	1.66	2.85		1.94	2.51	4.35	
C.D. at 5%	3.69	4.76	N.S.		3.70	4.78	N.S.		5.63	7.27	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

inorganic fertilizer levels in sunflower - pigeonpea intercropping system.

4.2.2 Yield and yield components

4.2.2.1 Number of pods per plant

The data on number of pigeonpea pods per plant as influenced by integrated nutrient management are presented in Table 26.

Integrated nutrient management in sunflower - pigeonpea intercropping system had significant influence on the number of pods produced by pigeonpea.

Organic sources had significant influence on the number of pods produced by pigeonpea. The number of pods produced by poultry manure received pigeonpea was significantly higher (96.45/plant) than that produced under FYM received pigeonpea (85.36/plant). Pigeonpea pods produced under FYM treated pigeonpea was 12 per cent lower than that produced under poultry manure treated pigeonpea.

Inorganic fertilizer levels had significant influence on the number of pods produced by pigeonpea. The pigeonpea grown under 100 per cent RDF level produced significantly higher number of pods per plant (115.07) and it was 29 and 46 per cent higher than that produced under 25 per cent RDF level (81.52) and No RDF level (66.68), respectively.

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to the number of pods produced by pigeonpea.

4.2.2.2 Number of seeds per pod

The data pertaining to number of seeds per pod as influenced by integrated nutrient management are presented in Table 26.

Organic sources, inorganic fertilizer levels and their interactions did not affect the number of pigeonpea seeds per pod significantly. However, the number of seeds per pod ranged from 3.53 to 3.78 in different treatments.

4.2.2.3 Seed yield per plant (g)

The data on seed yield per plant as influenced by integrated nutrient management are presented in Table 26.

Integrated nutrient management in sunflower - pigeonpea intercropping system had significant influence on the seed yield of pigeonpea per plant.

Organic sources had significant influence on seed yield of pigeonpea per plant. The seed yield of pigeonpea per plant recorded under vermicompost received treatment (32.57 g/plant) was 18 per cent higher than that recorded under FYM received treatment (26.87 g/plant) and it was on par with that recorded under poultry manure received treatment (32.18 g/plant).

Inorganic fertilizer levels had significant effect on the seed yield of pigeonpea per plant. The pigeonpea grown under 100 per cent RDF level recorded significantly higher seed yield (36.35 g/plant) and it was 23 and 30 per cent higher than that recorded under 25 per cent RDF level (27.92 g/plant) and No RDF level (25.43 g/plant), respectively.

Interaction effect of organics and inorganic fertilizer levels was not significant with respect to seed yield per plant of pigeonpea.

4.2.2.4 Hundred seed weight (g)

The data on hundred seed weight of pigeonpea as influenced by integrated nutrient management are presented in Table 26.

Effect of organic sources, inorganic fertilizer levels and their interactions were not significant on 100-seed weight (g). However, 100-seed weight ranged from 10.62 to 11.87 g under different treatments.

4.2.2.5 Seed yield (q/ha)

The data on seed yield of pigeonpea as influenced by integrated nutrient management are presented in Table 27.

Integrated nutrient management in sunflower – pigeonpea intercropping system had significant effect on seed yield of pigeonpea.

Plate 9. General view of the experimental plot after sunflower harvest

Plate 10. Pigeonpea plants showing T_7, T_{14} and T_3 treatments

Table 26. Yield components of pigeonpea as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	No. of pods per plant				No. of seeds per pod				Seed yield per plant (g)				100 seed weight (g)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	107.97	115.46	121.77	115.07	3.73	3.78	3.74	3.75	30.77	38.81	39.47	36.35	11.30	11.32	11.32	11.31
100% RDF + 75% RDF	88.08	106.72	107.69	100.83	3.70	3.72	3.71	3.71	29.46	34.96	34.50	32.97	11.21	11.15	11.15	11.17
100% RDF + 50% RDF	83.88	92.71	102.85	93.15	3.66	3.68	3.68	3.67	25.94	32.97	31.14	30.01	10.92	11.28	11.26	11.15
100% RDF + 25% RDF	81.67	80.56	82.32	81.52	3.58	3.59	3.59	3.59	24.70	29.97	29.09	27.92	10.74	10.67	11.87	10.76
100% RDF + No RDF	65.21	67.18	67.65	66.68	3.53	3.55	3.54	3.54	23.46	26.11	26.70	25.43	10.98	10.62	11.02	10.87
Mean	85.36	92.53	96.45	91.45	3.64	3.66	3.65	3.65	26.87	32.57	32.18	30.54	11.03	11.01	11.12	11.05
For comparing the means of																
Sources	Org	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em.±	2.97	3.83	6.63		0.10	0.13	0.23		1.71	2.21	3.83		0.28	0.35	0.62	
C.D. at 5%	8.60	11.01	N.S.		N.S.	N.S.	N.S.		4.97	6.41	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Organic sources did not have significant influence on the seed yield (q/ha) of pigeonpea. However, the pigeonpea grown under poultry manure recorded higher seed yield (8.37 q/ha) than recorded under FYM (8.01 q/ha) and vermicompost (8.27 q/ha).

Inorganic fertilizer levels had significant effect on seed yield of pigeonpea. The seed yield of pigeonpea recorded under 100 per cent RDF level was significantly higher (8.80 q/ha) when compared to that recorded under 25 per cent RDF level (8.06 q/ha) and No RDF level (7.38 q/ha). However, the seed yield recorded under 75 per cent RDF level (8.46 q/ha) and 50 per cent RDF level (8.37 q/ha) were on par with that recorded under 100 per cent RDF level. The seed yield of pigeonpea recorded under 100 per cent RDF level was eight and sixteen per cent higher than that recorded under 25 per cent RDF level and No RDF level, respectively.

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to the seed yield of pigeonpea.

4.2.2.6 Stalk yield (q/ha)

The data pertaining to stalk yield of pigeonpea as influenced by integrated nutrient management are presented in Table 27.

Organic sources did not have any significant effect on the stalk yield (q/ha) of pigeonpea. However, the pigeonpea grown under vermicompost recorded higher stalk yield (27.55 q/ha) than recorded under FYM (26.87 q/ha) and poultry manure (26.81 q/ha).

Variation in inorganic fertilizer levels influenced the stalk yield of pigeonpea significantly. The stalk yield of pigeonpea recorded under 100 per cent RDF level was significantly higher (30.89 q/ha) when compared to that recorded under 25 per cent RDF level (25.05 q/ha) and No RDF level (23.66 q/ha). However, the stalk yield recorded under 75 per cent RDF level (28.61 q/ha) and 50 per cent RDF level (27.16 q/ha) were on par with that recorded under 100 per cent RDF level. The stalk yield of pigeonpea recorded under 100 per cent RDF level was 19 and 23 per cent higher than that recorded under 25 per cent RDF level and No RDF level, respectively.

Interaction effect of organic sources and inorganic fertilizer levels was not significant with respect to the stalk yield of pigeonpea.

4.2.2.7 Harvest index (HI)

The data on harvest index of pigeonpea as influenced by integrated nutrient management are presented in Table 27.

Table 27. Seed yield (q/ha), stalk yield (q/ha) and harvest index of pigeonpea and sunflower seed equivalent yield (q/ha) as influenced by integrated nutrient management

Org Sunflower + Pigeonpea	Pigeonpea yield (q/ha)				Pigeonpea Stalk yield (q/ha)				Pigeonpea Harvest index				Sunflower seed equivalent yield (q/ha)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	8.61	8.81	8.98	8.80	30.09	31.51	31.08	30.89	0.222	0.218	0.224	0.221	22.10	24.16	23.92	23.39
100% RDF + 75% RDF	8.32	8.67	8.38	8.46	28.72	28.83	28.25	28.61	0.224	0.231	0.228	0.228	21.51	23.90	22.98	22.79
100% RDF + 50% RDF	8.02	8.52	8.58	8.37	26.68	27.68	27.12	27.16	0.231	0.235	0.240	0.235	20.77	23.42	22.17	22.12
100% RDF + 25% RDF	7.89	7.85	8.45	8.06	24.89	25.40	24.87	25.05	0.240	0.236	0.253	0.243	20.56	21.31	21.44	21.10
100% RDF + No RDF	7.21	7.48	7.45	7.38	23.95	24.31	22.72	23.66	0.231	0.235	0.246	0.237	19.24	19.89	19.95	19.69
Mean	8.01	8.27	8.37	8.22	26.87	27.55	26.81	27.08	0.230	0.231	0.238	0.233	20.84	22.54	22.08	21.82
For comparing the means of																
Sources	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em.±	0.19	0.24	0.42		1.21	1.56	2.71		0.004	0.005	0.009		0.46	0.59	1.03	
C.D. at 5%	N.S.	0.70	N.S.		N.S.	4.53	N.S.		N.S.	0.015	N.S.		1.33	1.72	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

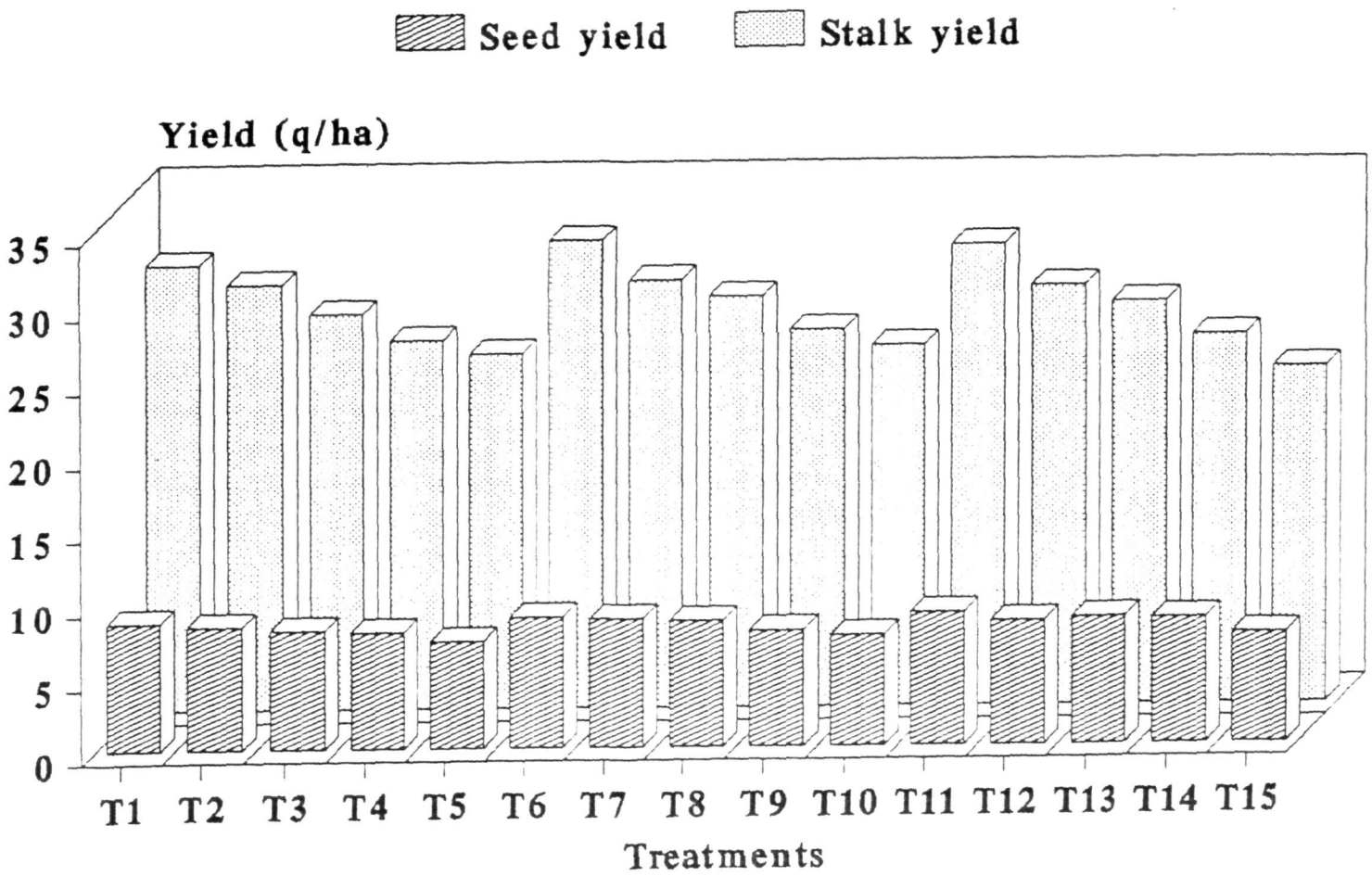


Fig. 4. Seed and stalk (q/ha) yield of pigeonpea as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system

Plate 11. Pigeonpea plants showing T_{14} and T_3 treatments

Plate 12. Pigeonpea plants showing T_7 and T_3 treatments

Organic sources did not have any significant influence on the harvest index of pigeonpea. However, pigeonpea grown under poultry manure recorded higher harvest index (0.238) than that recorded under FYM (0.230) and vermicompost (0.231).

Inorganic fertilizer levels had significant influence on the harvest index of pigeonpea. The pigeonpea grown under 25 per cent RDF level recorded significantly higher harvest index (0.243) when compared to that recorded under 100 per cent RDF level (0.221).

Interaction effect of organics and inorganic fertilizer levels also had non-significant influence on the harvest index of pigeonpea.

4.3 Sunflower seed equivalent yield (q/ha)

The data on sunflower seed equivalent as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 27.

Organic sources had significant influence on the sunflower seed equivalent. The sunflower seed equivalent recorded under vermicompost was significantly higher (22.54 q/ha) when compared to that recorded under FYM (20.84 q/ha). However, the sunflower seed equivalent recorded under poultry manure (22.09 q/ha) was on par with that recorded under vermicompost. The increase in sunflower seed equivalent under

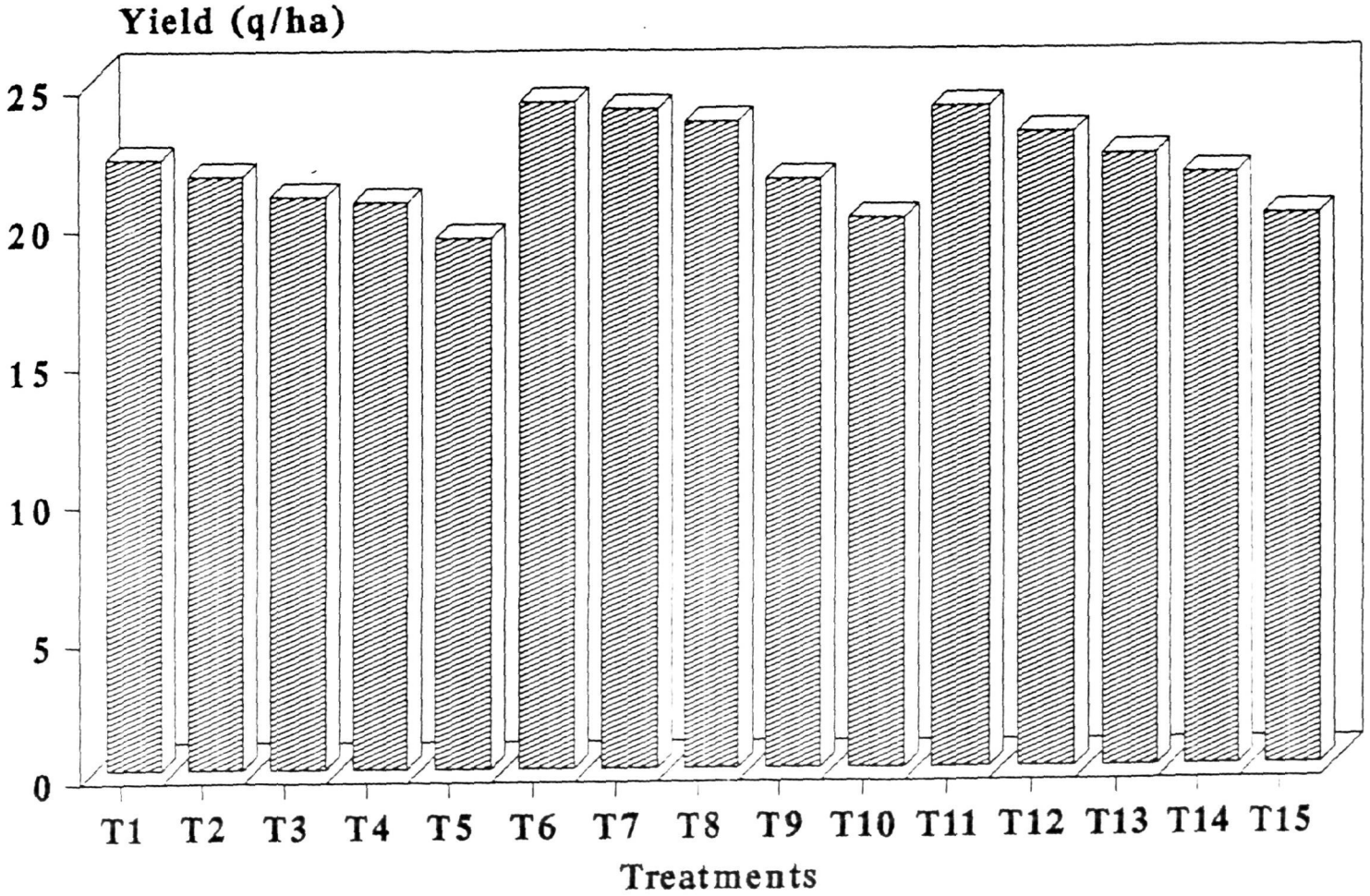


Fig. 5. Sunflower seed equivalent yield (q/ha) as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system

vermicompost was eight per cent over that recorded under FYM.

Inorganic fertilizer levels had significant effect on sunflower seed equivalent. Sunflower seed equivalent recorded under 100 per cent RDF was significantly higher (23.39 q/ha) when compared to that recorded under No RDF (19.69 q/ha). However, sunflower seed equivalent recorded under 75 per cent RDF (22.79 q/ha) and 50 per cent RDF (22.12 q/ha) were on par with that recorded under 100 per cent RDF. The increase in sunflower seed equivalent under 100 per cent RDF was 16 per cent over that recorded under No RDF.

Interaction effect of organic sources and inorganic fertilizer levels did not influence the sunflower seed equivalent significantly.

4.4 Nutrient concentrations and uptake in sunflower and pigeonpea crops

4.4.1 Nutrient concentrations (%)

4.4.1.1 Nutrient concentration of sunflower

The data on mean N, P and K concentration (%) in seeds and stem at harvest of sunflower as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 28a and b.

Organic sources, inorganic fertilizer levels and their interactions did not affect the N, P and K concentration (%) in seeds and stem of sunflower significantly. However, the N, P

Table 28a. Mean N, P, K concentrations (%) in stem and seeds of sunflower as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	Stem N content (%)				Seed N content (%)				Stem P content (%)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	0.62	0.62	0.64	0.63	2.54	2.63	2.65	2.61	0.03	0.03	0.03	0.030
100% RDF + 75% RDF	0.60	0.61	0.61	0.61	2.89	2.59	2.58	2.69	0.03	0.03	0.04	0.030
100% RDF + 50% RDF	0.57	0.59	0.60	0.59	2.63	2.47	2.61	2.57	0.05	0.03	0.03	0.032
100% RDF + 25% RDF	0.57	0.57	0.58	0.57	2.51	2.50	2.49	2.50	0.04	0.03	0.04	0.037
100% RDF + No RDF	0.54	0.54	0.57	0.55	2.53	2.49	2.48	2.50	0.03	0.04	0.04	0.035
Mean	0.58	0.59	0.60	0.59	2.62	2.54	2.56	2.57	0.03	0.03	0.04	0.033
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S Em ±	0.02	0.03	0.05		0.08	0.10	0.18		0.002	0.002	0.004	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant

RDF = Recommended dose of fertilizer

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 28b. Mean N, P, K concentrations (%) in stem and seeds of sunflower as influenced by integrated nutrient management

Stages	Seed P content (%)				Stem K content (%)				Seed K content (%)			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	0.41	0.43	0.42	0.42	0.55	0.58	0.61	0.58	0.72	0.72	0.79	0.74
100% RDF + 75% RDF	0.36	0.39	0.40	0.38	0.40	0.55	0.59	0.51	0.77	0.73	0.82	0.77
100% RDF + 50% RDF	0.43	0.38	0.45	0.42	0.46	0.49	0.56	0.50	0.82	0.73	0.74	0.76
100% RDF + 25% RDF	0.39	0.44	0.38	0.40	0.51	0.46	0.48	0.48	0.72	0.69	0.70	0.70
100% RDF + No RDF	0.45	0.39	0.37	0.40	0.45	0.48	0.47	0.47	0.71	0.81	0.67	0.73
Mean	0.41	0.41	0.40	0.41	0.48	0.51	0.54	0.51	0.75	0.74	0.75	0.74
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S Em ±	0.026	0.033	0.057		0.022	0.028	0.049		0.017	0.023	0.039	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

and K concentration in seeds were 2.57, 0.41 and 0.74 per cent, respectively and in stem were 0.59, 0.033 and 0.51 per cent, respectively.

4.4.1.2 Nutrient concentration of pigeonpea

The data on mean N, P and K concentration (%) in seeds and stem at harvest of pigeonpea as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 29a and b.

Organic sources recorded significant differences with respect to only P and K nutrients. Application of poultry manure recorded significnatly higher P content both in stem and seeds (0.14% and 0.39%) than recorded under FYM (0.12% and 0.30%). Poultry manure received treatment recorded significantly higher K content both in stem and seeds (1.35% and 1.26%) than recorded under FYM (1.20% and 1.18%).

With different levels of RDF, significant variations in nutrient content (N, P and K) in both stem and seeds were observed, significantly higher N content of 1.63 per cent in stem and 4.55 per cent in seeds were recorded with 100 per cent RDF level than recorded under No RDF level (1.29% and 4.06%). A similar trend was observed in case of both P and K nutrients. Significantly higher P and K content in stem (0.14% and 1.42%) and in seeds (0.42% and 1.36%) were recorded with 100 per cent RDF level than recorded under No RDF level (0.10% and 1.12% in stem and 0.25% and 1.17% in seeds).

Table 29a. Mean N, P, K concentrations (%) in stem and seeds of pigeonpea as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	Stem N content (%)				Seed N content (%)				Stem P content (%)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	1.58	1.63	1.67	1.63	4.79	4.40	4.56	4.55	0.13	0.14	0.16	0.14
100% RDF + 75% RDF	1.55	1.59	1.59	1.58	4.19	4.30	4.31	4.26	0.12	0.13	0.15	0.13
100% RDF + 50% RDF	1.52	1.55	1.58	1.55	4.12	4.18	4.22	4.17	0.12	0.12	0.14	0.13
100% RDF + 25% RDF	1.52	1.54	1.58	1.55	4.06	4.10	4.26	4.14	0.11	0.12	0.13	0.12
100% RDF + No RDF	1.28	1.29	1.31	1.29	4.01	4.04	4.11	4.06	0.09	0.10	0.10	0.10
Mean	1.49	1.52	1.55	1.52	4.23	4.20	4.27	4.24	0.12	0.12	0.14	0.124
For comparing the means of												
Source	Org	Inorg	Org. x Inorg.		Org	Inorg	Org. x Inorg		Org.	Inorg.	Org. x Inorg.	
S.Em ±	0.026	0.033	0.058		0.058	0.075	0.130		0.005	0.007	0.012	
C.D. at 5%	N.S.	0.10	N.S.		N.S	0.217	N.S.		0.016	0.020	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Table 29b. Mean N, P, K concentrations (%) in stem and seeds of pigeonpea as influenced by integrated nutrient management

Stages	Seed P content (%)				Stem K content (%)				Seed K content (%)			
Organics Sunflower + Pigeonpea	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	0.39	0.42	0.44	0.42	1.32	1.43	1.52	1.42	1.32	1.38	1.37	1.36
100% RDF + 75% RDF	0.35	0.38	0.42	0.38	1.26	1.29	1.38	1.31	1.21	1.29	1.31	1.27
100% RDF + 50% RDF	0.32	0.33	0.33	0.34	1.24	1.24	1.36	1.28	1.17	1.22	1.26	1.22
100% RDF + 25% RDF	0.27	0.27	0.38	0.30	1.13	1.26	1.30	1.23	1.12	1.20	1.19	1.17
100% RDF + No RDF	0.19	0.23	0.32	0.25	1.07	1.12	1.17	1.12	1.08	1.23	1.19	1.17
Mean	0.30	0.33	0.39	0.34	1.20	1.27	1.35	1.27	1.18	1.26	1.26	1.24
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em.±	0.015	0.020	0.034		0.046	0.060	0.103		0.026	0.034	0.058	
C.D. at 5%	0.044	0.057	N.S.		N.S.	0.173	N.S		0.075	0.097	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

There were no significant differences in the nutrients concentration (N, P and K) in seeds and stem of pigeonpea as influenced by integrated nutrient management.

4.4.2 Nutrient uptake (kg/ha)

4.4.2.1 Nutrient uptake of sunflower (kg/ha)

The data on N, P and K uptake (kg/ha) of sunflower as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 30.

Only organic sources recorded significant difference with respect to only N uptake (kg/ha). Application of vermicompost recorded significantly higher N uptake (277.46 kg/ha) than recorded under FYM (254.76 kg/ha) and it was on par with poultry manure received treatment (275.64 kg/ha). With respect to P and K uptake there were no significant differences. However, higher P and K uptake were recorded with poultry manure (38.59 and 106.70 kg/ha) followed by vermicompost (36.45 and 103.84 kg/ha) and FYM (33.74 and 93.41 kg/ha).

Inorganic fertilizer levels did not have any significant influence on the N, P and K uptake (kg/ha) of sunflower.

Interaction effect of organic sources and inorganic fertilizer levels had non-significant effect on the nutrient (N, P and K) uptake (kg/ha) of sunflower.

Table 30. Nutrient uptake (kg/ha) of sunflower as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	N				P				K			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	248.50	289.02	297.25	278.26	34.61	40.91	41.18	38.90	99.19	115.62	122.95	112.83
100% RDF + 75% RDF	272.90	285.23	275.63	277.92	30.49	36.56	38.89	35.31	91.49	111.42	120.37	107.76
100% RDF + 50% RDF	259.42	278.44	271.32	269.73	35.65	32.58	39.07	35.77	97.11	101.71	110.98	103.27
100% RDF + 25% RDF	249.63	269.62	268.67	263.64	32.29	39.18	37.77	36.41	92.37	91.39	93.01	92.26
100% RDF + No RDF	243.33	264.97	265.31	257.87	35.65	33.01	36.02	34.89	86.15	99.04	86.20	90.46
Mean	254.76	277.46	275.64	269.28	33.74	36.45	38.59	36.26	93.41	103.84	106.70	101.32
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	4.57	5.90	10.21		1.42	1.83	3.16		4.67	6.02	10.44	
C.D. at 5%	13.24	N.S.	N.S.		N.S.	N.S.	N.S.		N.S.	N.S.	N.S.	

N.S. = Non-significant.
RDF = Recommended dose of fertilizer.
FYM = Farmyard manure
VMC = Vermicompost
PM = Poultry manure

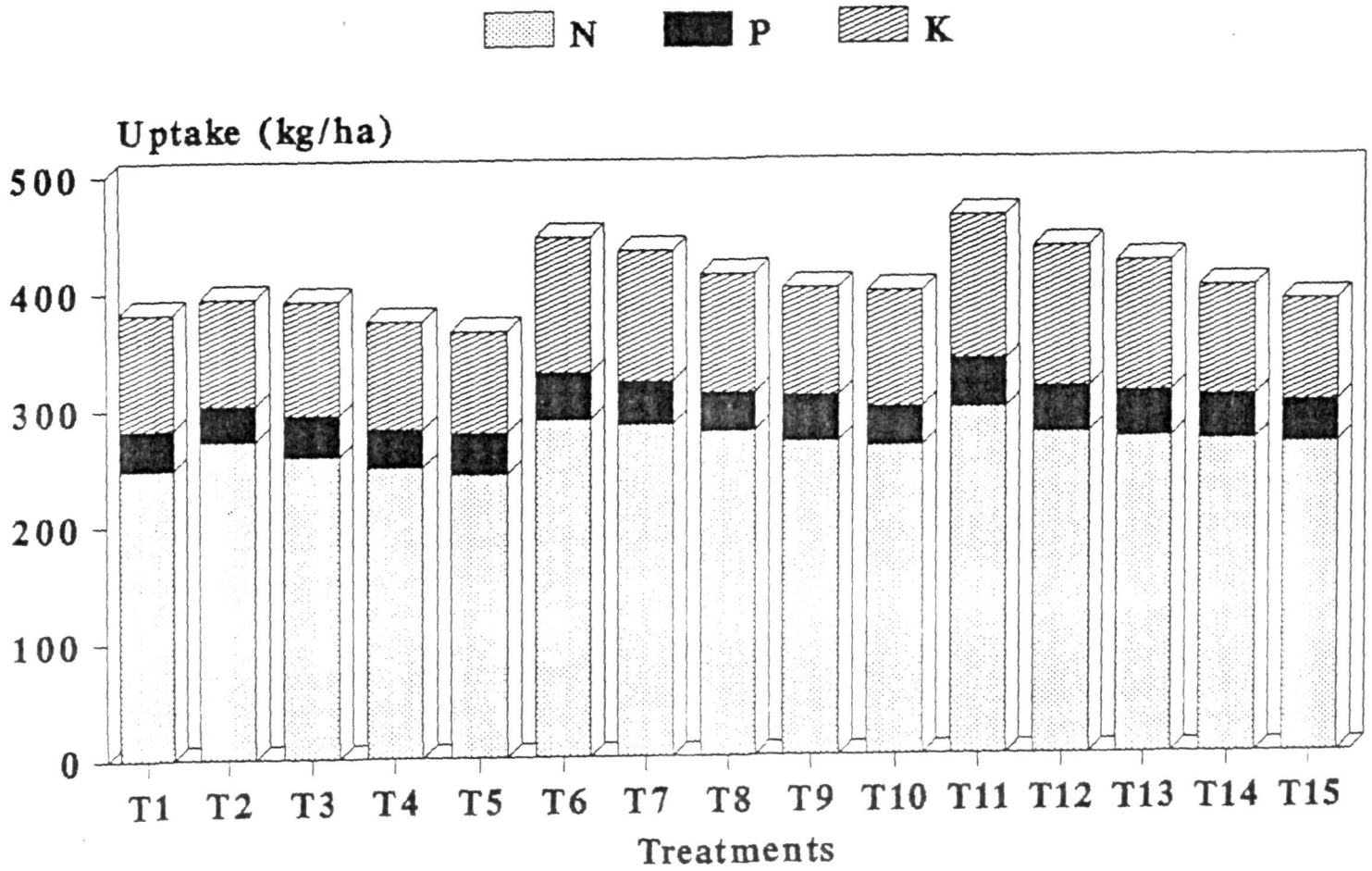


Fig. 6. Nutrient uptake (kg/ha) of sunflower as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system

Table 31. Nutrient uptake (kg/ha) of pigeonpea as influenced by integrated nutrient management

Organics Sunflower + Pigeonpea	N				P				K			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	96.81	100.82	110.97	102.87	40.12	46.94	51.47	46.18	79.02	93.63	106.87	93.17
100% RDF + 75% RDF	81.03	87.84	95.57	88.15	34.86	38.48	43.66	38.10	73.40	76.06	92.33	80.60
100% RDF + 50% RDF	76.61	80.19	86.55	81.12	32.74	34.42	39.10	35.42	59.79	62.97	74.62	65.79
100% RDF + 25% RDF	71.83	73.61	83.29	76.24	28.98	32.10	35.51	32.20	48.94	50.90	72.74	57.53
100% RDF + No RDF	67.12	67.46	72.76	69.11	27.28	29.81	31.74	29.61	35.53	41.87	56.38	44.59
Mean	78.68	81.98	89.83	83.50	32.80	36.35	40.30	36.48	59.34	65.09	80.59	68.34
For comparing the means of												
Source	Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.		Org.	Inorg.	Org. x Inorg.	
S.Em.±	3.94	5.09	8.82		1.71	2.21	3.82		3.54	4.58	7.93	
C.D. at 5%	N.S.	14.75	N.S.		4.95	6.39	N.S.		10.28	13.26	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

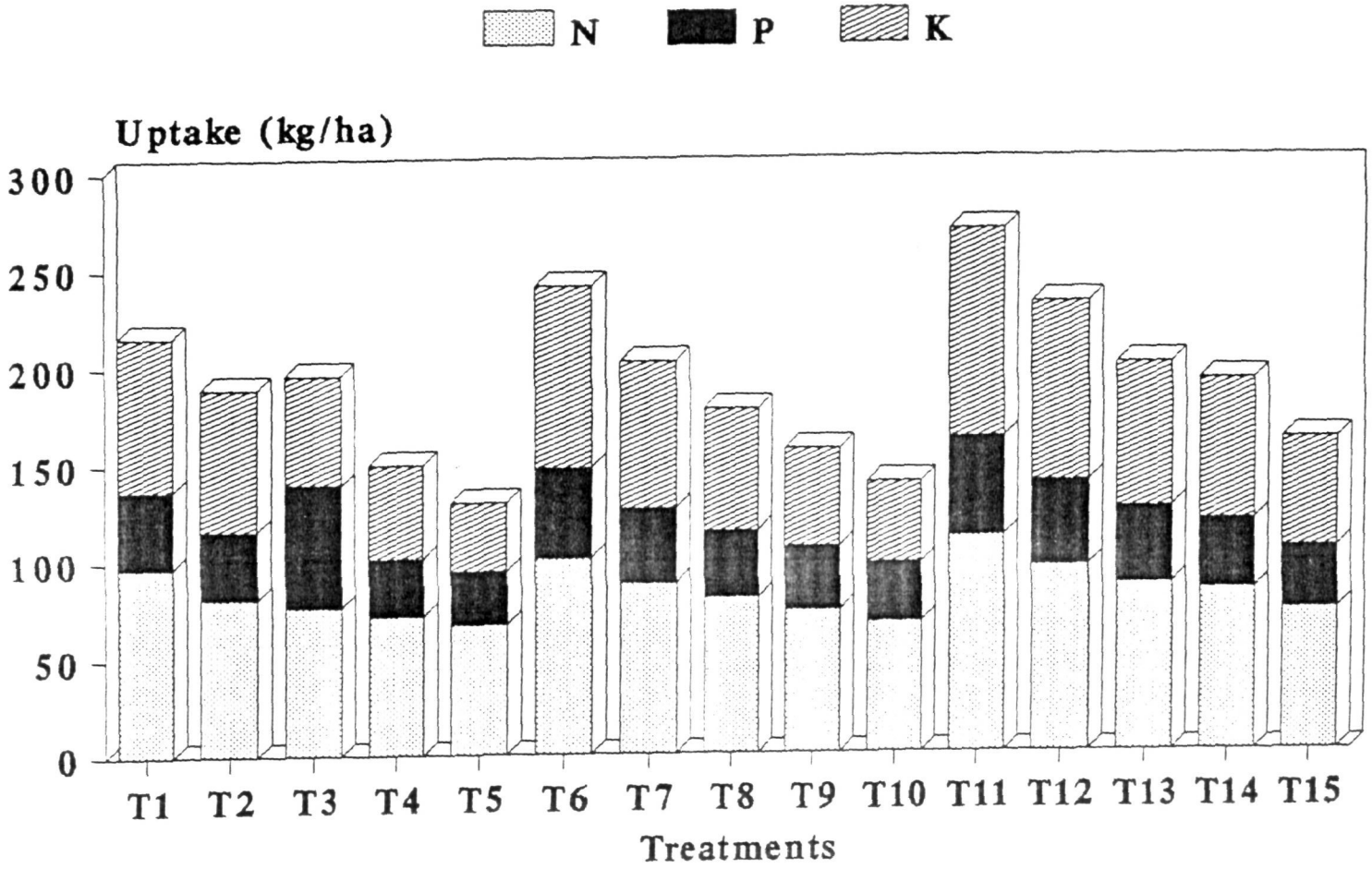


Fig. 7. Nutrient uptake (kg/ha) of pigeonpea as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system

4.5 Soil chemical analysis after harvest

4.5.1 Organic carbon (OC)

The data on organic carbon content in soil after harvest of the crops are presented in Table 32.

Organic sources, inorganic fertilizer levels and their interactions did not affect the organic carbon content of the soil significantly. However, combined application of FYM + 100 per cent RDF recorded highest organic carbon in the soil (0.642%) and least organic carbon was noticed with FYM + No RDF (0.598%).

4.4.2 Available soil nitrogen (kg/ha)

The data on available soil nitrogen (kg/ha) after harvest of the crops are presented in Table 32.

Available soil nitrogen after harvest of the crop differed significantly due to different fertilizer levels. Available soil nitrogen was significantly higher with 100 per cent RDF (172.22 kg/ha) than noticed under No RDF (125.22 kg/ha).

Application of organic sources resulted in non-significant differences in available nitrogen. However, higher available soil nitrogen (153.61 kg/ha) was noticed with application of poultry manure followed by application of vermicompost (153.00 kg/ha) and FYM (145.03 kg/ha).

Available soil nitrogen did not differ significantly due to interactions between organic sources and inorganic fertilizer levels.

4.5.3 Available soil phosporus (P)

Data pertaining to available soil phosphorus are presented in Table 32. There was significant differences between organic sources and inorganic fertilizer levels.

Available soil phosphorus differed significantly due to different levels of inorganic fertilizers. Significantly higher available soil P (32.44 kg/ha) was recorded with 100 per cent RDF than recorded under No RDF (19.48 kg/ha).

Significant differences in available soil phosphorus due to organic sources was noticed. Application of poultry manure recorded significantly higher available soil phosphorus (28.80 kg/ha) than recorded under farm yard manure (24.31 kg/ha) and it was on par with application of vermicompost (28.02 kg/ha).

Available soil phosphorus did not differed significantly due to interaction effects of organic sources and inorganic fertilizer levels.

4.5.4 Available soil potassium

The data on available soil potassium (kg/ha) after harvest of the crops are presented in Table 32.

Table 32. Organic carbon, available nitrogen, phosphorus and potassium in soil after harvest of crops as influenced by organic sources and inorganic fertilizer levels

Organics Sunflower + Pigeonpea	Organic carbon (%)				Available nitrogen (kg/ha)				Available Phosphorus (P) (kg/ha)				Available Potassium (kg/ha)			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	0.642	0.612	0.615	0.623	165.00	173.03	178.65	172.22	32.07	31.57	33.69	32.44	339.46	315.34	313.78	322.86
100% RDF + 75% RDF	0.604	0.613	0.610	0.609	154.83	165.03	162.81	160.89	28.17	30.83	31.58	30.19	268.20	296.27	304.93	289.80
100% RDF + 50% RDF	0.604	0.608	0.613	0.608	145.37	154.97	155.92	152.09	24.24	29.87	29.12	27.74	288.27	293.50	306.59	296.12
100% RDF + 25% RDF	0.603	0.600	0.612	0.608	139.85	146.83	140.28	142.32	21.96	27.69	26.43	25.36	285.86	290.59	300.43	292.29
100% RDF + No RDF	0.598	0.601	0.604	0.601	120.10	125.18	130.39	125.22	15.11	20.15	23.19	19.48	277.33	286.97	300.02	288.11
Mean	0.610	0.609	0.611	0.610	145.03	153.00	153.61	150.55	24.31	28.02	28.80	27.05	291.82	296.53	305.15	297.84
For comparing the means of																
Sources	Org.	Inorg	Org. x Inorg.		Org.	Inorg	Org. x Inorg.		Org.	Inorg.	Org. x Inorg		Org.	Inorg.	Org. x Inorg	
S.Em.±	0.015	0.019	0.033		3.71	4.79	8.30		1.14	1.47	2.55		6.42	8.29	14.36	
C.D. at 5%	N.S.	N.S.	N.S.		N.S.	13.88	N.S.		3.31	4.27	N.S.		N.S.	24.02	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

Variations in inorganic fertilizer levels had significant differences in available soil potassium. Significantly higher available soil potassium (322.86 kg/ha) was noticed with 100 per cent RDF than noticed under No RDF (288.11 kg/ha).

Available soil potassium did not differed significantly due to different organic sources. However, higher available soil potassium (305.15 kg/ha) was recorded with poultry manure followed by vermicompost (296.53 kg/ha) and FYM (291.82 kg/ha).

Available soil potassium did not differ significantly with respect to interactions of organic sources and inorganic fertilizer levels.

4.6 Economics of integrated nutrient management in sunflower - pigeonpea intercropping system

The data on economics as influenced by integrated nutrient management in sunflower - pigeonpea intercropping system are presented in Table 33.

Among the organic sources cost of cultivation was highest with vermicompost (Rs. 8287/ha). This was followed by FYM (Rs. 7718/ha) and poultry manure (Rs. 7298/ha). In case of inorganic fertilizer levels 100 per cent RDF recorded highest cost of cultivation (Rs. 8751/ha) and least cost of cultivation was recorded with No RDF (Rs. 6784/ha). With respect to organic sources and inorganic fertilizer level interaction highest cost of cultivation was recorded under vermicompost +

100 per cent RDF for sunflower and 100 per cent RDF for pigeonpea (Rs. 9437/ha) and least cost of cultivation was recorded with poultry manure + 100 per cent RDF for sunflower and No RDF for pigeonpea (Rs. 6398/ha).

In case of organic sources higher gross returns (Rs. 17622/ha) was recorded with application of vermicompost followed by poultry manure and FYM (Rs. 17545 and 16531/ha, respectively). Among the inorganic fertilizer levels 100 per cent RDF recorded highest gross returns (Rs. 18712/ha) and least gross returns was recorded with No RDF (Rs. 15754/ha). With respect to interactions highest gross returns was recorded under vermicompost + 100 per cent RDF for sunflower and 100 per cent RDF for pigeonpea (Rs. 17622/ha) and least gross returns was recorded with FYM + 100 RDF for sunflower and No RDF for pigeonpea (Rs. 15385/ha).

Net returns were significantly higher with the application of poultry manure (Rs. 10247/ha) than recorded under FYM (Rs. 8813/ha) and vermicompost (Rs. 9334/ha). Among the inorganic fertilizer levels 100 per cent RDF recorded highest net returns (Rs. 9961/ha) and least gross returns was recorded with No RDF (Rs. 8970/ha). With respect to interactions highest net returns was recorded under poultry manure + 100 per cent RDF for both sunflower and pigeonpea (Rs. 10933/ha) and least net returns was recorded with FYM + 100 per cent RDF for sunflower and No RDF for pigeonpea (Rs. 8568/ha).

Table 33. Economics of the integrated nutrient management in sunflower - pigeonpea inter cropping system

Organics Sunflower + Pigeonpea	Cost of cultivation (Rs/ha)				Gross returns (Rs/ha)				Net returns (Rs/ha)				Benefit : Cost ratio			
	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean	FYM	VMC	PM	Mean
100% RDF + 100% RDF	8618	9437	8198	8751	17677	19328	19130	18712	9059	9892	10933	9961	1.05	1.05	1.33	1.14
100% RDF + 75% RDF	8168	8862	7748	8259	17104	18475	18338	17972	8936	9612	10589	9712	1.09	1.08	1.37	1.18
100% RDF + 50% RDF	7718	8287	7298	7767	16531	17622	17545	17233	8813	9334	10247	9465	1.14	1.13	1.40	1.22
100% RDF + 25% RDF	7268	7712	6848	7276	15958	16769	16753	16493	8690	9056	9905	9217	1.19	1.17	1.45	1.27
100% RDF + No RDF	6818	7138	6398	6784	15385	15916	15961	15754	8568	8779	9563	8970	1.26	1.22	1.50	1.33
Mean	7718	8287	7298	7767	16531	17622	17545	17233	8813	9334	10247	9495	1.15	1.13	1.41	1.23
For comparing the means of																
Sources	Org	Inorg.	Org. x Inorg.		Org.	Inorg.	Org x Inorg		Org.	Inorg.	Org. x Inorg		Org	Inorg.	Org. x Inorg	
S Em ±	57.76	74.57	129.16		50.98	65.82	113.99		98.07	126.61	219.29		0.030	0.039	0.068	
C.D at 5%	167.41	216.13	N.S.		147.76	190.75	330.39		284.23	366.94	N.S.		0.088	0.114	N.S.	

N.S. = Non-significant.

RDF = Recommended dose of fertilizer.

FYM = Farmyard manure

VMC = Vermicompost

PM = Poultry manure

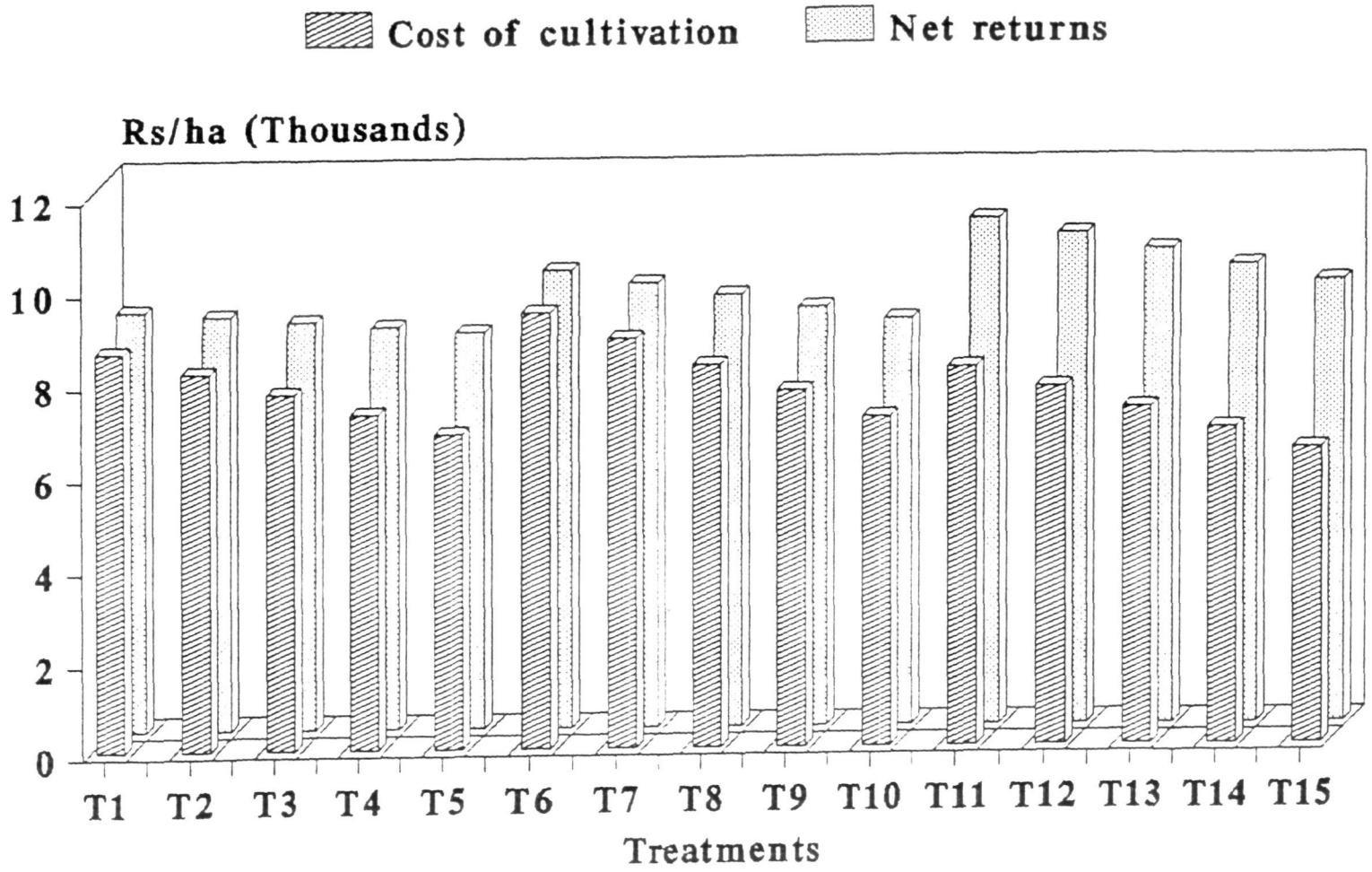


Fig. 8. Cost of cultivation and Net returns (Rs/ha) as influenced by integrated nutrient management in sunflower-pigeonpea intercropping system

Among organic sources significantly higher benefit : cost ratio was noticed in poultry manure (1.41) followed by FYM (1.15) and vermicompost (1.13). With respect to inorganic fertilizer levels No RDF recorded significantly higher B:C ratio (1.33) than recorded under 100 per cent RDF (1.14). There is no significant differences in B:C ratio as influenced by organic sources and inorganic fertilizer levels. However, highest B:C ratio was recorded under poultry manure + 100 per cent RDF for sunflower and No RDF for pigeonpea (1.50) and lowest B:C ratio was noticed under FYM + 100 per cent RDF for both sunflower and pigeonpea crops (1.05).

DISCUSSION

V. DISCUSSION

The results obtained from the experiment conducted during *kharif* season of 1998-99 under rainfed conditions to study the effect of organic sources and inorganic fertilizer levels in sunflower - pigeonpea intercropping system, on the growth and yield of component crops and economics of the integrated nutrient management in sunflower - pigeonpea intercropping system are discussed in this chapter.

The growth and yield of a pure crop is governed by soil and weather parameters besides management practices. Whereas, the imposition of intercropping not only alters the conditions available for the pure crop by competition but also influences the complementarity of one over the other. In the present day context of enhancing the productivity of both the oilseeds and the grain legumes, the combination of the important oilseed crop of sunflower with that of the most potential pulse crop of pigeonpea was brought to accrue greater yield advantages under some optimum combinations. Water and fertility resources to each of these crops and then examine their individual yield potentials as well as the overall productivity of a particular system.

5.1 Weather and crop growth

Crop growth is mainly dependent on environmental factors and fluctuations in weather conditions greatly influence on it. During the year 1998 a well distributed rainfall of 790.20 mm was received (Table 2). The maximum number of rainy days (22) during the month of June 1998-99 were recorded. Meteorological parameters indicated that maximum and minimum temperatures were conducive to crop growth and development. Relative humidity varied from 58 per cent in April to 93 per cent during October. Thus, the overall environment was conducive for better growth at all stages of crops growth.

5.2 Effect of organic sources and inorganic fertilizer levels on yield, yield components and oil content in sunflower and pigeonpea

The integrated nutrient management enrich the soil with nutrients. Which helps in producing higher grain and fodder yield. The integrated nutrient management is the maintainance and possible improvement of soil fertility for sustaining crop productivity on long term basis. This can be achieved by scientific management of different sources of nutrients for optimum growth, yield and quality of different crops.

In case of sunflower, among organic sources application of vermicompost recorded higher seed yield (13.24 q/ha) than poultry manure and FYM (12.68 and 11.83 q/ha). Application of vermicompost was comparable to 100 per cent RDF to sunflower

and 75 per cent RDF to pigeonpea (13.28 q/ha) (Table 15). This indicates the possibility of substitution of organic sources i.e., poultry manure (2.7 t/ha). Effects of poultry manure (12.68 q/ha) were on par with the application of 100 per cent RDF to sunflower and 50 per cent RDF to pigeonpea (12.70 q/ha) and effects of FYM (11.83 q/ha) were on par with the application of 100 per cent RDF to sunflower and 25 per cent RDF to pigeonpea (12.03 q/ha).

The seed yield of sunflower differed non-significantly with the application of organics, inorganic fertilizer levels and their combinations (Table 15). Application of vermicompost + 100 per cent RDF to both sunflower and pigeonpea recorded higher seed yield (14.25 q/ha) than the rest of the treatments. Application of either FYM, vermicompost or poultry manure in conjunction with 100 per cent RDF for both sunflower and pigeonpea increased the seed yield by 10.47, 19.44 and 16.22 per cent, respectively over application of either FYM, vermicompost or poultry manure in conjunction with 100 per cent RDF to sunflower and No RDF to pigeonpea. At 100 per cent RDF to sunflower and 75 per cent RDF to pigeonpea the per cent increase in seed yield with combination of any organics were 8.47, 18.87 and 14.61 per cent as compared to either FYM, vermicompost or poultry manure in conjunction with 100 per cent RDF to sunflower and No RDF to pigeonpea, respectively.

These studies indicate that, application of 100 per cent RDF to both sunflower and pigeonpea + vermicompost or 100 per cent RDF to both sunflower and pigeonpea + poultry manure helps to get higher yields of sunflower as compared to 100 per cent RDF to both sunflower and pigeonpea + FYM.

In case of pigeonpea, application of poultry manure recorded higher seed yield (8.37 q/ha) than vermicompost and FYM (8.27 q/ha and 8.01 q/ha). Application of poultry manure was comparable to 100 per cent RDF to sunflower and 50 per cent RDF to pigeonpea (8.37 q/ha) (Table 27). This indicates the possibility of substitution of recommended dose of fertilizer (25:50 kg NP/ha). Effects of vermicompost (8.27 q/ha) was on par with the application of 100 per cent RDF to sunflower and 50 per cent RDF to pigeonpa (8.37 q/ha) and effects of FYM (8.01 q/ha) was on par with the application of 100 per cent RDF to sunflower and 25 per cent RDF to pigeonpea (8.06 q/ha).

The seed yield of pigeonpea differed significantly with the application of inorganic fertilizer levels (Table 27). Application of poultry manure + 100 per cent RDF to both sunflower and pigeonpea recorded higher seed yield (8.98 q/ha) than the rest of the treatments. Application of either FYM, vermicompost and poultry manure in conjunction with 100 per cent RDF for both sunflower and pigeonpea crops increased pigeonpea seed yield by 16.26, 15.09 and 17.04 per cent, respectively over application of either FYM, vermicompost and

poultry manure in conjunction with 100 per cent RDF for only sunflower and No RDF to pigeonpea, respectively.

Integration of either FYM, vermicompost or poultry manure with 100 per cent RDF to both sunflower and pigeonpea and above organics with 100 per cent RDF to sunflower and 50 per cent RDF to pigeonpea were on par indicating the reduction in 50 per cent RDF to an intercrop i.e., pigeonpea by use of organics. Similarly, higher grain yield of sorghum was recorded with application of recommended dose of fertilizer with enriched FYM and soil inoculation of *Azospirillum* (Veerabadran and Rajendran, 1993). At Bangalore 25 to 50 per cent substitution of RDF in sunflwoer and groundnut was observed with application of vermicompost (Kale *et al.*, 1994). Krishnamoorthy (1995) who observed higher grain yield of *kharif* sorghum due to combined application of vermicompost (2.5 t/ha), *Azospirillum* (10 kg/ha) and RDF (100:75:37.5 kg NPK/ha).

Irrespective of organic sources of nutrients with application of 100 per cent recommended dose of fertilizer (RDF) to both sunflower and pigeonpea recorded significantly higher grain yield of pigeonpea (8.80 q/ha) as compared to 25 per cent RDF to pigeonpea and without fertilzier to pigeonpea (Table 27). Reduction in fertilizer dose to pigeonpea decreased the grain yield significantly (either 25 or 0% RDF).

The increase in seed yield of sunflower and pigeonpea with combined application of either FYM, vermicompost or

poultry manure along with 100 per cent RDF to both sunflower and pigeonpea were attributed to their favourable effects on yield components viz., head diameter (12.97 cm), number of seeds per head (964.67), seed yield per plant (28.99 g), 1000-seed weight (32.97 g) and chaffyness per cent (24.72) (Table 12 and 13). In case of pigeonpea, number of pods per plant (115.07), number of seeds per pod (3.75), seed yield per plant (36.35 g) and 100-seed weight (11.31 g) (Table 26).

In case of sunflower, head diameter, number of seeds per head, seed yield per plant, 1000-seed weight and per cent chaffyness were non-significant as influenced by organic sources, inorganic fertilizer levels and their interaction effect. However, irrespective of organic sources of nutrients with application of 100 per cent RDF for both sunflower and pigeonpea recorded higher head diameter, number of seeds per head, seed yield per plant, 1000-seed weight and per cent chaffyness. But, highest sunflower head diameter (13.26 cm) recorded under poultry manure + 100 per cent RDF for both sunflower and pigeonpea crops as compared to other treatments. Similarly highest number of seeds per head (975.33) and 1000-seed weight (33.21 g) were recorded under vermicompost + 100 per cent RDF for both sunflower and pigeonpea. But, per cent chaffyness was highest with FYM + 100 per cent RDF for sunflower and zero per cent RDF to pigeonpea (28.20%) (Table 12 and 13).

These studies indicate that, application of 100 per cent RDF to both sunflower and pigeonpea + vermicompost or 100 per cent RDF to both sunflower and pigeonpea + poultry manure helps to get higher values of yield components of sunflower as compared to 100 per cent RDF to both sunflower and pigeonpea + FYM. This may be attributed to higher per cent of nutrients observed under vermicompost and poultry manure as compared to FYM.

In case of pigeonpea, number of pods per plant and seed yield per plant with 75 per cent RDF to pigeonpea was on par with 100 per cent RDF to pigeonpea was applied in combination with different organics. In case of pigeonpea, number of pods per plant and seed yield per plant with 75 per cent RDF to pigeonpea was on par with 100 per cent RDF to pigeonpea when applied in combination with different organics. But it was significantly higher over no fertilizer and 25 per cent RDF to pigeonpea along with different organics. This may be attributed to slow release of nutrients. Similar results were reported by many workers (Krishnamurthy *et al.*, 1973; Sarig *et al.*, 1988; Porwal and Pushpendra Singh, 1992). Significant correlation was also observed in between chlorophyll content, 1000-grain weight and grain weight on main stem in oats (Grib *et al.*, 1990). Goudreddy *et al.* (1989) recorded application of farmyard manure at the rate of 5 t/ha increase the grain number per ear, grain weight per ear, 1000-grain weight of *rabi* sorghum on medium black soils of Dharwad. Application of

farmyard manure (FYM) @ five and ten tonnes per ha significantly increased the growth, yield attributes and yield of sunflower over no FYM and *Azotobactor* inoculation (Singh and Jagadev Singh, 1998). The increase in yield may also be attributed to the improvement brought about in soil physical conditions like soil structure and increased microbial activity resulting in better moisture utilization (Bhosekar and Raikhelkar, 1990 and Krishnamoorthy, 1995).

Recommended dose of fertilizer in combination with organics has recorded significantly higher harvest index as compared to 50 per cent RDF and No fertilizer treatments in case of pigeonpea. But, in case of sunflower recommended dose of fertilizer in combination with different organic sources did not record significant effect on harvest index (Table 27 and 15).

Combined application of organics with 100 per cent RDF to both the crops has resulted in significantly higher stalk yield as compared to lesser levels of RDF to pigeonpea i.e., 25 per cent RDF and No fertilizer to pigeonpea. But in case of sunflower, the variations in RDF levels to pigeonpea did not affect the sunflower stalk yield significantly (Table 27 and 15).

The higher stalk yield of both sunflower and pigeonpea in combined application of organic sources and 100 per cent RDF for both sunflower and pigeonpea treatments was due to better growth and development resulted in higher dry matter accumulation in stem, leaves, head, pods, etc., (Table 8, 9, 10,

11, 22a, 22b, 23a, 23b and 25). The increase in stalk yield was also due to more available nitrogen, phosphorus and potassium. This agrees with the findings of Jagtap and Pharande (1982). The oil content (%) in sunflower did not vary significantly (Table 14). This may be due to favourable effect of organic sources in addition to recommended dose of fertilizer.

5.3 Effect of organic sources and inorganic fertilizer levels on growth and growth components of sunflower and pigeonpea

Among the various growth factors that determine the growth of crop, nutrient supply is most important one.

Germination percentage did not differ significantly in both the crops with application of organics and different levels of fertilizers. Being a nutrient exhaustive crops, sunflower and pigeonpea responded to fertilizer application. Irrespective of organic sources, successive increase in recommended dose of fertilizer to pigeonpea has significantly increased the plant height of pigeonpea (Table 16a and b). Similarly increase in vigour of plants with fertilizer appliation was reported by Agnal (1990); Ilirpara *et al.* (1992) and Anon. (1993a). As indicated by plant height, the growth of the plants did not differ significantly with application of FYM, vermicompost and poultry manure. Similar findings were also reported by many workers (Pocovskay *et al.*, 1985) and Sarig *et al.* (1988), Krishnamoorthy and Varanabhaiah (1986).

Application of 100 per cent RDF to both sunflower and pigeonpea recorded higher plant height of both sunflower and pigeonpea as compared to other treatments. This increase in plant heights can be attributed to increased uptake of nitrogen. The results obtained in the present investigation are in accordance with those reported by Gupta and Gupta (1975).

Bheemaiah *et al.* (1986) and Krishnamoorthy (1995), observed increase in growth (plant height) with application of vermicompost, Azospirillum and other organics along with fertilizer. Application of vermicompost in addition to 50 per cent RDF has resulted improvement in plant height (Mastiholi, 1994).

Green leaves per plant in both the crops were highest with the application of organic sources + 100 per cent RDF for both sunflower and pigeonpea at all the stages (Table 5 and 19a and 19b). At Dharwad, during *kharif*, recommended dose of fertilizer has recorded higher number of leaves (Hunshal, 1978).

Integration of either FYM, vermicompost or poultry manure with 100 per cent RDF for both sunflower and pigeonpea has retained higher number of green leaves in sunflower and pigeonpea (5.21 and 154.16) as compared to No fertilizer application to pigeonpea (4.52 and 125.48) at 90 DAS. Krishnamoorthy (1995) reported significantly higher number of green leaves with combined application of vermicompost and *Azospirillum* in *kharif* sorghum. Nijhawan and Kanwar (1952)

reported increase in number of green leaves per plant with vermicompost application. Application of FYM increased green leaves at harvest (Bakale, 1976). Recommended dose of fertilizer to both the crops with organic sources has recorded significantly higher leaf area compared to 25 per cent or without fertilizer to pigeonpea (Table 6, 20a and 20b). These results are in confirmity with Agnal (1990); Hirpara *et al.* (1992) and Ishwar Singh *et al.* (1993). In case of pigeonpea, higher number of trifoliate leaves in above treatment was due to higher number of primary and secondary branches noticed in that treatment compared to other ones (Table 17a, 17b, 18a and 18b).

Recommended dose of fertilizers (RDF) to both crops with organic sources recorded significantly higher dry matter production (DMP) at all the stages of crops growth. Reduction in the fertilizer dose to pigeonpea has an adverse effect on dry matter production (Table 7 and 21a and 21b). However, in sunflower organic sources recorded significant variations among those vermicompost recorded significantly highest dry matter production of sunflower (83.12 g) as compared to FYM (76.42 g) at harvest. Similar observations were made by Warsi (1973) and Agnal (1990).

Further, combined application of either of the organics with 100 per cent RDF for both crops recorded maximum dry matter production during the entire crops growth period as a result of increase in dry matter accumulation in plant parts

viz., leaves, stem, petiole and head (Table 8, 9, 10 and 11) of sunflower and in case of pigeonpea are leaves, stem, petiole and pods (Table 22a, 22b, 23a, 23b, 24a, 24b and 25). These results are in confirmity with the findings of Goudreddy (1982); Devasenapathy and Subbarayalu (1985); Savalagi and Savalagi (1991) and Krishnamoorthy (1995).

Organics along with RDF to both the crops enhanced leaf area per plant (Table 6 and 20a and 20b). Higher leaf area in these treatments could be attributed to increased supply of nutrients upto harvest stages of both the crops. Maintainance of higher leaf area due to application of organics in cojunction with RDF to both the crops during crop growth period resulted in higher leaf area (LA) in these treatments ultimately increased the process of photosynthesis. These results are in confirmity with the findings of Pawar *et al.* (1987), Krishnamurthy *et al.* (1973) and Mastiholi (1994).

5.4 Effect of organic sources and inorganic fertilizer levels on nutrient uptake and nutrient availability in the soil after harvest of the crops

Uptake of N, P and K increased with progressive increase in the levels of fertilizers to pigeonpea. Hundred per cent recommended dose of fertilizer (RDF) along with organic sources resulted in maximum uptake of N, P and K (Table 30 and 31). This might be due to increased availability of nutrients in the soil solution with increase in fertility levels. Uptake of nutrients is infact associated with the metabolic

activities of plants and with the concentration and distribution of ions in the rhizosphere. Similar results were also reported by Roy and Wright (1974) and Deshmukh *et al.* (1994).

Soil analysis after harvest of the crops indicated that, organic carbon content did not differed significantly with variation in fertilizer levels and different organic sources (Table 32). Results are in confirmity with the findings of Anon., 1993b and Mastiholi (1994). Available P and K contents in the soil after harvest of the crops were highest (33 and 309 kg P and K/ha, respectively) with the application of RDF (Anon., 1992).

With respect to sunflower, only uptake of N was significantly higher with vermicompost (277.46 kg/ha) (Table 30) as compared to FYM (254.76 kg/ha) and it was on par with poultry manure (275.64 kg/ha). Uptake of P and K were did not vary significantly. Increase in uptake of N with vermicompost was 8.20 per cent over FYM. Vermicompost and poultry manure were found superior over FYM and recorded significantly higher uptake of N, P and K.

With respect to pigeonpea, uptake of N, P and K were significantly higher with poultry manure as compared to FYM and it was on par with vermicompost (Table 31). Increase in uptake of N, P and K with poultry manure were 12.41, 18.61 and 26.36 per cent, respectively over FYM.

With respect to inorganic fertilizer levels, uptake of N, P and K were significantly higher with 100 per cent RDF (Table 30 and 31) as compared to 50, 25 per cent RDF and No fertilizers to pigeonpea. Increase in uptake of N, P and K with 100 per cent RDF were 21, 23 and 29 per cent, respectively over 50 per cent RDF and 26, 30 and 38 per cent, respectively over 25 per cent RDF and 32, 36 and 52 per cent, respectively over no fertilizer.

The increase in grain and stalk yield and dry matter could be correlated with increase in uptake of N, P and K. It was observed, vermicompost and poultry manure found to alter the nutrient availability and also the plants ability to take up nutrients or even affect the growth mechanism of the plants (Springett and Syers, 1979). The wormi cast forms suitable base for survival of beneficial microbes whose activity is essential for releasing nutrients to higher plants (Atlavinyte and Vanagas, 1982). Application of vermicompost, poultry manure and FYM gave significantly higher N, P and K uptake. It was also observed improvement in physico-chemical and biological properties of soil with addition of organic manures. Krishnamoorthy (1995) also observed higher N, P and K uptake due to addition of vermicompost in conjunction with *Azospirillum*.

Organic carbon content increased due to application of FYM along with 100 per cent RDF for both sunflower and pigeonpea (0.642%) (Table 32). Results are in confirmity with

the findings of Gour *et al.* (1992); Helkaih *et al.* (1981); Hapse (1993) and Krishnamoorthy (1995). While comparing with no fertilizer application to pigeonpea, there was higher organic carbon content (0.623%) with the combined application of either vermicompost, poultry manure or FYM along with 100 per cent RDF to both sunflower and pigeonpea. Similar findings were reported by Koni (1983); Anon. (1993b) and Mastiholi (1994). Application of organic sources along with 100 per cent RDF for both sunflower and pigeonpea recorded highest available N, P and K in the soil (178.65, 33.69 and 339.46 kg/ha). Similar results were found by Rao and Dokhore (1994) and Mastiholi (1994). Kale and Bano (1988) reported that chemical composition of vermicompost was 0.66, 0.99 and 0.40 per cent N, P_2O_5 and K_2O, respectively has increased the availability of phosphorus. Increase in available P with vermicompost application was also reported by Kale *et al.* (1992) observed that phosphorus in the soil was more in vermicompost applied plots followed by FYM. It might be due to higher P content of vermicompost (0.75, 1.12 and 0.52 per cent of N, P_2O_5 and K_2O, respectively).

Uptake of N, P and K was highest with combination of organics and inorganic fertilizers viz., poultry manure + 100 per cent RDF for both sunflower and pigeonpea (275.64, 38.59 and 106.70 kg NPK/ha in sunflower and 89.83, 40.30 and 80.59 kg NPK/ha in pigeonpea, respectively) (Table 30 and 31). This was followed by vermicompost + 100 per cent RDF for both sunflower and pigeonpea were significantly superior over FYM + 100 per cent RDF for both sunflower and pigeonpea. Similar

trend was observed with the combined application of organics along with 50, 25 and 0 per cent RDF. These results are in confirmity with the findings of Kale *et al.* (1992); Alagawadi and Gaur (1992) and Deshmukh *et al.* (1994).

The integrated use of chemical fertilizers along with organic manures are also important for improving the soil properties. Application of poultry manure + 100 per cent RDF for both sunflower and pigeonpea recorded significantly higher available soil nitrogen (Table 32), followed by vermicompost + 100 per cent RDF for both sunflower and pigeonpea. Highest available P and K were recorded with the application of poultry manure + 100 per cent RDF for both sunflower and pigeonpea (33.69 and 313.78 kg PK/ha). However, application of vermicompost + 100 per cent RDF for both sunflower and pigeonpea obtained highest available P and K in the soil (31.57 and 315.34 kg PK/ha). This might be due to better residual effect of combined application of organic manures and inorganic fertilizers.

5.5 Economics of integrated nutrient management in sunflower - pigeonpea intercropping system

The economics of different integrated nutrient management treatments (organic manures + inorganic fertilizer levels) indicated that, net returns were highest with poultry manure + RDF (Rs. 10247/ha) followed by vermicompost + RDF (Rs. 9334/ha) and FYM + RDF (Rs. 8813/ha). But benefit cost ratio in vermicompost + RDF (1.13) was lower than application

of FYM + RDF (1.15) and poultry manure + RDF (1.41). Despite of lower gross returns, net returns in FYM and poultry manure applied treatments were increased because of FYM's lower cost and poultry manure's lesser quantity to supply same amount of N. The net returns with 100 per cent RDF for both sunflower and pigeonpea and 100 per cent RDF for sunflower and 75 per cent RDF for pigeonpea were on par. Indicating that, about 25 per cent to 50 per cent fertilizer can be saved in inter cropping system. Similarly B:C ratio was highest with application of 100 per cent RDF to sunflower and No fertilizer to pigeonpea (1.33). It is evident that cheap source of plant nutrients such as poultry manure was most effective in sunflower - pigeonpea intercropping system. The net returns with vermicompost were found higher than FYM at all inorganic fertilizer levels but it was recorded lower B:C ratio due to higher cost. It is profitable if farmer prepares vermicompost on his own farm with his on farm resources. Once farmer goes to self preparation of vermicompost than ultimately there was lower cost of cultivation in vermicompost then only it was feasible. Otherwise it can't be feasible but by applying vermicompost will maintain the sustainable soil health. But the beneficial effects of vermicompost with respect to maintainance of soil helath cannot be ignored for suitable productivity. On the other hand deleterious effect of fertilizers on soil physical, chemical and biological properties should also be considered in nutrient management system. With respect to poultry manure as it contains higher concentration of N, P and K than FYM

and vermicompost. So its requirement is less to supply same quantity of nutrients. Thus, cost of cultivation will be lesser. It is also profitable if its availability is solved. In the present investigation it was observed that application of poultry manure + 100 per cent RDF to sunflower and 50 per cent RDF to pigeonpea, farm yard manure + 100 per cent RDF to sunflower and 50 per cent RDF to pigeonpea. The results are in confirmity with the findings of Mastiholi (1994) and Krishnamoorthy (1995) and he stated that, application of vermicompost plus *Azospirillum* along with RDF recorded highest net returns and benefit cost ratio.

Practical application of the results

1. Highest sunflower seed equivalent yield can be obtained with integrated nutrient application of vermicompost (4.7 t/ha) + 100 per RDF to both sunflower (35:50:35 kg NPK/ha) and pigeonpea (25:50 kg NP/ha) or poultry manure (2.7 t/ha) + 100 per cent RDF to both sunflower and pigeonpea crops.

2. Highest net returns can be obtained by the combined application of poultry manure + 100 per cent RDF to both sunflower and pigeonpea.

3. Application of 50 per cent RDF to pigeonpea and 100% RDF to sunflower + poultry manure was found most cost effective and recorded highest B:C ratio.

Future line of work

1. To evaluate nutrient management in sunflower + pigeonpea intercropping system with various methods of evaluation of crop mixtures.

2. To evaluate the land based and crop based fertilization for sunflower + pigeonpea intercropping system.

3. It is important to know the long term effects of application of organic sources on soil properties.

SUMMARY

VI. SUMMARY

A field experiment was conducted at Agricultural College Farm, Dharwad, on medium black soil under rainfed conditions during *kharif* season of 1998-99 to study the effect of organic sources and inorganic fertilizer levels in intercropping of sunflower and pigeonpea on the growth and yield of the component crops, total yields and the economics of the integrated nutrient management in intercropping system. There were 15 treatments, three organic sources (FYM, vermicompost and poultry manure) and five inorganic fertilizer levels. The results are summarised in this chapter.

Maximum plant height of sunflower at 60, 90 DAS and at harvest was recorded with the application of poultry manure + 100 per cent RDF for both sunflower and pigeonpea, while the least plant height was observed in FYM + 100 per cent RDF to sunflower and No fertilizer to pigeonpea treatment. Application of either of the organic sources + 100 per cent RDF for both sunflower and pigeonpea recorded maximum plant height at all the crop growth stages. With respect to pigeonpea also similar results were found at 150, 180 DAS and at harvest. Highest number of green leaves per plant and leaf area were noticed in either of the organics + 100 per cent RDF for both sunflower and pigeonpea treatment in both sunflower and pigeonpea crops. Combined application of vermicompost + 100 per cent RDF for both crops and poultry manure + 100 per cent RDF for

both crops recorded maximum number of green leaves per plant at all the crop growth stages. With respect to pigeonpea maximum number of primary and secondary branches were noticed at 150, 180 DAS and at harvest with either of the organics + 100 per cent RDF for both the crops.

Total dry matter production was highest with combined application of either of the organics along with 100 per cent RDF for both the crops at all the crop growth stages. While it was lowest with combined application of either of the organics along with 100 per cent RDF for sunflower and No fertilizer for pigeonpea. Maximum total dry matter production was recorded under combined application of either vermicompost or poultry manure with 100 per cent RDF for both crops. Dry matter accumulation of leaf, stem, petiole and head were highest with combined application of either vermicompost or poultry manure + 100 per cent RDF for both the crops. With respect to pigeonpea dry matter accumulation of leaf, stem, petiole and pods also were highest with either of the organics + 100 per RDF for both the crops. With respect to sunflower, dry matter production and accumulation in leaf, stem and petiole did not differ significantly amongst fertilizer levels to pigeonpea and organics. But, with respect to pigeonpea dry matter production and accumulation in leaf, stem and pods differ significantly amongst fertilizer levels.

Head diameter was higher with either of organics along with 100 per cent RDF for both the crops compared to other

treatments. Combined application of either vermicompost or poultry manure with 100 per cent RDF for both the crops attained maximum head diameter of sunflower. Number of seeds per head did not differ significantly due to fertilizer levels and organic manures. Number of seeds per head was maximum under application of either of vermicompost or poultry manure + 100 per cent RDF for both crops compared to other treatments. Lowest number of seeds per head was with application of FYM + 100 per cent RDF for sunflower and No fertilizer to pigeonpea. Thousand seed weight and seed yield per plant were higher with either of organics + 100 per cent RDF for both the crops. Combined application of either vermicompost or poultry manure along with 100 per cent RDF for both the crops recorded maximum 1000-seed weight and seed yield per plant. Seed yield was highest with combined application of vermicompost + 100 per cent RDF for both the crops (14.25 q/ha) and it was least with application of FYM + 100 per cent RDF for sunflower and No fertilizer for pigeonpea (11.12 q/ha). Poultry manure with 100 per cent RDF for both the crops (13.81 q/ha) was recorded similar results as that of vermicompost + 100 per cent RDF for both the crops.

Number of pods per plant and seed yield per plant were higher with vermicompost or poultry manure + 100 per cent RDF for both the crops. Combined application of poultry manure + 100 per cent RDF for both crops recorded maximum number of pods per plant and seed yield per plant and it was significantly higher than FYM + 100 per cent RDF for sunflower

and No fertilizer for pigeonpea and on par with vermicompost + 100 per cent RDF for both crops. Number of seeds per pod and 100 seed weight were higher with combined application of either of the organics + 100 per cent RDF for both the crops. Number of seeds per pod and 100 seed weight did not differ significantly amongst fertilizer levels and organic manures. Seed yield was highest with poultry manure + 100 per cent RDF for both crops (8.98 q/ha) and it was least with application of FYM + 100 per cent RDF for sunflower and No fertilizer to pigeonpea (7.21 q/ha). Combined application of either poultry manure or vermicompost with 100 per cent RDF for both the crops recorded on par results.

Combined application of either vermicompost or poultry manure + 100 per cent RDF for both crops recorded on par yield as that of vermicompost or poultry manure + 100 per cent RDF for sunflower and 50 per cent RDF for pigeonpea. The results indicates possibility of saving 50 per cent RDF due to combined application of organics and inorganic fertilizers are applied together in sunflower - pigeonpea intercropping system.

Stalk yield of both crops were maximum with application of organics with full dose of fertilizers to both crops compared to lesser dose of fertilizers. Highest stalk yields of sunflower and pigeonpea were recorded with the application of vermicompost + 100 per cent RDF for both the crops. However, application of poultry manure + 100 per cent RDF for both

crops recorded maximum harvest index in both the crops. Per cent oil content in the seeds of sunflower was maximum with the combined application of organics with 100 per cent RDF for both the crops.

Highest uptake of N, P and K were observed with combined application of organics and 100 per cent RDF for both crops and lowest uptake of nutrients was observed with lower doses of fertilizer to pigeonpea. Combined application of either vermicompost or poultry manure with 100 per cent RDF for both crops resulted in higher uptake of N, P and K from the soil in both the crops. Fertilizer levels and organics did not record significant difference in organic carbon content of the soil. Combined application of either vermicompost or poultry manure with 100 per cent RDF for both crops increased the organic carbon content compared to lower doses of fertilizer to pigeonpea. Available soil N, P and K were significantly higher due to combined application of organics with 100 per cent RDF for both crops. Application of organics and fertilizer levels on available soil P and K differed significantly. Highest available soil P and K were recorded with combined application of either vermicompost or poultry manure with 100 per cent RDF for both crops compared to other treatments.

Economics of the integrated nutrient management on cost of cultivation in the treatments involving vermicompost application were more due to higher cost of vermicompost. Highest gross returns were obtained with combined application

of vermicompost + 100 per cent RDF for both crops. Whereas, net returns were maximum with the application of poultry manure in conjunction with 100 per cent RDF for both crops. This might be due to lower quantity of poultry manure required to supply same quantity of N. The highest benefit : Cost ratio was noticed with the combined application of poultry manure + 100 per cent RDF to sunflower and No fertilizer to pigeonpea followed by FYM + 100 per cent RDF to sunflower and No fertilizer to pigonpea treatment.

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* Originals not seen.

APPENDIX

APPENDIX - I

Sl. No.	Particulars	Price (in Rs.)
1.	Seed material	
	a. Sunflower (KBSH-1)	50.00 per kg
	b. Pigeonpea (JS-1)	15.00 per kg
2.	Inorganic fertilizers	
	a. Urea	336.00 per qtl.
	b. SSP	308.00 per qtl.
	c. MOP	390.00 per qtl.
3.	Organic manures	
	a. FYM	200.00 per t.
	b. Vermicompost	600.00 per t.
	c. Poultry manure	400.00 per t.
4.	Plant protection chemicals	
	a. Monocrotophos	300.00 per l
	b. Endosulphon	210.00 per l
	c. Dithane-M-45	200.00 per kg
	d. Bavistin	550.00 per kg
5.	Labour wages	
	a. Men labour	30.00 per day
	b. Women labour	30.00 per day
	c. Bullock pair with a man	80.00 per day
6.	Miscellaneous	
	a. Land rent	1000.00 per ha per year
	b. Marketing and handling charges	2% of the gross returns
7.	Out put	
	a. Sunflower	800.00 per q.
	b. Pigeonpea	900.00 per q.

INTEGRATED NUTRIENT MANAGEMENT IN RAINFED SUNFLOWER (*Helianthus annuus* L.) AND PIGEONPEA (*Cajanus cajan* (L.) MILL sp.) INTERCROPPING SYSTEM.

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ABSTRACT

An experiment was conducted at Main Research Station, University of Agricultural Sciences, Dharwad, during *kharif* season of 1998 to study the effect of integrated nutrient management in sunflower-pigeonpea intercropping system. The experiment was laid out in Randomized Block Design (Factorial) with fifteen treatment combinations, comprising three organic sources and five fertilizer levels. The treatments were replicated three times.

Highest sunflower seed equivalent yield can be obtained with combined application of either vermicompost (4.7 t/ha) or poultry manure (2.7 t/ha) with 100 per cent RDF to both sunflower (35:50:35 Kg NPK /ha) and pigeonpea (25:50:0 Kg NPK/ha). This is due to higher seed yields of Sunflower (13. 24 and 12. 68 q/ha) and pigeonpea (8. 27 and 8. 37 q/ha) were recorded in the above treatments. The higher yields of both the crops is due to the better yield attributing characters like head diameter, number of seeds per head, number of pods per plant, seed yield per plant and 1000 seed weight were recorded in the same treatments.

With respect to oil content there is no significant variation among the treatments. But, among the organic sources poultry manure recorded higher (41.41%) oil content than the other two organic sources.

In sunflower, vermicompost recorded significantly higher N uptake (278 kg/ha) as compared to FYM (255 kg/ha) and it was on par with poultry manure (276 kg/ha). There is no significant difference with respect to P and K uptake. In pigeonpea, application of 100 per cent RDF to both crops recorded significantly higher N (103 kg/ha), P (40 kg/ha) and K (81 kg/ha) uptake as compared to lower doses of RDF to pigeonpea. Among the organic sources poultry manure recorded significantly higher P (40 kg/ha) and K (81 kg/ha) uptake as compared to other two organic sources. However, interaction effect of organic sources and inorganic fertilizer levels had no significant effect on the nutrient uptake by both sunflower and pigeonpea crops.

Highest net returns (Rs. 10933/ha) was obtained by the combined application of poultry manure with 100 per cent RDF to both sunflower and pigeonpea than that recorded under FYM with 100 per cent RDF to only sunflower and no RDF to pigeonpea (Rs. 8568/ha).

Application of poultry manure plus 100 per cent RDF to sunflower and without RDF to pigeonpea was found most cost effective and recorded highest B : C ratio (1. 50).