NITROGEN SUBSTITUTION THROUGH ORGANIC SOURCES IN IRRIGATED WHEAT (Triticum aestivum L.) AND THEIR EFFECTS IN BAJRA-WHEAT SEQUENCE

By

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Reg. No. 93011

A Thesis Submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH

RAHURI 413 722 DIST - AHMEDNAGAR.

Maharashtra State (India)

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

In

AGRONOMY

DEPARTMENT OF AGRONOMY
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI, DIST- AHMEDNAGAR, M. S.(INDIA)

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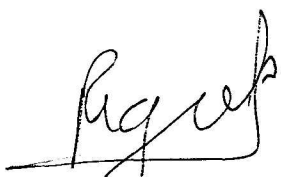
1995

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part there of has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma



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CERTIFICATE

This is to certify that the thesis entitled, "**NIGROGEN** *SUBSTITUTION* **THROUGH ORGANIC SOURCES IN IRRIGATED WHEAT (Triticum aestivum L.) AND THEIR EFFECTS IN BAJRA-WHEAT SEQUENCE**", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRONOMY**, embodies the results of a piece of bona fide research work carried out by **Shri. R.D. NIGADE**, under my guidance and supervision and no part of the thesis has been submitted for any other degree, diploma or publication in any other farm.

The assistance and help received during the course of this investigation and sources of literature referred to have been duly acknowledged.

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Regards

Place : MPKV, Rahuri.

Dated : 15 / 6 /1995.

(Ram D. Nigade)

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LIST OF ABBREVIATIONS

@	:	At the rate of
C.D.	:	Critical diference
cm	:	Centimeter (s)
dm^2	:	Decimeter square (s)
et al.	:	And others
Fig.	:	Figure
FYM	:	Farm yard manure
g	:	Gram (s)
ha	:	Hectare
i.e.	:	That is
K	:	Potassium
kg	:	Kilogramme (s)
m	:	Meter (s)
max.	:	Maximum
min.	:	Minimum
mm	:	Millimeter
N	:	Nitrogen
NS	:	Not-significant
P	:	Phosphorus
q	:	Quintal (s)
Rs.	:	Rupees
S.E.	:	Standard error
Sig.	:	Significant
t	:	Tonne (s)
viz.	:	Namely
%	:	Per cent

ABSTRACT

NITROGEN SUBSTITUTION THROUGH ORGANIC SOURCES IN IRRIGATED WHEAT (Triticum aestivum L.) AND THIER EFFECTS IN BAJRA-WHEAT SEQUENCE

By

RAMCHANDRA DATTATRAYA NIGADE

A candidate for the degree of

MASTER OF SCIENCE (AGRICULTURE)

1995

Research Guide	: **Prof. K.K. Khade**
Department	: **Agronomy**

The present investigation entitled "Nitrogen SUBSTITUTION through organic sources in irrigated wheat (Triticum aestivum L.) and their effects in bajra-wheat sequence" was carried out in rabi season of 1993-94 at Post Graduate Institute Farm of Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment was laid out in Randomised Block Design with four replications and twelve treatments. The treatments consists of three levels of nitrogen viz., 60, 90 and 120 kg N/ha through different sources viz., chemical fertilizer, FYM and vermicompost with 60 kg P_2O_5 and 60 kg K_2O/ha as common dose. In addition there were three treatments viz., 120 kg N + 10 t FYM/ha, 90 kg N/ha applied as half N through fertilizer and remaining half through FYM and vermicompost. The gross and net plot sizes were 4.50 x 3.60 m^2 and 3.60 x 2.70 m^2, respectively.

The soil of the experimental field was clayey in texture with fairly good water holding capacity and slightly alkaline in reaction. The soil was low in available nitrogen, medium in available phosphorus and fairly rich in available potash. In general the climatic condition was good during the crop growth period.

The growth attributes of wheat were expressed in terms of plant height, number of tillers, leaf number and leaf area, dry matter accumulation per plant etc. The maximum height of plant (90.08 cm) with more number of leaves (8.65/plant), were observed with application of 120 kg N through fertilizers + 10 t FYM/ha. As regards the number of tillers it was also higher with 120 kg N + 10 t FYM/ha. The minimum number of tillers/plant were observed with, application of graded levels of nitrogen through FYM. However maximum leaf area (9.850 sq.dm) and dry matter accumulation (7.075 g) per plant was noticed with application of 120 kg N supplimented with 10 t FYM/ha.

The yield contributing characters viz., number of productive tillers, length of panicle, number of grains per panicle and test weight were increased with the increasing in the levels of nitrogen. The maximum values of these characters were observed with 120 kg N supplimented with 10 t FYM/ha. The

yields in terms of grain and straw are reported. It is observed that the maximum grain (48.23 q/ha) and straw (58.89 q/ha) yields were obtained with the application of 120 kg N supplimented with 10 t FYM/ha.

The uptake of N, P_2O_5 and K_2O in wheat grain and straw was maximum with the application of 120 kg N/ha through fertilizer with 10 t FYM/ha. The protein content in the grain was more (13.44 %) with same level of fertilizer. The maximum benefit cost ratio (1.22) was obtained due to application of 120 kg N/ha through chemical fertilizer only.

The nutrient status of soil after bajra-wheat sequence indicated that application of nitrogen partly through inorganic and organic sources help in maintaining the organic carbon status at higher level. The nitrogen balance studies after crop sequence indicated that the available nitrogen status of soil was reduced due to application of nitrogen through organic sources than inorganic sources. This might be due to slow release of nitrogen through organic sources. In general it was observed that application of nitrogen in combination of inorganic and organic sources found superior for getting good yield and maintain better soil health.

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Introduction

1. INTRODUCTION

Amongst the cereals, wheat (Triticum aestivum L.) is predominant in regard to it's antiquity and its importance as a food of mankind. Wheat contributes more calories and more protein to the worlds diet than any other crop. Due to its adaptability to varying soils and climatic conditions and also for easy cultivation, wheat is superior to that of any other crop.

Wheat has diverse uses. About 80 to 85 per cent consumption of the wheat is in the form of chapatee (Unleavened flat bread). It is also used for preparation of breads, biscuits and other products. From nutritional point of view, wheat grain contains starch, soluble sugars, cellulose and hemicellulose, fats, various minerals like P & Fe, vitamins like thiamine riboflavin and nicotinic acid. Most important of all, wheat is the cheapest source of gluten and particularly the lysine content. Besides its value as food grain, wheat straw (bhusa) is also an important cattle feed.

The area under wheat in India is about 24.23 million ha with production of about 58.85 million tonnes and the average yield is about 23.48 q/ha. Wheat is one of the most important rabi cereal crop in Maharashtra. It occupies an area of about 6.80 m.ha with production of 7.98 m.tons and the average yield is 11.74 q/ha (Anon 1993). The lower per hectare production of wheat in Maharashtra might be due to shorter growing period and higher proportion under rainfed conditions.

Fertilizer price hikes alongwith related pollution hazards caused by injudicious use and over fertilization in command areas have evoked awareness among the farmers and researchers for exploitation and utilization of organic resources available in the country. In the past, the use of organic manures have been reported to improve physical, chemical and biological properties of soils (Acharya et al. 1998). However, due to low nutrient content and slow acting nature these organics alone may not be able to meet the nutritional demand of high yielding crops and thus they are used as supplementary to chemical fertilizers.

Organic manures like FYM and compost have been traditionally important inputs for maintaining soil fertility and ensuring yield suitability. It plays a direct role in supplying macro and micro nutrients. Besides supplying nutrients to the current crop very often leave substantial residual effect on succeeding crop in the system. It was observed that fertilizer requirement of rabi crop could be reduced by 25 per cent through substituting 25 per cent nitrogen needs of kharif crop through FYM. At most of the locations, the integrated use of chemical fertilizers and FYM resulted markedly higher productivity than that with application of chemical fertilizers alone. (Hegde and Dwivedi, 1993).

Recently there is boom of vermicompost in the state of Maharashtra and a considerable number of farmers have shown eagerness in using it for the crop production. Vermicompost is

the mixture of earthworms eggs, casts, faces decomposed compost and soil. The vermicompost generally passes a good structure, porosity and moisture holding capacity coupled with reasonable quantities of plant nutrients (Edward et al. 1985). It is supposed that it will be substitute for the conventional inorganic fertilizers.

Wheat follows after kharif sorghum or bajra under irrigation or many times it is grown as a rainfed crop on kharif fallow land. In Western Maharashtra on large scale it is also grown after groundnut. Bajra-wheat sequence is predominant in North Western Plain zone and Central zone of India. Even with application of recommended dose of fertilizers, yield potential of this system (cereal-cereal) has reached to a plateau due to deterioation in soil health (Roshanlal and Hooda, 1993). In sustained crop production, organic manure plays an important role. Inorganic manures on the other hand, will continue to be one of the main instrument for quickening the pace of agricultural production. The results of a large number of experiments on manures and fertilizers conducted in the country and abroad revealed that neither the chemical fertilizers alone nor the organic sources exclusively can achieve the production sustainability of soil as well as crops under highly intensive cropping system. Therefore it becomes necessary to know the suitable combination of chemical fertilizer with organic manures for higher crop production and profitability.

With increase in population, our compulsion would be not only to stabilize agricultural production but to increase

it further in sustainable manner. The nation has witnessed that the green revolution with high input use has reached plateau and is now sustained with diminishing return and falling dividend. Nevertheless, the intensive use of inputs has not polluted the soil water and environment but its slow degradation in the soil also causing injury to human beings. It is because of this, the health conscious developed countries and the sophisticated domestic population are ready to pay more premium price for food raised without chemicals.

The present investigation are aimed to develop suitable integrated nutrient supply system for cereal based cropping sequence involving more efficient use of fertilizers in conjunction with judicious combination of organic farm wastes would help in long term to maintain sustainability of soil with the following objectives.

1. To find out nitrogen economy through FYM and vermicompost.
2. To explore the possibility of supplementing nitrogen for wheat through organic sources like FYM and vermicompost.
3. To study the comparative economics of organic and inorganic sources of fertilizers in wheat.
4. To work out the optimum dose of nitrogen for wheat grown after bajra.

Review of Literature

2. REVIEW OF LITERATURE

Nitrogen being major nutrient, it plays important role in crop production. In general, soils of Maharashtra are deficient in nitrogen as a result there is positive response to nitrogenous fertilizers. However, continuous applications of chemical fertilizers adversely affect the soil health. For maintaining good health of soil and better crop production use of organic source of nutrients is important.

Nitrogen substitution partly through various organic sources like FYM, compost, vermicompost and partly through inorganic fertilizers proved to be best in terms of productivity. A brief review of research work done on the performance of bajra-wheat sequence in relation to different sources of fertilizers and its effect on improvement of the soil fertility is presented in this chapter.

In general, the information available on growth and yield of wheat alone and in bajra-wheat sequential cropping on substitution of nitrogen through organic and inorganic sources is meagre and — have been discussed in the below paragraphs.

2.1 Effect of chemical fertilizers

2.1.1 Growth contributing characters

Most of the investigators reported that the nitrogen favourably influenced the growth characters such as

plant height and tillers in wheat. Similarly the yield and yield contributing characters namely productive tillers, length of panicle, number of grains per panicle, 1000 grain weight, total yield of grain are also found to be increased by nitrogen application.

2.1.1.1 Plant height

Application of 100 kg N/ha produced 4 cm more plant height than that with 60 kg N/ha as reported by Auti (1980). Thus it appears that height of wheat plant increased with increase in nitrogen dose upto 160 kg per hectare. It was also observed by Singh and Agarwal (1983) that the plant height increased markedly upto 80 kg N/ha.

Plant height of wheat recorded with the application of 120 + 60 + 60 kg NPK/ha was the highest during entire growth and was significantly more than the rest of the reduced levels tried as reported by Nikam (1985).

The maximum plant height of wheat with 120 kg N/ha was reported by Dhuka et al. (1991) and it was significantly superior over 40 kg N/ha. Similarly Patel and Upadhayaya (1993) reported that with application of 150 kg N/ha produced maximum plant height in wheat than 120 kg N/ha.

2.1.1.2 Tillering

The trial conducted at Rahuri by Borse and Mahajan (1980) on wheat revealed that there was positive response to nitrogen fertilization in terms of obtaining productive tillers

with 100 kg N/ha over 50 kg N/ha and thereafter the differences were non significant. It was also observed by Reddy and Prasad (1980) that by application of nitrogen significantly increased the number of grain producing tillers over no nitrogen. The study conducted by Rao and Bhardwaj (1981) showed that there was significant increase in earbearing shoots per meter row length upto 120 kg N/ha.

Application of nitrogen @ 120 kg/ha recorded more productive tillers per unit area as reported by Bhaliya et al. (1983). The number of effective tillers were not increased in case of unirrigated wheat crop beyond application of 30 and 60 kg N/ha (Singh and Agarwal, 1983). The increase in total number of effective tillers per plant with increase in nitrogen dose were observed by Singh and Awasthi (1983).

The significant increase in number of effective tillers per plant with the increasing levels of nitrogen upto 120 kg/ha was reported by Singh et al. (1984). Each increment of nitrogen level increased the number of ears significantly upto 120 kg/ha (Sambasiva et al., 1984).

The number of total tillers and productive tillers per plant produced with application of 120 + 60 + 60 kg NPK/ha was maximum at all the stages of growth and was significantly more than that recorded with 60 + 30 + 30 kg NPK/ha level as observed by Nikam (1985).

Application of 120:60:60 kg NPK/ha produced significantly more effective tillers (Girothia et al., 1987).

Significant difference due to varying levels of nitrogen were observed on producing the effective tillers, showing higher values with all N (120 kg N/ha) applied through urea (Patel et al., 1992).

Application of N through inorganic sources to the extent of 100 kg/ha increased number of tillers/m row length (Gajendra, 1993). Though there was no difference between the tillers produced due to 50 kg & 100 kg N/ha. Effective tillers per metre row length increased significantly upto 120 kg N/ha as reported by Patel and Upadhayaya (1993). Application of sub optimum level of fertilizer (60:30:30 kg NPK/ha) significantly reduced the number of tillers per metre row length due to poor fertility status as reported by Singh et al. (1993).

2.1.1.3 Leaf number and leaf area

Maximum number of functional leaves and leaf area per plant was obtained with full dose of fertilizer i.e. 100 kg N + 50 kg P_2O_5/ha than the reduced dose of fertilizers i.e. 60 kg N + 30 kg P_2O_5/ha as reported by Auti (1980). Leaf area in case of wheat crop was found to be more with the increase in the nitrogen levels from 120 kg N to 160 kg N/ha as pointed out by Zope (1981).

The LAI increased to a maximum extent upto 75 days after sowing and then declined thereafter. The LAI decreased with the advancement of age. At lower level of nitrogen the LAI was comparatively higher with increase in the levels of

nitrogen. The LAI was comparatively higher with increase in the levels of nitrogen, the LAI was reduced reported by Sambasiva et al. (1982).

The functional leaf number and leaf area per plant due to application of 120:60:60 kg NPK/ha was highest throughout the growth period as reported by Nikam (1985).

Jadhav (1989) reported that the mean maximum leaf area was recorded on 42nd day. The leaf area per plant was significantly increased with the increased levels of fertilizer application to wheat.

2.1.1.4 Dry matter production

The dry matter production was significantly influenced due to different levels of fertilizers on all the days of observations as reported by Auti (1980). Application of 100 kg N + 50 kg P_2O_5/ha significantly produced more dry matter than application of 60 kg N + 30 kg P_2O_5/ha. Dry matter production per plant significantly increased with application of 100 kg N/ha over 50 kg N/ha and the dry matter produced due to 100 and 150 kg N/ha were on par (Borse and Mahajan, 1980).

Balasubramanian and Singh (1982) reported that the grain and straw dry matter of wheat at different growth stages significantly increased with increasing in the levels of N from 0 to 180 kg N per hectare.

The study conducted by Nikam (1985) revealed that the total dry matter production increased significantly with

every successive increase in the levels of fertilizers and the maximum dry matter production was observed with 120:60:60 kg NPK/ha and it was significantly more than other lower levels of fertilizer. The dry matter production in the plant was maximum at harvest of wheat as reported by Jadhav (1989). He further reported that the dry matter production per plant was significantly increased with increase in the levels of fertilizer to wheat crop.

2.1.2 Yield contributing characters

2.1.2.1 Length of panicle

Earhead length of wheat with 100 kg N + 50 kg P_2O_5/ha was significantly more than 60 kg N + 30 kg P_2O_5 as observed by Auti (1980). The study conducted by Dahatonde (1981) revealed that there was significant response to nitrogen fertilization in increasing earhead length upto 80 kg N/ha. Application of 120 kg N/ha produced maximum spike length of wheat in 1977-78, whereas in 1978-77, dose of 90 kg N/ha was on par with 60 kg and 120 kg N/ha as reported by Singh and Agarwal (1983). There was significant response to nitrogen fertilization in increasing earhead length with application of nitrogen upto 150 kg N/ha as observed by Singh and Awasthi (1983). Nikam (1985) reported that the panicle length recorded with 120:60:60 kg NPK/ha was the highest (8.19 cm) and was significantly more than 60:30:30 kg NPK/ha. While, studying the effect of N fertilization on length of spike by Dhuka *et al.* (1991), it was observed that, the length of spike obtained with 80 and 120 kg N/ha was more or less same but it was

significantly higher than 40 kg N/ha. Length of panicle was found to increase significantly with successive increase in the levels of fertilizer upto 100:50:50 level (Pol et al., 1991). Singh et al. (1992) reported that length of panicle responded significantly to application of nitrogen. The maximum panicle length was obtained with 120 kg N/ha. Patel and Upadhayaya (1993) also observed that length of earhead increased significantly upto 120 kg N/ha.

2.1.2.2 Number of spikelets per panicle

The study conducted by Bhaliya et al. (1983) indicated that application of 120 kg N/ha recorded highest spikelets per ear. While Nikam (1985) reported that the spikelets number produced with 120:60:60 kg NPK/ha was the highest (20.00) and significantly more than that with 60:30:30 kg NPK/ha level. Number of spikelets per panicle was also significantly increased by N application as observed by Dhuka et al. (1991).

2.1.2.3 Number of grains per panicle

Application of 100 kg N + 50 kg P_2O_5/ha produced significantly more number of grains per earhead than that due to 60 kg N + 30 kg P_2O_5/ha (Auti, 1980). A trial conducted at Rahuri by Borse and Mahajan (1980) revealed that there was a significant response to nitrogen fertilization for number of grains per earhead upto 100 kg N/ha level.

Sharma (1981) reported that each successive increase in the level of fertilizer from N_0 P_0 K_0 to N_{120} P_{60}

K_{60} increased the number of grains per panicle. Application of 80 kg N/ha gave significantly more number of grain per earhead as compared to 60 and 40 kg N/ha which were at par (Raghu et al., 1983). The number of grains per earhead was significantly increased with increasing in the level of nitrogen upto 120 kg N/ha (Singh et al., 1984). This may be probably due to the favourable effect of nitrogen on grain formation and development.

Nikam (1985) reported that the number of grains per panicle was increased significantly with every successive increment in the level of fertilizer. However, the difference between application of 120:60:60 and 100:50:50 kg NPK/ha levels were not significant and the number of grains per panicle recorded in 120:60:60 kg NPK/ha was the highest (39.60). Similar observations were reported by Dhuka et al. (1991); Pol et al., (1991) and Singh et al., (1992). The grains per spikelet were increased with increase in the N levels to the extent of 120 kg N/ha.

2.1.2.4 Thousand grain weight

An experiment conducted at Niphad revealed that the mean thousand grain weight increased significantly with application of 100 + 50 + 40 kg NPK/ha over control (Anonymous, 1984). The study conducted by Nikam (1985) revealed that application of 120:60:60 kg NPK/ha produced maximum thousand grain weight of wheat (43.87 g) and was significantly more than rest of the N levels tried. It was observed by Girothia et al.

(1987) that thousand grain weight was not affected by fertilizer application.

The thousand grain weight was increased with the increase in the fertilizer levels but the test weight obtained with the application of 90:45:30 kg NPK/ha and 120:60:40 kg NPK/ha were on par (Upadhaya and Dubey, 1991). The study conducted by Pol (1991) revealed that test weight were found to increase significantly with the increase in the fertilizer levels upto 100:50:50 kg NPK/ha. Similar observations were recorded by Singh et al. (1992). However, Chougule et al. (1993) observed reverse trend in which thousand grain weight was not significantly influenced by application of fertilizer and it was slightly decreased with increase in the levels of fertilizer. Thousand grain weight increased upto 150 kg N/ha than its lower level (Patel and Upadhaya, 1993).

2.1.3 Grain and straw yield

Application of nitrogen @ 100 and 150 kg/ha significantly increased grain and straw yield of wheat over 50 kg N/ha under Rahuri condition (Borse and Mahajan, 1980). The study conducted by Malik (1981) revealed that the grain and straw yield increased with increasing in the levels of nitrogen upto 120 kg N/ha. Bhaliya et al. (1983) also reported similar results.

The maximum grain yield of wheat was obtained with 90 kg N/ha and was on par with 60 kg N/ha was observed by Singh and Gulani (1983). The response in terms of grain per kg of

nitrogen for 30, 60, 90, 120 and 150 kg N/ha were 18.2, 15.0, 10.7, 6.7 and 4.9 kg respectively. The response of nitrogen was positive which produced productive tillers, higher number of grains per earhead and improvement in thousand grain weight. The response of nitrogen was upto 120 kg N/ha.

A field trial conducted at IARI New Delhi, revealed that due to application of nitrogen grain and straw yields were increased over control. Successive increment of nitrogen upto 80 kg/ha increased the grain and straw yield (Sambasiva et al., 1984).

Nikam (1985) reported that per hectare grain and straw yields obtained with 120:60:60 kg NPK/ha were the highest and significantly more than other reduced levels tried except 100:50:50 kg NPK/ha which was on par. The grain yield increased with increasing in the fertilizer dose upto 120:60:60 kg NPK/ha (Girothia, 1987). Further increase in the levels of fertilizers i.e. 180:90:90 kg NPK/ha did not cause additional increase in yield. However, straw yield increased with the increase in dose of fertilizer upto 180:90:90 kg NPK/ha. This may be due to improvement in vegetative growth of crop.

The grain and straw yields at 80 and 120 kg N/ha were equal but significantly superior over 40 kg N/ha as observed by Dhuka et al. (1991). With increase in the fertilizer levels grain yield increased upto 90:45:30 kg NPK/ha. But there was no variation between the yields obtained with 90:45:30 and 120:60:40 kg NPK/ha as reported by Upadhaya and

Dubey (1991). Application of 120 and 160 kg N/ha produced equally better yield of grain and straw than 80 kg N/ha. Application of nitrogen at 80 kg N/ha increased grain and straw yield of wheat by 12.1 and 10.9 per cent over 40 kg N/ha, respectively. Similar results were obtained by Singh et al. (1992).

Grain and straw yields were found to be increased with addition of fertilizer over the optimum dose but response to various levels of fertilizers below the optimum dose was not consistent (Naphade et al., 1993). However, a significant reduction in yield was observed when the fertilizer dose was decreased to the extent at 50 per cent of optimum dose.

Patel and Upadhayaya (1993) observed that the grain and straw yields were significantly increased with increasing rates of N upto 120 kg/ha.

2.1.4 Quality of wheat grain

2.1.4.1 Concentration of nitrogen, phosphorus and potash in plant and grain

An experiment conducted by Auti (1980) revealed that the fertilizer dose had significant effect on the per cent concentration of N and P in grain and straw. The treatment of 100:50:00 kg NPK/ha exhibited significantly more P content in grain of wheat than that of lower level of 60:30:00 kg NPK/ha. The N concentration in grain and straw with recommended dose of fertilizer increased from 2.94 to 1.64 per cent, respectively. The lowest concentration of P (0.17) and K (0.20) per cent in

wheat grain in control was reported by Sinha et al. (1981). The study conducted by Reddy and Bharadwaj (1983) revealed that application of nitrogen increased N and K contents but reduced P content in grain and straw while, application of phosphorus upto 50 kg P_2O_5/ha enhanced the nitrogen, phosphorus and potassium content in grain and straw.

Nikam (1985) in the studies on effect of fertilizers on NPK concentration in grain and straw, indicated that concentration of nitrogen, phosphorus and potash increased with increase in the levels of NPK. The maximum NPK concentration was recorded with the level of 120:60:60 kg NPK/ha at all the stages of crop growth and in all the constituent plant parts. N uptake through grain and straw increased with an increase in the level of nitrogen. The increase in N uptake through grain and straw was 25.5 and 53.7 per cent with 80 kg N/ha and 30.4 and 56.0 per cent with 120 kg N/ha over 40 kg N/ha, respectively as reported by Dhuka et al. (1992).

2.1.4.2 Uptake of nitrogen, phosphorus and potash by grain and straw at harvest

Vaishya and Singh (1981) reported that nitrogen uptake by grain was noticed upto 120 kg N/ha in all seed rates. Progressive increase in N uptake by straw was observed with increase in the levels of nitrogen upto 160 kg/ha. Singh and Agarwal (1983) revealed that the nitrogen uptake by wheat crop was significantly higher upto 90 kg N/ha in 1976-77, whereas in 1977-78, it was markly significant upto 60 kg N/ha. The total uptake of nitrogen, phosphorus and potash in grain and straw

were increased with the increase in the levels of fertilizers. The highest uptake was noticed due to 120:60:60 kg NPK/ha level as reported by Nikam (1985).

Pol (1991) observed that the uptake of major nutrients like NPK was also found to increase appreciably with increase in the levels of fertilizers. Naphade et al. (1993) reported that mean total NPK uptake increased with progressive increase in the supply of NPK to the crop probably because of higher availability of these nutrients.

2.1.4.3 Protein concentration in grain

The study conducted by Auti (1980) revealed that the protein content in grain increased with increase in the levels of nitrogen. Singh and Awasthi (1983) observed that the protein content in grain increased significantly with increase in nitrogen level upto 150 kg N/ha.

It was observed by Nikam (1985) that the protein, wet gluten and dry gluten content in grain increased with increase in the levels of NPK from 60:30:30 to 120:60:60 kg NPK/ha. Jadhav and Koregave (1988) revealed that the protein content in wheat grain and straw and protein production was significantly more when wheat was grown with full fertilizer dose than half dose.

Patel et al. (1991) observed that there was significant increase in protein content with increasing levels of N. Similar results were reported by Pol et al. (1991). Singh et al. (1992) observed that the maximum value of protein

was obtained with 120 kg N/ha followed by 100 and 80 kg N/ha. Chougule et al. (1993) reported that increase in nitrogenous fertilizer increase the protein content and pelshenke value in wheat grain. Patel and Upadhayaya (1993) revealed that protein content was significantly increased upto 150 kg N/ha.

2.2 Effect of organic manures

2.2.1 Growth contributing characters

The application of earthworm compost to wheat crop increased the plant height, number of tillers, number of leaves, earhead length and dry matter per plant over control (Nijwan and Kanwar, 1952). The vegetative growth of paddy crop (cv. IR20) was influenced by the wormcast was superior than fertilizer. The field study conducted by Cisse (1988) revealed that the application of organic manure to groundnut increased the number of branches per plant and growth rate at later stage of crop development.

Field studies conducted for three years showed that application of FYM @ 10 tons/ha increased the number of spikelet per meter row length over no FYM application. Also the number of grains per spike, 1000 grain weight and grain weight per spike recorded significantly higher values than no FYM application (Negi et al., 1988). Application of FYM @ 20 tons/ha has resulted to increase all other yield contributing characters of maize except length and girth of cobs (Khanday et al., 1990).

The application of vermicompost showed significant change in internodal distance of 4th and 5th node, girth of stem, number of leaves and root growth. The application of vermicompost increased height, girth and length of internode of sugarcane (Jambhekar, 1990). The application of vermicompost increases the height, girth of stem of pomogranate than control and chemical fertilizers (Jambhekar, 1991).

The general, stand and vigour of grape vine was found quite healthy with dark green leaves in the vermiculture treatment and also increased number of canes and girth of cane than control as reported by Gunjal and Nikam (1992).

2.2.2 Yield and quality of crops

Application of earthworms compost to wheat increased the number of grains per plant and grain yield as compared to control as reported by Nighawan and Kanwar (1952).

A field experiment conducted at Hanumangarh revealed that under desert tract there was not possibility of nitrogen economy through use of FYM in comparision with fertilizer combination due to high temperature prevailing during summer months (Khan et al., 1982). Yield of wheat and bajra increased with increasing levels of FYM and nitrogen. Cumulative mode of FYM was found best followed by direct and residual in wheat and bajra. The response to wheat to added FYM @ 15 tons/ha was at higher order in absence of nitrogen. Increasing in the doses of FYM upto 30 tons/ha significantly increased the grain yield over control (Rahul and Singh, 1982).

However, the yields obtained by 30 and 45 t/ha were on par. The residual effect of FYM applied to kharif crop produced almost equal grain yield of wheat in rabi season to that of cumulative effect i.e. residue of FYM + application of FYM (Singh and Dubey, 1987).

Application of FYM @ 10 ton/ha resulted in significant increase in grain and straw yield of wheat was reported by Negi et al. (1988). The study conducted by Khanday et al. (1990) revealed that application of 20 t FYM/ha resulted in significantly more grain yield of maize. Field trial conducted on sugarcane crop by Deshpande (1990) showed that the production with worm cast treated plot was the same as that of with chemical fertilizers. The only difference was in quality of sugarcane. The application of worm compost increased sugar content in sugarcane. The combination of FYM and bio-fertilizers consistently increased the grain yield of wheat over control as observed by Badiyala and Verma (1991).

The study conducted by Mishra et al. (1992) revealed that mean pod yield of groundnut received with enriched compost at 10 to 12 tons/ha was significantly higher than unenriched compost and biogas slurry. However, it was on par with FYM application and application of equivalent quantity of N through urea. Enriched compost was superior to other organic manure in terms of yield of groundnut as well as residual effect on wheat crop.

The maximum grain and dry matter yields were obtained due to application of compost prepared from microbial inoculants plus recommended dose of fertilizers which were 19 and 29 per cent higher over compost plus recommended dose of fertilizer alone in the studies on wheat at College of Agriculture, Pune during 1992 (Anonymous, 1993).

The application of vermicompost @ 5 MT/ha increased the cane yield by 12.66 MT/ha over control (Hapse, 1993). The application of vermicompost along with FYM, cane trash and paddy straw improved yield and recovery of sugarcane as compared to use of chemical fertilizers as reported by Jambhekar et al. (1993).

2.2.3 Nutrient uptake and residual fertility

Under higher application of FYM to the extent of 45 t/ha applied twice in a year which contain about 3.18 per cent organic carbon. In case the lower amount of organic matter (15 t FYM/ha) was added which has retained higher percentage of organic carbon in the soil. Winter application of FYM leaves more organic carbon in the soil than summer application as reported by Rahul and Singh (1982). The study conducted by Singh et al. (1983) revealed that application of FYM significantly increased organic carbon and available P and K status in the soil.

Bhriguvanshi (1988) indicated that organic carbon status of clay loam to sandy loam soils was significantly improved by the application of FYM alone, it played a definite role in improving

the water holding capacity of the soil which was due to the improvement in structural condition of soil.

Gupta et al. (1988) observed that, organic carbon and available P content in soil was increased upto 52 days after application of FYM. The available N content of the soil increased upto 20 days after FYM application and thereafter decreased at all the FYM levels. Sharma et al. (1989) conducted an experiment on effect of organic wastes alone and in combination with earthworms on the available nutrient status of soil with wheat and maize as test crop. They observed that the residual fertility of soil was improved significantly due to addition of increased dose of organic wastes. The periodical changes in C/N ratio of the soil enriched with organic wastes in combination with earthworms revealed a marked decrease in their values over the control and compost alone.

Hooda et al. (1991) reported that, during winter season nitrogen uptake in wheat crop was more under FYM source compared to other treatments. Phosphorus uptake also showed the same trend. Among the different organic sources of N for rice only FYM registered its residual effect on the succeeding wheat. FYM and wheat cut straw incorporation resulted in significantly lower N uptake than fertilizer and green manure treatment (Bhandari et al., 1992).

Shinde (1992) observed that, the physico-chemical and biological properties were found to be highly influenced by addition of FYM, compost and farm wastes. The addition of

organic manures greatly influenced the water stable aggregates, organic carbon content and thereby more nutrient availability.

A field trial conducted at Padegaon revealed that, due to use of vermicompost, there was increase in soil available NPK content at harvest. However, pH and EC as well as soil clay content was also increased due to use of vermicompost, indicating use of vermicompost was not much beneficial in problematic soils (Jadhav et al., 1993). Jambhekar et al. (1993) showed that pH of soil after harvest of the sugarcane was slightly elevated in vermicompost system. However, EC of soil was substantially decreased as compared to that of original soil. After harvest of the sugarcane, level of all three major nutrient was found to be increased.

2.3 Effect of organic and inorganic sources (interaction)

2.3.1 Growth and yield of crop

Sharma (1981) reported that each successive increase in the level of fertilizer a significant increase in growth and yield was recorded. Application of FYM @ 12 tons/ha in conjunction with different fertilizer levels exhibited a significant increase in the grain and straw yield of wheat over fertilizer treatment alone. The interaction effect of fertilizers and FYM was found to be significant upto a level of N_{60}, P_{30} and K_{30}.

The highest average grain production was recorded with NPK + FYM and the lowest yield obtained with nitrogen alone

indicating beneficial effects of application of fertilizer (100% NPK + 15 t FYM/ha) on acidic red soil (Sinha et al., 1981).

Gill and Meelu (1982) obtained increased grain yield of rice with the combined use of organic and inorganic sources of fertilizers. Complementary use of both these sources was advantageous and substantial amount of inorganic N was saved. Two third N applied through FYM and supplemented one third N through inorganic sources were equally beneficial.

Patel et al. (1992) reported that grain yield of wheat obtained with 120 kg N/ha applied through inorganic fertilizers was similar to that obtained with 90 kg N/ha through inorganic fertilizers + 30 kg N/ha through castor, 90 kg N through inorganic + 30 kg N through oak compost. It indicated that the application of N partly through caster cake or oak compost helped in maintaining the grain yield similar to that full dose of N applied through inorganic fertilizers. Among the growth and yield attributes significant difference due to treatments were observed on effective tillers, showing higher values with all N applied through urea. The combined application of organic manures with chemical fertilizers showed beneficial effects over chemical fertilizers (Shinde, 1992).

Kasole et al. (1993) revealed that, among the N management practices the combined application of N as 50 per cent through FYM and 50 per cent N through fertilizers gave significantly higher grain yield of sorghum (50.28 q/ha) than under 100 per cent recommended dose of NPK through

fertilizer (48.3 q/ha). However, during rabi season significantly superior yield (37.04 q/ha) of wheat was recorded in treatment of 50 per cent recommended NPK dose through fertilizer and 50 per cent substitution N through wheat cut straw applied to sorghum during kharif and 100 per cent recommended NPK dose through fertilizer to wheat. The integrated use of FYM and fertilizer at optimum level proved significantly better than fertilizer alone as reported by Naphade et al. (1993).

2.3.2 Nutrient uptake and residual fertility

Results of a long term experiment with application of P_2O_5, K_2O and FYM in different combinations revealed that pH and EC of the soil remained more or less unaffected

Total and available N increased significantly with application of FYM and phosphate but not with K. Available P increased by 3 and 4 ppm with 30 and 60 kg P_2O_5/ha, respectively. FYM had positive, while K had no effect on available P content of soil. Available K increased with FYM and K application but not with phosphate (Chaudhary et al., 1981).

Prasad et al. (1983) observed a marked change in soil pH due to continuous use of fertilizer, FYM [illegible] ne. The application of FYM in combinations w[illegible] had no influence on soil pH but the initial leve[illegible]rbon of soil was increased. FYM in combinations [illegible] NPK dose had greater accumulation of available P and K than full dose of NPK only. Application of nitrogen alone decreases the available N and P content of the soil.

Bhriguvanshi (1988) reported that the pH of the soil remained almost unchanged by the action of fertilizer and manure. Organic carbon was significantly improved by the application of FYM or in conjunction with nitrogenous fertilizer. Application of FYM with NPK increased the nutrients uptake greatly as compared to the application of NPK alone. This might be attributed to the increasing efficiency of the fertilizers and FYM in respect of the nutrient uptake observed by Naphade et al. (1993).

Application of FYM plus full recommended dose of NPK to wheat crop was studied by Acharya et al. (1988) and reported that the improvement in structural index, infiltration rate, water retention characteristics, organic carbon content, available NPK status of the soil in addition to higher yields than treatment receiving one and half time more of recommended dose of NPK. Continuous N application and control plots considerably deteriorated the soil physical and chemical properties.

2.4 Effect of cropping sequence

2.4.1 Growth and yield of crop

Singh et al. (1981) reported that hybrid pearlmillet responded significantly to the application of N, P and FYM but did not respond to applied K. Wheat was found highly responsive to the direct application of N and P. Application of 12 tons of FYM could substitute 30 kg N/ha during kharif and 20 kg N during rabi in bajra-wheat sequence.

With each successive increase in the level of NPK fertilizer a significant increase in growth and yield of wheat was recorded. Application of FYM at 12 t/ha in conjunction with different fertilizer levels exhibited a significant increase in the yield of grain and straw of wheat over fertilizer treatment alone. The interaction effects of fertilizer and FYM were found to be significant at the level of N_{60}, P_{30} and K_{30}. A significant residual effect of 12 tons FYM/ha and that of N_{120}, P_{60}, K_{60} was recorded on the grain yield of mung in a wheat-mungbean sequence (Sharma, 1981).

A field experiment was conducted at Hanumangarh to study the possibility of nitrogen economy through use of FYM in comparision with fertilizer combination of N, P and K in a crop sequences viz., bajra-wheat-moong. Results revealed that under desert tract there was no possibility of economizing nitrogen through use of FYM due to high temperature and low moisture during summer. The residual effect of FYM was significant in moong crop as stated by Khan et al. (1982).

Rahul and Singh (1982) observed that yield of wheat and bajra increased with increasing in the dose of FYM and nitrogen, cumulative mode of FYM was found best followed by direct and residual in both wheat and bajra. The response of wheat to added FYM @ 15 tons/ha was of higher order in absence of nitrogen than that with 120 kg N/ha. The best combination was 15 tons of FYM with 120 kg N/ha.

Application of 100 and 150 kg N/ha to pearlmillet gave significantly higher grain yield of wheat over 50 kg N/ha as reported by Singh et al. (1983). The residual effect at higher doses of nitrogen might have been attributed to the fact that the residual nitrogen might have been utilized. Results obtained from a field experiment conducted on bajra-wheat sequence for 8 years have shown the mean response of an order of 5.6, 5.5, 4.9 q/ha in bajra and 13.2, 12.1 and 10.0 q/ha in wheat with 60 kg P_2O_5/ha when applied as cumulative, direct and residual phases of manuring, respectively. Direct and residual effect of FYM at 15 t/ha to both the crops were equivalent to 30 kg P_2O_5/ha with same mode of application as observed by Chahal et al. (1984).

An experiment conducted at Ludhiana to study the N and P requirement of wheat sown after different kharif crops indicated that the yield of wheat sown after maize, arhar and fallow remained at par with each other and was significantly higher than that after bajra. Bajra thus proved the poorest preceeding crop because of the widest C:N ratio of its roots. Groundnut remained a poorer kharif crop for wheat than maize, arhar and fallow due to its greater consumption of N than that of others and lower CEC of roots of wheat sown after it than that of the one grown after other crop (Gogoi and Sandhu, 1984).

Raj et al. (1984) reported that wheat grain yield in fallow-wheat rotation was significantly higher than that of bajra-wheat rotation of all the nitrogen levels studied. This

indicated that preceeding bajra crop left the soil poor in fertility. It was further observed that response of wheat to applied nitrogen was obtained upto 120 kg N/ha in bajra-wheat rotation, whereas it was only upto 80 kg N/ha in fallow-wheat rotation.

Comparative study on legume-wheat and fallow-wheat sequence showed better performance over sorghum-wheat sequence. It is possible to save nitrogen to the extent of 30 kg N/ha when legume was included in the crop sequences as reported by Shinde et al. (1984). The study conducted by Yadav and Singh (1986) revealed that the yield of wheat after pulses was higher as compared to fallow at 90 and 120 kg N/ha.

Ramshe and Patil (1987) indicated that yield attributes were favourably influenced by the preceeding groundnut crop and that was reflected on maximum grain yield production of wheat. For obtaining specific yield level of wheat as 30 q/ha the bajra-wheat crop sequence required 66 kg N/ha, whereas green gram-wheat, groundnut-wheat and cowpea-wheat crop sequences required 36, 43 and 60 kg N/ha, respectively. The N economy at this specific yield level of wheat was to the extent of 30, 23 and 26 kg/ha through preceeding green gram, groundnut and cowpea for fodder, respectively as compared to bajra-wheat.

The study conducted by Jadhav and Koregave (1988) revealed that, grain and straw yield of wheat and monetary returns and net profit were more with groundnut-wheat cropping

sequence as compared to sorghum-wheat cropping system. The economy in fertilizer use to wheat to the extent of 20.80, 25.75 kg N and 10.19 and 12.69 kg P_2O_5/ha could be achieved due to groundnut with half and full dose of fertilizer, respectively. Wheat would be fertilized with recommended dose of fertilizer when grown after sorghum. However, fertilizer dose to wheat could be reduced to 2/3 of the recommended level of fertilizer when it was grown after groundnut. Higher grain yield of wheat was obtained when it was grown after (paired row (30/90 cm) + 2 rows of intercrops). Significantly higher wheat yield was obtained after bajra + cow pea intercropping system than growing wheat after the pure crop of bajra (Balyan and Seth, 1989).

Hooda et al. (1991) reported that the highest grain yield of bajra was obtained with 100 per cent nitrogen application through chemical fertilizers. The residual effect on succeeding wheat crop was significantly better over control. The partial replacement of nutrients (N) with either FYM or green manure gave yield of pearlmillet at par to that obtained in case of 100 per cent NPK applied through fertilizer. Replacement of nutrient with FYM was better as compared to green manure or wheat straw.

Application of N and P fertilizer directly to groundnut at initial stage had better effect on grain yield of wheat in groundnut-wheat sequence as reported by Gajendra Giri (1993). It was further reported that neither nutrients applied to wheat nor to groundnut in the subsequent season showed any improvement. There was no carry over effect of N on wheat crop

hence yield and yield attributes of wheat remained unchanged under various N levels applied to preceeding groundnut.

The study conducted by Kasole et al. (1993) at Rahuri revealed that combined application at N through organic and inorganic sources as 50 per cent N through FYM and remaining 50 per cent N through fertilizer gave significantly higher grain yield of sorghum followed by 100 per cent recommended dose of NPK through fertilizer. However, during subsequent rabi season significantly superior yield of wheat was recorded due to application of 50 per cent NPK through fertilizer and remaining 50 per cent through wheat cut straw applied during kharif season and full recommended dose of NPK through fertilizer to wheat.

An agronomic investigation was carried out to study the effect of preceeding bajra crop on yield of wheat. Results indicated that highest grain and straw yield of wheat was obtained under full dose of inorganic fertilizers. The organic treated plot recorded higher grain and straw yield over 75 per cent recommended NP dose applied through chemical fertilizer (Roshanlal and Hooda, 1993).

2.4.2 Nutrient uptake and residual fertility

The study conducted by Singh et al. (1981) revealed that marked residual response to FYM to wheat crop was observed but there was no residual response to P application. The response of P was of higher order in wheat as compared to pearlmillet. A field experiment conducted on bajra-wheat sequence showed that cumulative use of 60 kg P_2O_5/ha raised the

available P level. However N and K status decreased with continuous cropping. The studies further revealed that pH and EC were some what reduced due to continuous cropping. The levels of organic carbon also decreased with fertilizer use and continuous cropping as reported by Chahal et al. (1984).

The lowest yield of wheat was obtained in bajra-wheat sequence. That might be due to greater amount of potassium removal from the soil as compared to other preceeding crop. It was observed that high absorption potassium coupled with lowest removal of N by bajra might have distributed the balance of nutrients in the soil leading to an adverse effect on yield of wheat (Gogoi and Sandhu, 1984).

All the kharif preceeding crops improved the residual N and K status in the soil over the initial values. Groundnut and bajra had better effects in improvement of NPK in the soil. The initial P status in the soil was decreased to some extent after all the kharif crops. The residual available N in the soil after wheat when, it was preceeded by leguminous crop was more, while residual P after preceeding black gram and bajra and K after preceeding groundnut and bajra were significantly more than the rest of the crops. Increase in the levels of nitrogen for wheat increased the residual N in the soil, whereas P and K were higher in magnitude at no nitrogen and lower level of nitrogen for wheat (Ramshe and Patil, 1987).

Jadhav and Koregave (1988) observed that, the N and P uptake was increased significantly when wheat was grown after

groundnut as compared to after sorghum. N and P uptake was also increased significantly when wheat was preceeded by sorghum or groundnut with full dose as compared to half dose.

Bhandari et al. (1992) showed that, among the different organic sources of N for rice only FYM and wheat cut straw incorporation resulted in significantly lower N uptake than 100 per cent fertilizer and green manure treatment.

Patil et al. (1993) reported that, all the organic manures viz., FYM, wheat cut straw and sunnhemp incorporated in combination with inorganic sources invariably resulted in improvement on available N status of soil. Thereby marked uptake pattern by sorghum and wheat was observed. Application of 50 per cent recommended dose of NPK through fertilizer plus 50 per cent through wheat cut straw incorporated in kharif registered the highest uptake of N in rabi followed by the treatment of 50 per cent recommended dose of NPK through fertilizer plus 50 per cent through green manuring in kharif. The substituation of 50 per cent NPK through FYM or green manuring proved to be superior to other treatments.

Roshanlal and Hooda (1993) conducted an agronomic investigation to study the effect of preceeding bajra crop on yield of wheat. Results indicated that the soil fertility status after bajra was higher in those treatments where organic sources were adopted as compared to inorganic fertilization. The effect of residual soil fertility on succeeding wheat crop was significantly better over control.

Most of the investigator reported that the nitrogen favourably influenced the growth characters like plant height, tillering, leaf number, leaf area and dry matter accumulation with successive increase in nitrogen dose upto 120 kg N/ha. Yield contributing characters such as length of panicle, number of spikelets per panicle, number of grains per panicle thousand grain weight was also found to be increased. The grain and straw yield increased with increasing the fertilizer dose upto 120:60:60 kg NPK/ha.

Field studies conducted by many of the investigators showed that, the addition of organic manures not only contribute to the yield increase but also improve the physico-chemical properties of the soil. Application of 10 t FYM /ha resulted in significant increase in grain and straw yield of wheat.

Application of FYM @10 t/ha in conjunction with different fertilizer levels exhibited a significant increase in the growth and yield of wheat over fertilizer treatment alone. Complementary use of both organic and inorganic sources was advantageous and substantial amount of N through inorganic sources was saved.

It was revealed by many researchers that the yield of wheat and bajra inceased with increase in the dose of FYM and nitrogen. Legume-wheat and fallow-wheat showed better performance over bajra-wheat sequence. Wheat would be fertilized with recommended dose of fertilizer when grown after sorghum or bajra. However, fertilizer dose to wheat could be reduced to 2/3 of the recommended level of fertilizer when it was grown after legumes.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation was carried out on irrigated wheat during rabi season of 1993-94. The details of the materials used and the technique followed during the conduct of the experiment are given in this chapter under different headings as follows.

3.1 Details of the experimental materials

3.1.1 Experimental site

The experiment was laid out at the Post Graduate Institute, Central Campus Farm in 'B' Block Survey No. 50 of Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar during rabi 1993-94.

3.1.2 Soil

The soil of the experimental site was uniform and levelled. In order to study the some physical properties and nutrient status of the soil of the experimental field, the soil samples from 0 to 30 cm depth of previously planned experiment as per treatment were taken from the experimental area before lay out the experiment. Physical properties of the soil as clay, silt, fine sand, coarse sand and the nutrient status as available nitrogen, available P_2O_5, available K_2O, organic carbon and pH were determined. The data on physical and chemical properties are given in Table 1.

Table 1 : Initial physico-chemical properties of experimental site and methods used

Sr. No.	Soil property		Method used
1.	Coarse sand (%)	8.10	International pipette method (Piper, 1966)
2.	Fine sand (%)	25.50	--//--
3.	Silt (%)	15.50	--//--
4.	Clay (%)	50.90	--//--
5.	Textural class	clayey	
6.	pH (1:2.5 soil:water)	8.20	Glass electrode method (Piper, 1966)
7.	Organic carbon (%)	0.59	Walkey and Black rapid titration method (Piper, 1966)
8.	Organic matter (%)	1.01	Organic carbon per cent x 1.724
9.	Available nitrogen (kg/ha)	125.00	Alkaline potassium permagnate method (AOAC 1975)
10.	Available phosphate (kg/ha)	12.81	Olsens method (Olsen & Dean 1965)
11.	Available potash (kg/ha)	450.00	Flame photometer (Hanway and Haidal, 1967)

Table 2 : Initial chemical composition of soil (0-30 cm) as per treatment from experimental site

Sr. No.	Treatment	Organic carbon	Available kg/ha		
			N	P	K
1.	120 kg N/ha through chemical fertilizer	0.52	101.29	13.39	363.45
2.	90 kg N/ha through chemical fertilizer	0.53	107.40	17.81	383.05
3.	60 kg N/ha through chemical fertilizer	0.52	110.38	22.00	411.45

Table 2 Contd...

Sr. No.	Treatment	Organic carbon	Available kg/ha		
			N	P	K
4.	120 kg N/ha through FYM	0.57	74.05	22.78	426.45
5.	90 kg N/ha through FYM	0.56	80.75	24.51	442.22
6.	60 kg N/ha through FYM	0.52	89.16	25.81	458.25
7.	120 kg N/ha through vermicompost	0.59	96.30	19.72	368.75
8.	90 kg N/ha through vermicompost	0.56	98.78	20.85	391.65
9.	60 kg N/ha through vermicompost	0.57	105.25	22.83	443.87
10.	120 kg N/ha through fertilizer + 10 t FYM	0.63	102.87	19.84	360.00
11.	45 kg N/ha through fertilizer + 45 kg N/ha through FYM	0.53	97.69	25.08	395.60
12.	45 kg N/ha through fertilizer + 45 kg N/ha through vermicompost	0.51	90.61	21.61	379.85

3.1.3 Geo particular and climatic conditions

The soil of the experimental plot was clayey in texture, low in available nitrogen, low in available phosphorus and high in available potassium; It was slightly alkaline in reaction.

Geographically the central campus of Mahatma Phule Krishi Vidyapeeth, Rahuri is situated in between 19°-47′ North to 19°-57′ North latitute and 74°-19′ East longitude. The altitude varies from 495 to 569 meter above mean sea level.

Climatically the area fall in semi-arid sub tropical zone with annual precipitation varying from 307 to 568 mm. The rainfall is erratic and ill distributed coupled with frequent droughts. The rainy days vary from 19 to 66 in different years. Out of total annual rainfall about 80 per cent is received from June to September from south west monsoon while late rains are received in the month of October.

3.1.4 Climatic condition during the experimental period

In order to have an idea about the climatic conditions prevailed during the period of the present investigation, the weekly data on weather parameters obtained from the central meteorological observatory located in 'B' block are recorded for 1993-94 in rabi season and presented in Table 3.

Table 3 : Meteorological data during rabi 1993-94 (November 1993 to March 1994)

Month	Meteoro-logical week	Mean Temp °C		Relative Humidity %		Rainfall (mm)	No. of rainy days
		Max	Min	Morning	Evening		
Nov. 93	45	29.4	12.9	72	35	--	--
	46	30.5	18.7	74.	49	--	--
	47	30.3	16.3	77	37	6.0	1
	48	28.4	7.6	71	23	--	--
Dec. 93	49	24.0	6.7	88	64	70.3	2
	50	27.2	10.4	84	37	--	--
	51	26.8	7.3	84	31	--	--
	52	28.9	9.4	82	37	--	--

Table 3 contd...

Month	Meteoro-logical week	Mean Temp °C		Relative Humidity %		Rainfall (mm)	No. of rainy days
		Max	Min	Morning	Evening		
Jan. 94	1	28.9	11.2	86	39	--	--
	2	29.2	13.0	86	40	1.00	--
	3	27.0	8.7	85	40	--	--
	4	24.2	13.9	81	36	--	--
	5	28.4	8.6	78	29	--	--
Feb. 94	6	29.7	11.8	72	28	--	--
	7	30.9	11.8	79	25	--	--
	8	30.7	10.8	74	24	--	--
	9	33.3	10.9	78	19	--	--
Mar. 94	10	34.6	14.2	84	17	--	--
	11	36.8	15.4	62	18	--	--
	12	37.9	16.4	59	23	--	--
	13	37.6	17.4	59	31	--	--
Total	--	--	--	--	--	77.3	3

During the season, the mean maximum temperature ranged from 24.2°C to 37.9°C, while the mean minimum temperature ranged from 6.7°C to 18.7°C during the rabi season of 1993-94 with relative humidity ranging from 59 to 88 per cent in the morning and 16 to 84 per cent at the evening. In general climatic condition for wheat sown during rabi season of 1993-94 was fairly high temperature at germination and initial growth stage. There was comparatively high relative humidity during the month of December and January. The total rainfall received

during rabi 1993-94 was 77.3 mm in 3 rainy days. Out of which the maximum rainfall 70.3 mm was received in the first week of December which was useful for heavy tillering of wheat crop.

3.2 Cropping history of the experimental field

The cropping history of the experimental field for the previous three years are presented in Table 4. The present investigation was carried out in plots preceded by bajra experiment.

Table 4 : Cropping history of the experimental field for previous three years

Year	Kharif	Rabi	Summer
1990-91	Tur	Fallow	Green manuring
1991-92	Cowpea	Mustered	---
1992-93	---	Wheat	---
1993-94	Bajra	Present investigation	---

3.3 Seeds and fertilizers

3.3.1 Seeds

The seed of wheat variety HD 2189 was obtained from Central Store, Mahatma Phule Krishi Vidyapeeth, Rahuri.

3.3.2 Fertilizers

Nitrogen was given through 3 different sources such as chemically through urea containing 46 per cent N, FYM containing 0.74 per cent N, vermicompost containing 1.08 per cent N, Phosphorus through single super phosphate containing 16 per cent P_2O_5 and potash through murate of potash containing 60

per cent K_2O. All P and K was applied as basal dose prior to sowing to all the treatments.

3.4 Methods

3.4.1 Experimental details

The experiment was laid out in a Randomised Block Design with four replications. There were twelve treatments with three sources of nitrogen viz., inorganic, FYM and vermicompost. Each having three levels of nitrogen as 120, 90 and 60 kg N/ha. Additional three treatments were combination of inorganic and organic fertilizers. The details of the treatments alongwith symbol used are presented in Table 5. The plan of layout is depicted in Fig. 1.

3.4.2 The other details of the experiment are as follows

a) Total number of plots 48

b) Plot size
   Gross : 4.50 x 3.60 m^2
   Net : 3.60 x 2.70 m^2

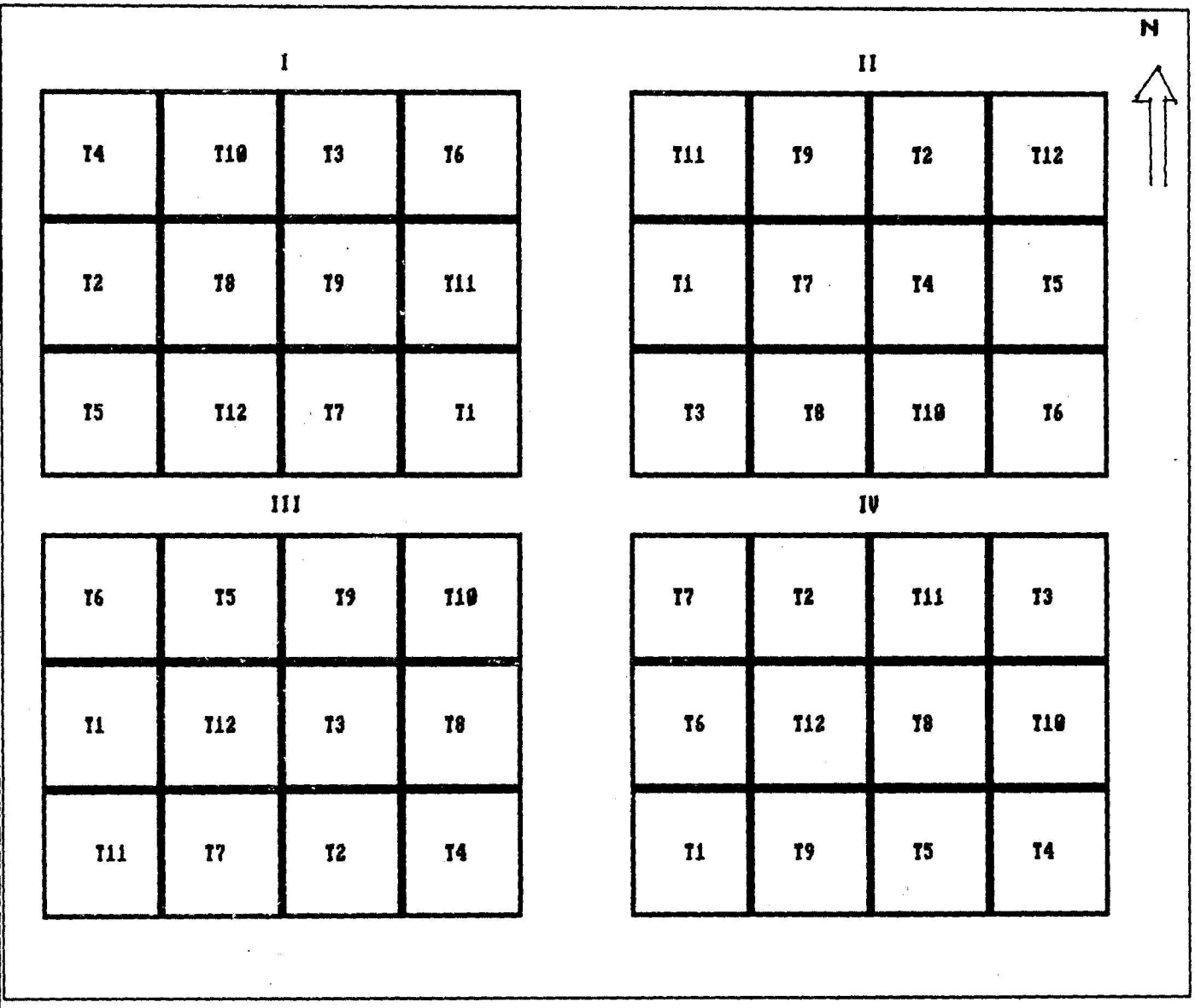
c) Method of sowing : line sowing

d) Date of sowing : 28/11/1993

e) Row to row spacing : 22.5 cm.

3.4.3 Field operations

The details of the various cultural operations carried out in the experimental plot during rabi season of 1993-94 are presented in Table 6.



Total number of plots : 48

Plot size :

Gross : 4.50 x 3.60 m^2

Net : 3.60 x 2.70 m^2

Row to row spacing : 22.5 cm

Design : R.B.D.

Replications : Four

Treatments : Twelve

Method of sowing : Line sowing

Fig.1: Plan of layout

Table 5 : Details of treatments and symbols used

Sr. No.	Treatments	Symbols
1.	Recommended dose of nitrogen (120 kg N/ha) through fertilizer	T_1
2.	Application of 75 per cent of recommended dose of nitrogen (90 kg N/ha) through fertilizer	T_2
3.	Application of 50 per cent of recommended dose of nitrogen (60 kg N/ha) through fertilizer	T_3
4.	100 per cent of recommended dose of nitrogen through FYM alone (120 kg N/ha)	T_4
5.	75 per cent of recommended dose of nitrogen (90 kg N/ha) through FYM alone	T_5
6.	50 per cent of recommended dose of nitrogen (60 kg N/ha) through FYM alone	T_6
7.	100 per cent of recommended dose of nitrogen (120 kg N/ha) through vermicompost alone	T_7
8.	75 per cent of recommended dose of nitrogen (90 kg N/ha) through vermicompost alone	T_8
9.	50 per cent of recommended dose of nitrogen (60 kg N/ha) through vermicompost alone	T_9
10.	100 per cent of recommended dose of nitrogen through fertilizer + recommended dose of FYM (120 kg N/ha + 10 t FYM/ha)	T_{10}
11.	37.5 per cent of recommended N through fertilizer + 37.5 per cent recommended N through FYM (45 kg N through fertilizer + 45 kg N through FYM/ha)	T_{11}
12.	37.5 per cent of recommended N through fertilizer + 37.5 per cent recommended N through vermicompost (45 kg N through fertilizer + 45 kg N through vermicompost per hectare)	T_{12}

Table 6 : Schedule of field operations carried out in the experimental plot during rabi season of 1993-94

Sr.No.	Field operations	Frequency	Date
A)	**Preparatory tillage**		
	1. Rotavatory operation	1	23.11.93
	2. clod crushing	1	25.11.93
	3. Collection of stubbles	1	26.11.93
	4. Preparation of layout	1	27.11.93
	5. Levelling of beds	1	27.11.93
B)	**Sowing and fertilizer application**		
	1. Fertilizer application	1	28.11.93
	2. Sowing and covering	1	28.11.93
C)	**Post sowing**		
	1. Irrigations	5	29.11.93 28.12.93 13.1.94 31.1.94 15.2.94
	2. Weeding	1	25.12.93
	3. Hoeing	1	23.12.93
	4. Top dressing	1	28.12.93
D)	**Harvesting**	1	18.3.94
E)	**Threshing**	1	20.3.94

3.4.3.1 Preparation of layout

The purpose of the study was to see the residual effect of organic material left after the experiment on bajra, the experimental layout for wheat was prepared by superimposing the plot of wheat by keeping the same treatment.

3.4.3.2 Sieving of organic manure

The FYM and vermicompost which is utilized for the experimental purpose was sieved and undecomposed bigger size material and stones were separated.

3.4.3.3 Fertilizer application

Wheat was fertilized as per the treatments. But only organic fertilizer were applied 3 days before sowing to that treatment plots on 25.11.93 and well mixed with help of kudali. Where as the chemical fertilizers were applied on 28.11.93 before sowing.

3.4.3.4 Sowing

The experimental plot was sown on 28.11.93. The seeds were sown by adopting line sowing in shallow furrows opened by the marker.

3.4.3.5 Weeding

Mechanical weeding was done on 23th December 1993 whereas the hand weeding was done on 25th December 1993.

3.4.3 Irrigations

First irrigation was given on 29th November 1993 immediately after sowing to ensure the proper germination and subsequent four irrigation were given as per requirement of the crop as given in Table 6.

3.5 Biometric and other observations

3.5.1 Sampling techniques

For recording various growth observations five plants were selected at random from each net plot. The price labels were tied to each plant for easy identification. All the observations on plant height, number of leaves, panicles length, number of grains per earhead, number of spikelets per panicle

were recorded on these plants. The detailed schedule adopted for recording various growth observations is given in Table 7.

3.5.2 Growth studies

3.5.2.1 Plant count

The number of plants emerged were recorded on the 20th day after sowing. In every net plot 3 spots of one meter length were selected at random and the number of plants per meter length was recorded.

3.5.2.2 Height of the plant

Five randomly selected plants were used for observations of the height of the plant. It was recorded on the main shoot from the ground level to the base of last fully opened leaf upto the stage of panicle emergence. After panicle initiation, the height was measured from ground level to the base of panicle in cm.

3.5.2.3 Number of tillers per plant

The total number of shoots from each of one meter length from 3 random places from each net plot was counted. The average number of tillers per plant was computed by dividing the number of shoots, excluding the main shoot by the number of main shoots, recorded on the 20th day of growth.

3.5.2.4 Number of functional leaves per plant

The total number of fully opened green leaves per plant was recorded as functional leaves.

Table 7 : Schedule of biometric observations

Sr. No.	Characters observed	Frequency of observa-tions	No.of plants selected randomly	Observations recorded in days after sowing
A) Preharvest study				
1.	Emergence count	1	at one meter length	20
2.	Height of plant (cm)	4	5	30,60,90 & at harvest
3.	No.of functional leaves per plant	3	5	30,60 & 90 day
4.	Total number of tillers per plant	4	5	30,60,90 & at harvest
5.	Leaf area (sq.dm) per plant	3	2	30,60 & 90 day
6.	Dry matter per plant (g)	4	2	30,60,90 & at harvest
7.	Productive tillers per plant	1	5	At harvest
B) Post harvesting study				
1.	Length of panicle (cm)	1	5	At harvest
2.	Number of spikelets per panicle	1	5	At harvest
3.	Number of grains per panicle	1	5	At harvest
4.	Weight of grain per plant (g)	1	5	At harvest
5.	Thousand grain weight (g)	1	Represen-tative sample from net plot	At harvest
6.	Grain yield per net plot and per hectare	1	Net plot and per hectare	At harvest

Table 7 contd...

Sr. No.	Characters observed	Frequency of observa-tions	No.of plants selected randomly	Observations recorded in days after sowing
7.	Straw yield per net plot and per hectare	1	Net plot and per hectare	At harvest
8.	Total biomass per net plot and per hectare	1	Net plot and per hectare	At harvest
C) Chemical analysis				
1.	Physical and chemical properties of soil	1	Aggregate representative samples reduced from samples collected from 12 spots in experimental field	Before laying out of the expt.
2.	Plant analysis for nitrogen, phosphorous and potash content		1	At harvest
3.	Total uptake of nitrogen (kg/ha)		1	At harvest
4.	Total uptake of phosphorous (kg/ha)		1	At harvest
5.	Total uptake of potash (kg/ha)		1	At harvest
D) Quality				
1.	Nitrogen, phosphorous and potassium concentration in grain		1	At harvest
2.	protein percentage in grain		1	At harvest

3.5.2.5 Leaf area per plant (sq.dm)

The two randomly selected plants from net plot were uprooted for dry matter study and used for determining the leaf area. The functional leaves carefully removed from the stem and they were grouped in to three classes as per the size viz. small medium and large, and its leaf area was measured on leaf area meter directly.

3.5.2.6 Dry matter per plant

The dry matter per plant was recorded at an interval of 30 days after sowing by utilizing the same plant uprooted for leaf area study. The plants were cut at the ground level, air dried and finally dry weight was recorded after drying in oven at 60°C to 65°C until the constant weight was obtained.

3.5.3 Post harvest studies

3.5.3.1 Length of panicle

The length of panicle was measured from the basal spikelets to the tip of the panicle, excluding awns from five randomly selected panicle. The mean length of panicle was then worked out in cm.

3.5.3.2 Number of spikelets per panicle

The number of spikelets per panicle were counted from the same panicles which were used for measuring the panicle length, at harvest and the mean per panicle was worked out.

3.5.3.3 Number of grains per panicle

The same panicle in each treatment which were used for the study of mean length of panicle were used for this study. The grain number per panicle was counted and the mean was computed.

3.5.3.4 Weight of grain per plant

The grain weight in gram per plant from five randomly selected plants was recorded and average was computed to obtain grain weight per plant.

3.5.3.5 Thousand grain weight

The random samples of grains from the total grain produce obtained from each net plot was drawn, then thousand grains were counted and weighted to obtain thousand grain weight from each treatment.

3.6 Yields

3.6.1 Yield of total biomass per plot

The harvested produce from net plot was dried for some days and was weighed to record the total biomass per plot.

3.6.2 Yield of grain per plot

The panicle of the plants were threshed after drying and winnowed. The grain weight obtained was recorded as per treatments.

3.6.3 Yield of straw per plot

After threshing the panicle the weight of straw arrived at by deducting the weight of grain from the weight of

total produce per plot. The per hectare yield of grain, straw and total biomass was then computed.

3.6.4 Straw to grain ratio

The ratio was estimated from the yield of grain and straw obtained from the net plot in the corresponding treatments. It is estimated by dividing the straw weight by grain weight.

3.7 Economic studies

3.7.1 Gross monetary returns

The gross monetary returns were worked out by considering the prevailing market prices of the produce during the year of experimentation.

3.7.2 Cost of cultivation

The cost of cultivation was worked out by considering the amount required for the purchase of inputs like seeds, fertilizers, irrigation charges etc and the expenditure on the labours and bullocks required for field operations etc.

3.7.3 Net monetary returns

The net monetary returns were worked out by substracting the cost of cultivation from the gross monetary returns of the corresponding treatment.

3.7.4 Benefit cost ratio

The benefit cost ratio was worked out by considering the per hectare values of net profit and cost of cultivation.

3.8 Chemical study

The observational plants collected at harvest were used for chemical analysis. The dried straw samples after grinding were passed through Wiley mill (20 mesh) and used for chemical analysis. Grain samples were ground in an electric grinder and used for chemical analysis.

3.8.1 Plant analysis for nutrient content

1. Nitrogen was estimated by modified Kjeldahis method (Parkinson and Allen, 1975).

2. Protein content of the grain was determined by multiplying percent nitrogen in grain with concentration factor 6.25 (A.O.A.C. 1975).

3. Phosphorus was determined in aliquot of the acid extract by measuring the intensity of the vanado phosphomolybdate yellow colour with spectronic 20 (640 μ) (Jackson, 1973).

4. Potash was determined in an aliquot of the acid extract by measuring its concentration in flame photometer method (Chapman and Pratt, 1960).

Nutrient uptake

The uptake of nitrogen, phosphorus and potash by grain and straw was calculated by multiplying per cent N, P and K concentration in grain and straw with their respective yields. Total uptake was recorded by summing up the respective uptake by grain and straw.

3.8.2 Soil analysis

Composite soil samples from 0-30 cm soil depth from each net plot were collected after harvest of the crop. They were ground in wooden pastel and mortar after air drying and passed through 2 mm sieve and were used for chemical analysis. For the determination of organic carbon, soil samples were passed through 0.8 mm sieve.

1. Organic carbon was determined by Walkey-Blacks wet oxidation method (Jackson, 1973).

2. Soil pH was determined (1:2.5 Soil:water) (Jackson, 1973).

3. EC at 25°C was measured by Electrical conductivity meter method (Jackson, 1973).

4. Available nitrogen : Available nitrogen was determined by modified alkaline potassium permangnate method (Subbiah and Asija, 1956).

5. Available phosphorus : Available phosphorus was determined by modified Olsen's method (Olsen and Dean, 1965).

6. Available potassium : Available potassium was determined by Flame photometer method (Hanwey and Heidal, 1967).

3.9 Statistical analysis and interpretation of data

The data thus recorded were statistically analysed by using the techniques of analysis of variance (Fisher, 1970) and test of significance was carried out as given by Cochran and Cox (1967) and Panse and Sukhatme (1985). In the tabular data

in the text C.D. values have been given for comparison only in cases where 'F' test was significant, figures for S.E. ± are given. The data regarding interactions which are significant only were presented, suitable graphical illustrations of data have been given at the appropriate places. The statistical analysis was carried out by computer.

Results and Discussion

4. RESULTS AND DISCUSSION

An experiment on 'Nitrogen substitution through organic sources in irrigated wheat and their effects in bajra-wheat sequence' was conducted during rabi, 1993-94. The detail results of the said investigation are presented below under appropriate subheadings.

4.1 Plant count

The data on mean initial plant count of wheat per metre row length at 20 days after sowing as influenced by various treatments are presented in Table 8.

The mean number of initial plant of wheat crop was 50.50 per meter row length at 20 days. Data presented in Table 8 indicated that the initial plant count per metre row length was not significantly influenced due to different treatments, indicating thereby that the initial plant stand was uniform.

4.2 Growth studies

4.2.1 Plant height

The plant height generally indicate the vigour and growth of the plant. The data pertaining to the mean plant height as influenced periodically by the different treatments are presented in Table 9 and graphically shown in Fig. 2. The mean plant height in cm increased progressively from 12.93 cm at 30th day of observation to 71.62 cm at harvest stage of the crop.

Table 8 : Mean number of plants per meter length as affected by different treatments

Sr. No.	Treatments	Mean number of plants per meter length at 15 days after sowing
1.	120 kg N/ha through fertilizer	50.75
2.	90 kg N/ha through fertilizer	50.25
3.	60 kg N/ha through fertilizer	51.00
4.	120 kg N/ha through FYM	50.00
5.	90 kg N/ha through FYM	51.50
6.	60 kg N/ha through FYM	49.25
7.	120 kg N/ha through vermicompost	50.75
8.	90 kg N/ha through vermicompost	49.75
9.	60 kg N/ha through vermicompost	48.00
10.	120 kg N/ha through fertilizer + 10 t FYM	53.00
11.	45 kg N through fertilizer + 45 kg N through FYM	51.25
12.	45 kg N through fertilizer + 45 kg N through vermicompost	50.50
	F test	N.S.
	S.E. ±	1.25
	C.D. at 5 %	---
	Mean	50.50

The plant height differed significantly due to different levels and sources both organic and inorganic during all the stages of growth. Application of 120 kg N with 10 t FYM/ha produced maximum plant height, the height being 90.08 cm per plant at harvest and it was significantly higher than rest of the treatments except recommended levels given through sources to which it was on par during all the stages of growth. Application of 90 kg N through inorganic sources produced next higher plant height which was equally good with recommended N with 10 t FYM/ha and recommended dose through inorganic sources during 30 days after sowing.

As regards application of recommended dose of nitrogen through vermicompost produced more plant height than its equivalant dose through FYM, but they were on par during all the stages of growth except at harvest. At harvest it is decreased than application of recommended dose through vermicompost produced significantly more plant height than same dose given through FYM.

Application of 90 kg N/ha through inorganic sources produced higher plant height than 45 kg N through inorganic sources and remaining 45 kg N either through vermicompost or FYM but all these treatments were on par during all the growth stages.

The minimum plant height was produced due to application of 60 kg N through FYM during all the stages of growth.

Table 9 : Mean height of plant (cm) as influenced periodically by different treatments

Sr. No.	Treatments	Days after sowing			
		30	60	90	At harvest
1.	120 kg N/ha through fertilizer	15.60	61.80	82.20	87.00
2.	90 kg N/ha through fertilizer	15.08	59.70	78.85	82.33
3.	60 kg N/ha through fertilizer	13.98	52.00	71.68	75.05
4.	120 kg N/ha through FYM	11.08	44.65	66.03	68.23
5.	90 kg N/ha through FYM	10.58	39.70	54.00	56.85
6.	60 kg N/ha through FYM	10.43	36.95	47.33	52.25
7.	120 kg N/ha through vermicompost	12.05	45.93	70.08	73.95
8.	90 kg N/ha through vermicompost	11.13	40.83	55.25	59.68
9.	60 kg N/ha through vermicompost	10.38	38.20	50.53	54.08
10.	120 kg N/ha through fertilizer + 10 t FYM	15.65	65.50	84.68	90.08
11.	45 kg N through fertilizer + 45 kg N through FYM	14.33	57.25	74.48	79.88
12.	45 kg N through fertilizer + 45 kg N through vermicompost	14.90	59.50	78.68	80.10
	F test	Sig.	Sig.	Sig.	Sig.
	S.E. ±	0.57	1.429	1.606	1.637
	C.D. at 5 %	1.65	4.116	4.627	4.717
	Mean	12.93	50.17	67.65	71.62

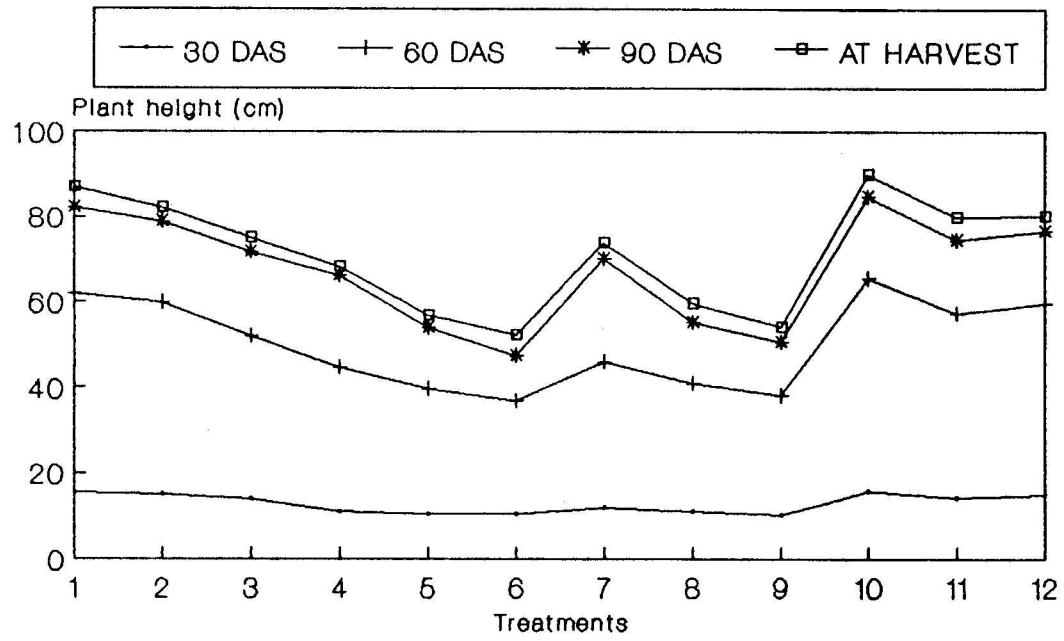


Fig.2: Mean plant height (cm) as influenced by different treatments at various stages of growth

Increase in height of wheat with increase in nitrogen dose was reported by Auti (1980), Agarwal (1983), Nikam (1985), Dhuka et al. (1991) and Upadhayaya (1993). Increase in plant height due to application of 12 t FYM/ha alongwith different fertilizer levels was also reported by Sharma (1981) and Shinde (1992).

4.2.3. Number of tillers per plant

The data on mean number of tillers per plant are presented in Table 10 and graphically depicted in Fig. 3.

The data indicated that the mean number of tillers per plant differed significantly due to different treatments during all the stages of growth. At harvest mean number of tillers per plant were 1.02.

Application of 120 kg N/ha with 10 t FYM/ha produced maximum tillers per plant and the highest being 2.86 per plant at 60 DAS and it was significantly higher over rest of the treatments during all the growth stages except 60 DAS during which it was at par with 120 kg N/ha through inorganic sources.

Application of 90 kg N/ha half of which given through vermicompost and remaining half through inorganic sources produced higher number of tillers than half N given through FYM and remaining half through inorganic sources and full through inorganic sources but all these were on par.

As regards application of recommended dose of nitrogen through vermicompost produced more number of tillers

Table 10 : Mean number of tillers per plant as influenced periodically by different treatments

Sr. No.	Treatments	Days after sowing			
		30	60	90	At harvest
1.	120 kg N/ha through fertilizer	2.103	2.820	1.970	1.165
2.	90 kg N/ha through fertilizer	2.027	2.688	1.948	1.065
3.	60 kg N/ha through fertilizer	2.003	2.520	1.905	0.940
4.	120 kg N/ha through FYM	1.933	2.403	1.828	0.980
5.	90 kg N/ha through FYM	1.943	2.373	1.813	0.933
6.	60 kg N/ha through FYM	1.925	2.205	1.798	0.813
7.	120 kg N/ha through vermicompost	1.998	2.465	1.865	1.005
8.	90 kg N/ha through vermicompost	1.945	2.388	1.823	0.933
9.	60 kg N/ha through vermicompost	1.925	2.288	1.795	0.882
10.	120 kg N/ha through fertilizer + 10 t FYM	2.202	2.860	2.093	1.323
11.	45 kg N through fertilizer + 45 kg N through FYM	2.072	2.690	1.968	1.085
12.	45 kg N through fertilizer + 45 kg N through vermicompost	2.095	2.713	1.980	1.103
	F test	Sig.	Sig.	Sig.	Sig.
	S.E. ±	0.030	0.050	0.031	0.037
	C.D. at 5 %	0.085	0.143	0.088	0.107
	Mean	2.014	2.536	1.899	1.018

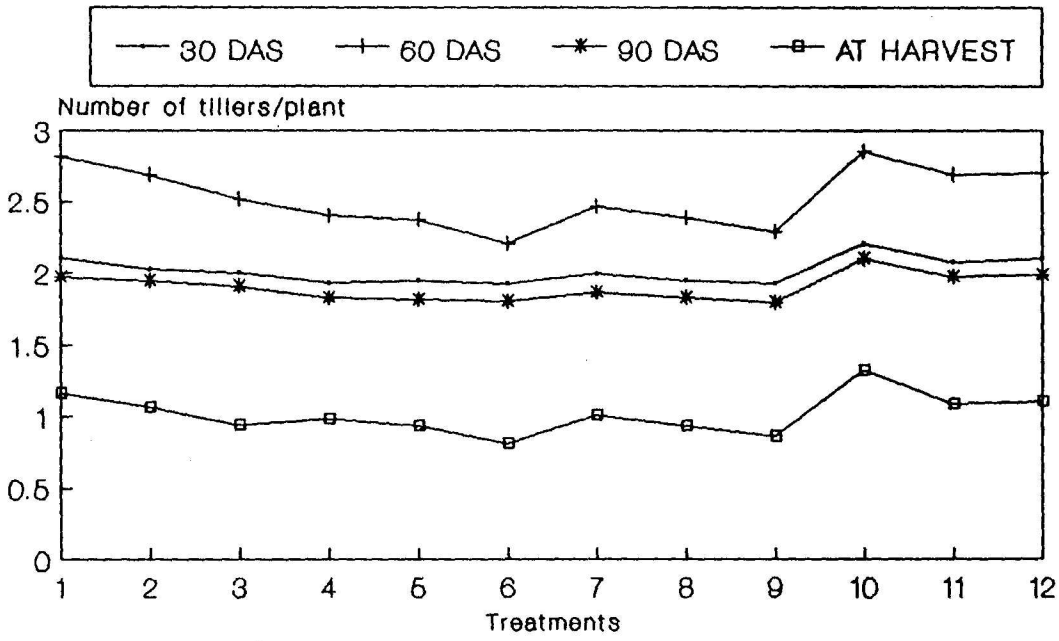


Fig.3: Mean number of tillers per plant as influenced periodically by different treatments

per plant than the same dose applied through FYM but they were on par during all the stages of growth except at 30 DAS.

The minimum tiller number per plant was observed due to application of 60 kg N through FYM or vermicompost.

The results are in conformity with the findings obtained by Rao and Bharadwaj (1981), Bhaliya et al. (1983), Singh and Awasthi (1983), Singh et al. (1984), Nikam (1985), Girothia et al. (1987), Patel et al. (1992), Shinde (1992), Patel and Upadhyaya (1993) and Singh et al. (1993).

4.2.3 Functional leaf number per plant

Data pertaining to mean functional leaf number per plant as affected periodically by different treatments are presented in Table 11 and graphically shown in Fig. 4.

From the data presented in Table 11, it was seen that the mean leaf count per plant was more in early growth stages and declined there after with advancement in age of crop due to sencencence of leaves at later stages. The mean functional leaves per plant at 30th, 60th and 90th days were 7.62, 6.03 and 4.13, respectively. The mean number of functional leaves per plant was significantly influenced due to different levels of nitrogen through inorganic and organic sources.

The application of 120 kg N through fertilizer with 10 t FYM/ha produced the maximum functional leaf number per plant at all the growth stages and it was significantly higher

Table 11 : Mean functional leaf number per plant as influenced periodically by different treatments

Sr. No.	Treatmetns	Days after sowing		
		30	60	90
1.	120 kg N/ha through fertilizer	8.30	7.05	4.85
2.	90 kg N/ha through fertilizer	8.10	6.45	4.30
3.	60 kg N/ha through fertilizer	7.45	5.80	3.95
4.	120 kg N/ha through FYM	7.18	5.90	3.95
5.	90 kg N/ha through FYM	7.28	5.15	3.77
6.	60 kg N/ha through FYM	6.80	5.10	3.57
7.	120 kg N/ha through vermicompost	7.30	5.80	4.10
8.	90 kg N/ha through vermicompost	7.08	5.45	3.85
9.	60 kg N/ha through vermicompost	6.78	5.10	3.55
10.	120 kg N/ha through fertilizer + 10 t FYM	8.65	7.30	4.90
11.	45 kg N through fertilizer + 45 kg N through FYM	8.15	6.55	4.25
12.	45 kg N through fertilizer + 45 kg N through vermicompost	8.38	6.70	4.45
	F test	Sig.	Sig.	Sig.
	S.E. ±	0.105	0.126	0.088
	C.D. at 5 %	0.304	0.363	0.254
	Mean	7.619	6.029	4.125

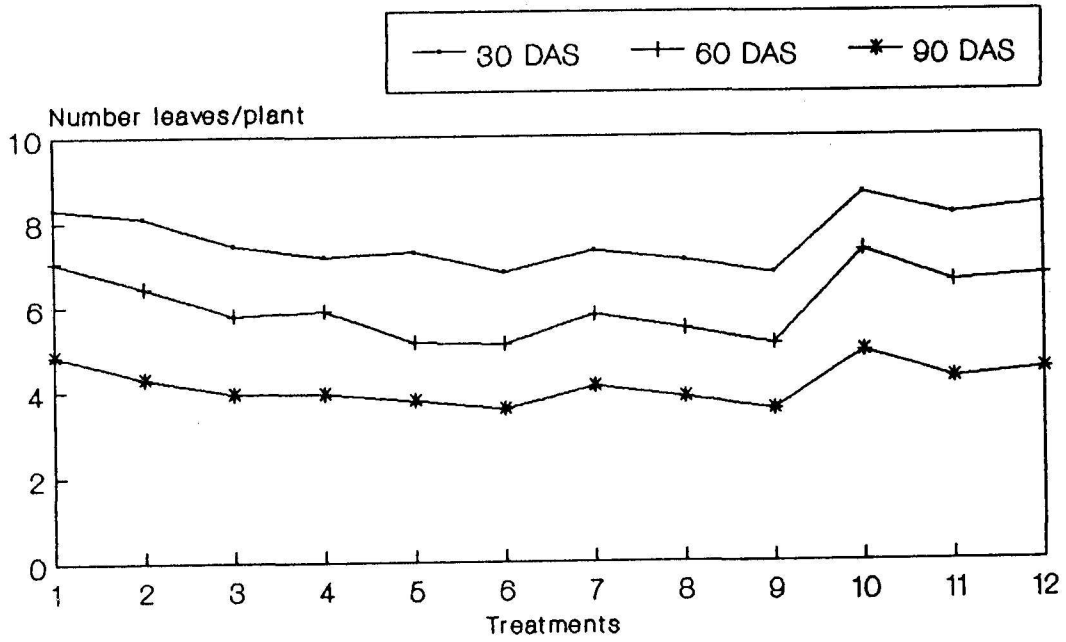


Fig.4: Mean functional leaf number per plant as influenced periodically by different treatments

than rest of the treatments except recommended levels given through inorganic sources to which it was at par. It was followed by application of 45 kg N through fertilizer + 45 kg N through vermicompost produced next higher leaf number which was equally good with recommended dose through inorganic sources during 30 and 60 days after sowing. However, it was on par with 90 kg N supplied through inorganic sources and 45 kg N through fertilizer + 45 kg N through FYM.

As regards application of full dose of nitrogen through vermicompost produced more number of functional leaves than its application through FYM but both were at par.

4.2.4 Leaf area per plant

The data regarding the mean leaf area per plant (dm^2) as affected periodically by different treatments are presented in Table 12 and graphically depicted in Fig. 5.

It was observed from the Table 12 that the mean leaf area per plant increased rapidly upto 60 DAS and reaching maximum of 7.655 dm^2 per plant and thereafter it declined due to the senenscence of matured leaves.

Leaf area per plant was maximum and significantly more with the application of 120 kg N through inorganic sources + 10 t FYM/ha at all the growth stages than rest of the treatments. It was followed by 120 kg N/ha through fertilizers.

Application of 90 kg N i.e. 45 kg N through fertilizer and remaining 45 kg N either through vermicompost or

Table 12 : Mean leaf area per plant (dm^2) as influenced periodically by different treatments

Sr. No.	Treatmetns	Days after sowing		
		30	60	90
1.	120 kg N/ha through fertilizer	5.66	9.21	8.20
2.	90 kg N/ha through fertilizer	4.30	8.65	7.98
3.	60 kg N/ha through fertilizer	3.72	7.58	7.45
4.	120 kg N/ha through FYM	3.18	6.97	6.00
5.	90 kg N/ha through FYM	2.97	8.37	5.80
6.	60 kg N/ha through FYM	2.29	5.41	4.90
7.	120 kg N/ha through vermicompost	3.45	7.89	6.97
8.	90 kg N/ha through vermicompost	3.18	6.69	6.10
9.	60 kg N/ha through vermicompost	2.85	6.14	5.48
10.	120 kg N/ha through fertilizer + 10 t FYM	6.27	9.85	9.15
11.	45 kg N through fertilizer + 45 kg N through FYM	4.29	8.45	8.05
12.	45 kg N through fertilizer + 45 kg N through vermicompost	4.41	8.65	8.11
	F test	Sig.	Sig.	Sig.
	S.E. ±	0.118	0.157	0.155
	C.D. at 5 %	0.340	0.453	0.445
	Mean	3.880	7.655	7.015

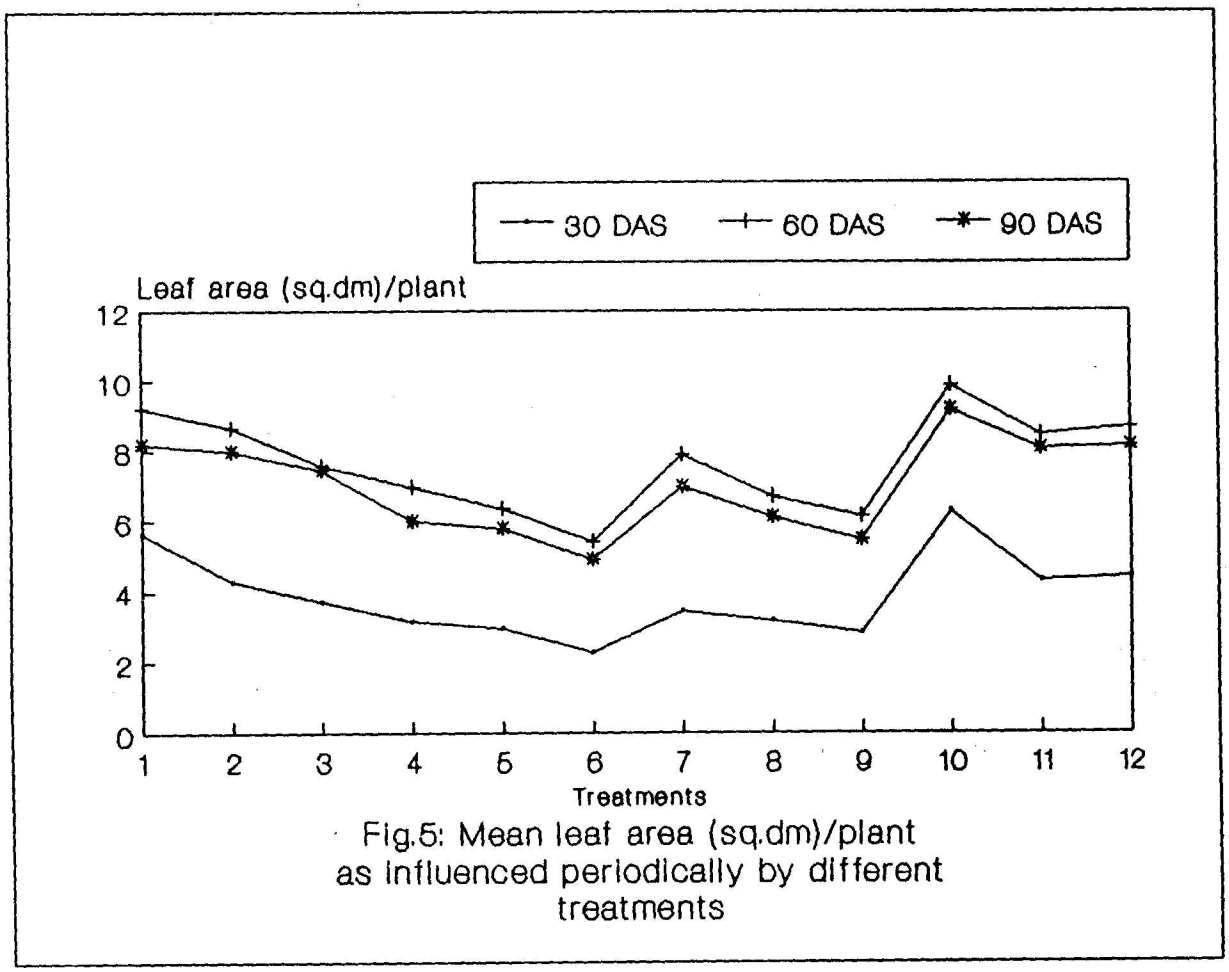


Fig.5: Mean leaf area (sq.dm)/plant as influenced periodically by different treatments

FYM produced significantly higher leaf area than application of full dose of nitrogen through either of the sources.

As regards application of 120 kg N either through vermicompost or FYM, vermicompost showed its superiority over FYM. The lowest leaf area per plant was observed with application of 60 kg N through FYM. Similar results were obtained by Auti (1980), Zope (1981), Nikam (1985) and Jadhav (1989).

4.2.5 Dry matter accumulation

The data pertaining to the dry matter accumulation per plant as affected by different treatments are presented in Table 13 and graphically shown in Fig. 6. The mean dry matter accumulation per plant was 0.824, 1.900, 4.293 and 5.304 g during 30, 60, 90 and at harvest, respectively.

The dry matter production differed significantly due to different levels and both the sources (organic and inorganic) during all the stages of growth.

Application of 120 kg N with 10 t FYM/ha produced maximum dry matter during all the stages of growth and the highest being 7.075 g per plant at harvest. It was significantly superior over rest of the treatments except on 90 DAS during which it was at par with recommended dose and 75 per cent of recommended dose through fertilizer. Application of 90 kg N applied partly through inorganic and partly through vermicompost produced higher dry matter than same quantity of N

Table 13 : Mean dry matter accumulation(g) per plant as influenced periodically by different treatments

Sr. No.	Treatments	Days after sowing			
		30	60	90	At harvest
1.	120 kg N/ha through fertilizer	0.811	2.954	5.582	6.437
2.	90 kg N/ha through fertilizer	0.721	2.578	5.285	6.087
3.	60 kg N/ha through fertilizer	0.525	2.221	4.474	5.293
4.	120 kg N/ha through FYM	0.548	1.165	3.945	4.823
5.	90 kg N/ha through FYM	0.533	0.963	3.380	4.487
6.	60 kg N/ha through FYM	0.476	0.863	3.212	4.217
7.	120 kg N/ha through vermicompost	0.579	1.446	4.305	5.195
8.	90 kg N/ha through vermicompost	0.531	0.967	3.603	4.624
9.	60 kg N/ha through vermicompost	0.500	0.878	3.378	4.400
10.	120 kg N/ha through fertilizer + 10 t FYM	0.985	3.415	5.730	7.075
11.	45 kg N through fertilizer + 45 kg N through FYM	0.602	2.599	4.342	5.458
12.	45 kg N through fertilizer + 45 kg N through vermicompost	0.873	2.748	4.552	5.550
	F test	Sig.	Sig.	Sig.	Sig.
	S.E. ±	0.054	0.126	0.202	0.133
	C.D. at 5 %	0.155	0.362	0.583	0.383
	Mean	0.624	1.900	4.293	5.304

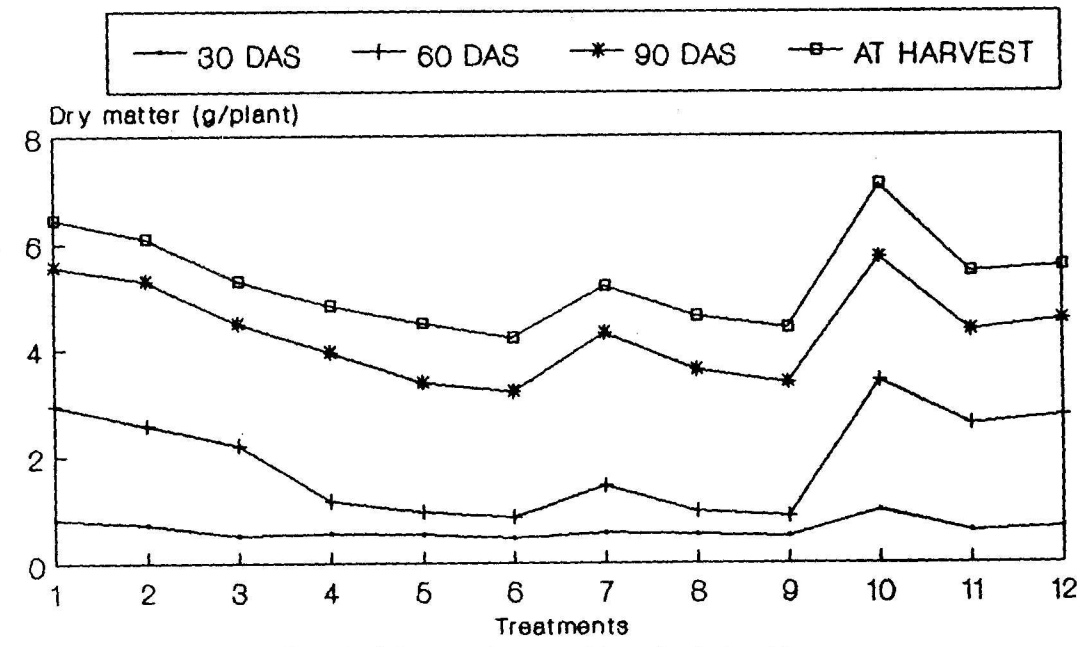


Fig.6: Mean dry matter (g/plant) as affected by different treatments at various growth stages

applied partly through inorganic and partly through FYM during all the stages of growth.

As regards application of full dose through vermicompost produced more dry matter than same dose applied through FYM and both were at par.

The minimum dry matter was obtained due to 60 kg N applied either through FYM or vermicompost during all the stages of growth.

It was evident from the data in Table 13 that the accumulation of dry matter increased with advancement in age of crop. The results are inconfirmity with the results obtained by Auti (1980), Borse and Mahajan (1980), Balasubramanian and Singh (1982), Nikam (1985) and Jadhav (1989).

4.3 Studies on yield contributing characters

The data regarding the mean number of productive tillers per plant, length of panicle, number of spikelets per panicle, number of grains per panicle, grain weight (g) per plant at harvest and thousand grain weight (g) are presented in Table 14 and 15, respectively.

4.3.1 Number of productive tillers per plant

It would be evident from the data in Table 14 that the mean number of productive tillers per plant was 0.823.

The mean maximum number of productive tillers (1.11/plant) was observed with application of 120 kg N through fertilizers with 10 t FYM/ha and was significantly higher than

Table 14 : Mean number of productive tillers per plant, length of panicle and number of spikelets per panicle as influenced by different treatments

Sr. No.	Treatmetns	No. of productive tillers per plant	Length of panicle (cm)	No. of spikelets per panicle
1.	120 kg N/ha through fertilizer	0.91	8.17	20.98
2.	90 kg N/ha through fertilizer	0.89	8.09	20.00
3.	60 kg N/ha through fertilizer	0.78	7.63	18.10
4.	120 kg N/ha through FYM	0.77	5.99	13.45
5.	90 kg N/ha through FYM	0.75	5.59	12.25
6.	60 kg N/ha through FYM	0.72	3.97	11.43
7.	120 kg N/ha through vermicompost	0.79	6.64	16.30
8.	90 kg N/ha through vermicompost	0.77	5.90	14.80
9.	60 kg N/ha through vermicompost	0.74	4.05	14.45
10.	120 kg N/ha through fertilizer + 10 t FYM	1.11	8.45	22.53
11.	45 kg N through fertilizer + 45 kg N through FYM	0.88	7.90	19.60
12.	45 kg N through fertilizer + 45 kg N through vermicompost	0.90	7.98	19.85
	F test	Sig.	Sig.	Sig.
	S.E. ±	0.030	0.272	0.856
	C.D. at 5 %	0.086	0.784	2.467
	Mean	0.833	6.706	16.98

rest of the treatments. It was followed by application of 120 kg N/ha (0.913 tillers/plant) and was significantly higher than rest of the treatments except application of 90 kg N/ha either through fertilizer alone or partly through fertilizer and partly through FYM or vermicompost.

The minimum productive tiller per plant was obtained due to application of 60 kg N either through FYM or vermicompost.

The results are in line with those obtained by Reddy and Prasad (1980), Rao and Bharadwaj (1981), Bhaliya et al. (1983), Singh and Awasthi (1983), Singh et al. (1984), Sambasiva et al. (1984), Nikam (1985), Girothia et al. (1987), Patel et al. (1992), Gajendra (1993), Patel and Upadhyaya (1993) and Singh et al. (1993).

4.3.2 Length of panicle

Length of panicle was significantly influenced due to different treatments. The maximum and significantly more panicle length (8.45 cm) was recorded due to application of 120 kg N through chemical fertilizer + 10 t FYM/ha than rest of the treatments except application of 120 kg N/ha through fertilizer and 90 kg N either through inorganic sources or partly through inorganic and vermicompost or inorganic and FYM were equally effective in producing same size panicle length.

Application of 120 kg N/ha given through vermicompost produced panicle of higher length than the same dose applied through FYM. However, both were at par.

4.3.3 Number of spikelets per panicle

It was evident from the data in Table 14 that the mean number of spikelets per panicle was 18.98. The mean number of spikelets per panicle differed significantly due to different treatments. The application of 120 kg N through fertilizer + 10 t FYM/ha produced maximum and significantly more spikelets per panicle than rest of the treatments except application of 120 kg N/ha through fertilizer which were at par.

Application of 90 kg N either through fertilizer or half through inorganic source and remaining half through vermicompost or half through inorganic source and remaining half through FYM and 60 kg N/ha through inorganic source were equally effective in producing spikelets per panicle.

As regards application of recommended dose of nitrogen through vermicompost produced significantly more number of spikelets than its equivalant dose given through FYM. The lowest spikelets number was due to application of 60 kg N/ha through FYM.

4.3.4 Number of grains per panicle

The data in Table 15 indicate that the mean number of grains per panicle was 34.40.

The differences in the mean number of grains per panicle due to different treatments were significant. The highest number of grains (46.43) per panicle was observed with application of 120 kg N applied through fertilizer supplemented

Table 15 : Mean number of grains per panicle, grain weight (g) per plant and thousand grain weight (g) at harvest as influenced by different treatments

Sr. No.	Treatmetns	No. of grains/ panicle	Grain weight/ plant (g)	Thousand grain weight (g)
1.	120 kg N/ha through fertilizer	43.28	2.16	45.13
2.	90 kg N/ha through fertilizer	40.13	2.08	44.28
3.	60 kg N/ha through fertilizer	38.16	1.94	42.93
4.	120 kg N/ha through FYM	27.42	1.65	40.50
5.	90 kg N/ha through FYM	25.10	1.53	37.88
6.	60 kg N/ha through FYM	21.95	1.35	36.38
7.	120 kg N/ha through vermicompost	34.86	1.74	43.00
8.	90 kg N/ha through vermicompost	30.62	1.51	38.13
9.	60 kg N/ha through vermicompost	24.48	1.39	36.98
10.	120 kg N/ha through fertilizer + 10 t FYM	46.43	2.28	46.78
11.	45 kg N through fertilizer + 45 kg N through FYM	39.55	1.98	43.63
12.	45 kg N through fertilizer + 45 kg N through vermicompost	40.80	2.02	44.15
	F test	Sig.	Sig.	Sig.
	S.E. ±	2.393	0.051	0.646
	C.D. at 5 %	6.895	0.146	1.862
	Mean	34.40	1.80	41.81

with 10 t FYM/ha. It was significantly higher than rest of the treatments but on par with application of 120 kg N/ha through fertilizer, 90 kg N/ha either through inorganic sources or half through inorganic and vermicompost or half through inorganic source and remaining through FYM and all these were equally effective in producing grain number per panicle.

Application of recommended dose through vermicompost produced significantly higher number of grains per panicle than similar dose applied through FYM.

4.3.5 Grain weight (g) per plant at harvest

The data in Table 15 indicate that the mean grain weight per plant was 1.80 g. The differences in the mean grain weight per plant due to various treatments were significant. Application of 120 kg N through fertilizer + 10 t FYM/ha produced significantly more grain weight than rest of the treatments except with 120 kg N/ha applied through fertilizer which was on par.

The next higher grain weight per plant obtained was due to application of 120 kg N/ha and was on par with application of 90 kg N/ha through organic source or half through organic source and remaining half through vermicompost. The application of 120 kg N/ha through vermicompost produced higher grain weight per plant than same quantity applied through FYM but both were on par.

4.3.6 Thousand grain weight

The data presented in Table 15 revealed that the mean thousand grain weight was 41.81 g.

The differences in the mean thousand grain weight due to various treatments studied were significant. The test weight recorded with application of 120 kg N through fertilizer supplemented with 10 t FYM/ha produced maximum weight of grain (46.78 g), which was significantly superior than the rest of the treatments except application of 120 kg N through fertilizer to which it was at par.

The next higher test weight was obtained due to 90 kg N/ha applied through inorganic source and produced significantly higher 1000 grain weight than rest of the treatments but on par with application of 90 kg N/ha applied half through inorganic source and remaining half either through vermicompost or FYM.

Application of 120 kg N/ha through vermicompost produced significantly higher 1000 grain weight than its application through FYM.

The minimum 1000 grain weight was obtained due to 60 kg N/ha half of it through inorganic source and remaining half either through vermicompost or FYM.

The values of yield contributing characters viz., length of panicle, number of spikelets per panicle, number of grains per panicle and grain weight per plant and test weight

were the highest with application of 120 kg N through fertilizer with 10 t FYM/ha and values were 8.45 cm, 22.53, 46.43, 2.28 and 46.78 g, respectively. Similar results were reported by Auti (1980), Dahatonde (1981), Singh and Agarwal (1983), Singh and Awasthi (1983), Nikam (1985), Dhuka et al. (1991), Pol et al. (1991), Singh et al. (1992) and Patel and Upadhyay (1993) in respect of length of panicle Bhaliya et al. (1983), Nikam (1995) and Dhuka et al. (1991) in respect of number of spikelets per panicle. Auti (1980), Borse and Mahajan (1980), Sharma (1981), Rahul et al. (1983), Singh et al. (1984), Nikam (1985), Dhuka et al. (1991), Pol et al. (1991), Singh et al. (1992) in respect of number of grains per panicle. Anonymous (1984), Nikam (1985), Girothia et al. (1987), Upadhyaya and Dubey (1991), Pol et al. (1991), Singh et al. (1992), Chougule et al. (1993) and Patel and Upadhyaya (1993) in respect of 1000 grain weight.

4.4 Yield studies

The data pertaining to the yield of grain, straw, total biomass quintal per hectare and straw to grain ratios as affected by different treatments are presented in Table 16 and graphically depicted in Fig. 7.

It was clear from the data in Table 16 that the mean grain, straw and total biomass per hectare was 33.50, 45.81 and 81.37 q/ha, respectively. The mean grain to straw ratio was 1:1.37.

4.4.1 Yield of grain per hectare

The grain yield was significantly influenced due to various treatments under study.

It could be seen from the data in Table 16 that the application of 120 kg N through fertilizer + 10 t FYM/ha recorded the highest grain yield (48.22 q/ha) were significantly superior over all other treatments. Except with application of 120 kg N/ha through fertilizer which was on par.

The yield obtained with application of 120 kg N/ha through fertilizer was on par with 90 kg N/ha applied through fertilizer. The grain yield recorded with 90 kg N/ha through chemical fertilizer was on par with the application of same quantity of which half through fertilizer and remaining half through vermicompost.

Application of 120 kg N/ha through vermicompost produced higher grain yield than its application through FYM but both were at par. It was observed that application of 60 kg N/ha through FYM produced minimum yield and was at par with same quantity applied through vermicompost or even 90 kg N/ha through FYM.

4.4.2 Yield of straw per hectare

The data presented in Table 16 indicate that the per hectare straw yields were significant due to various treatments. Application of 120 kg N/ha through fertilizer with 10 t FYM/ha produced significantly higher straw yield (58.89

Table 16 : Mean yield of grain, straw and total biomass per hectare and grain to straw ratio as affected by different treatments

Sr. No.	Treatments	Grain yield/ per hectare (Qtl)	Straw yield/ per hectare (Qtl)	Yield of bio-mass/ hectare (Qtl)	Grain to straw ratio
1.	120 kg N/ha through fertilizer	45.65	55.14	100.80	1:1.21
2.	90 kg N/ha through fertilizer	42.44	52.98	95.42	1:1.25
3.	60 kg N/ha through fertilizer	37.16	47.32	84.49	1:1.27
4.	120 kg N/ha through FYM	30.61	41.15	71.76	1:1.34
5.	90 kg N/ha through FYM	27.39	37.55	64.94	1:1.37
6.	60 kg N/ha through FYM	24.43	34.46	58.90	1:1.41
7.	120 kg N/ha through vermicompost	34.72	44.75	79.47	1:1.29
8.	90 kg N/ha through vermicompost	31.38	41.67	73.05	1:1.33
9.	60 kg N/ha through vermicompost	27.52	37.55	65.07	1:1.36
10.	120 kg N/ha through fertilizer + 10 t FYM	48.22	58.89	107.12	1:1.22
11.	45 kg N through fertilizer + 45 kg N through FYM	37.42	47.84	85.91	1:1.28
12.	45 kg N through fertilizer + 45 kg N through vermicompost	39.09	50.41	89.53	1:1.29
	F test	Sig.	Sig.	Sig.	---
	S.E. ±	1.473	2.000	3.649	---
	C.D. at 5 %	4.243	5.762	10.512	---
	Mean	33.51	45.81	81.37	1:1.37

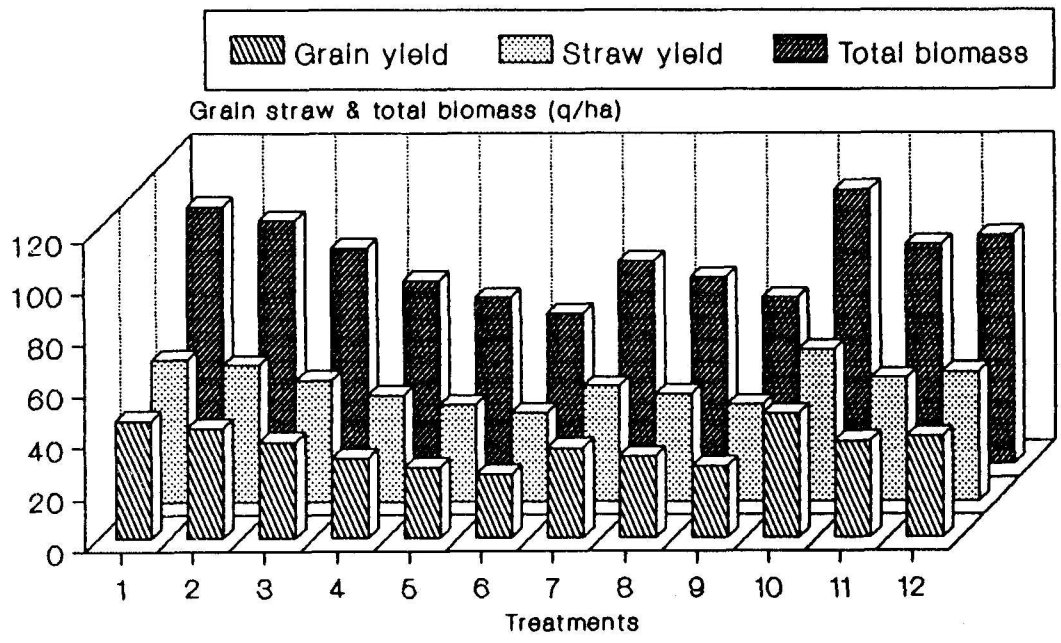


Fig.7: Mean yield of grain, straw and total biomass (q/ha) as influenced by various treatments

q/ha) than the rest of the treatments except with 120 kg N/ha through fertilizer which was on par. Application of 90 kg N/ha through fertilizer produced equivalent quantity of straw with 120 kg N/ha applied through inorganic source and 90 kg N/ha half of which applied through inorganic fertilizer and remaining half through vermicompost, were at par. Application of 120 kg N/ha through vermicompost produced higher fodder than the same applied through FYM but both of them were at par.

Minimum fodder yield was obtained due to application of 60 kg N/ha applied through either vermicompost or FYM.

4.4.3 Total biomass yield per hectare

The differences in the total biomass yield in q/ha, due to various treatments were significant.

Total biomass production on hectare basis was maximum (107.12 q) with the application of 120 kg N/ha through fertilizer + 10 t FYM/ha and was significantly more than rest of the treatments except with the application of 120 kg N/ha through fertilizer. The next higher biomass production was due to 90 kg N/ha through inorganic source and it was significantly higher than rest of the treatments but on par with the same quantity applied half of which through inorganic source and remaining half either through vermicompost or FYM.

Application of 120 kg N/ha through vermicompost produced higher biomass than its application through FYM but both of them were at par. The minimum quantity of biomass was

obtained due to application of 60 kg N/ha through vermicompost or FYM.

4.4.4 Grain to straw ratio

The data pertaining to the grain to straw ratio are presented in Table 16.

The data were not statistically analysed hence the inferences were drawn from the mean values.

The grain to straw ratio obtained with application of 60 kg N/ha through FYM was the widest (1:1.41) while it was narrowest with the application of 120 kg N/ha through fertilizer (1:1.21). In general grain to straw ratio was narrow with the application of nitrogen through fertilizer as compared to nitrogen applied through organic sources.

Consequent upon the expression of growth characters and yield attributes discussed earlier the trend remains same. Application of 120 kg N/ha through fertilizer supplemented with 10 t FYM/ha produced maximum grain yield (48.22 q/ha), straw yield (58.89 q/ha) and total biomass (107. 11 q/ha) and it was significantly superior over rest of the treatments but was on par with 120 kg N/ha applied through fertilizer alone.

Several research workers have reported that application of 120 kg N/ha or more produced significantly higher grain and straw yields than that of reduced levels of N Borse and Mahajan (1980), Malik (1981), Bhaliya *et al.* (1983), Singh and Gulani (1983), Sambasiva *et al.* (1984), Nikam (1985),

Girothia (!987), Dhuka et al. (1991), Upadhyaya and Dubey (1991) and Naphade et al. (1993). However, application of organic manure in conjunction with recommended dose of nitrogen has produced significantly higher grain and straw yields than the recommended dose. Similar observations were made by Sharma (1981), Sinha et al. (1981), Gill and Meelu (1982), Patel et al. (1992), Shinde (1992), Kasole et al. (1993) and Naphade et al. (1993).

4.5 Economical studies

The data in respect of economics of fertilizer application are presented in Table 17.

The maximum gross monetary returns of Rs. 27060/ha were obtained with 120 kg N/ha + 10 t FYM/ha. It was followed by application of 120 kg N/ha given through fertilizer alone (Rs. 25583/ha). However, while considering the net profit the trend changed. The maximum net profit (Rs. 17642/ha) was with application of 120 kg N/ha through fertilizer alone and it was followed by application of 90 kg N/ha through fertilizer. Substitution of nitrogen partly or completely through organic source reduced the net profit due to its prices. The maximum benefit cost ratio (2.22) was obtained with the application of 120 kg N/ha through fertilizer and the lowest being obtained (0.03) with the application of 120 kg N/ha given through FYM.

Table 17: Mean cost of cultivation, total monetary returns, net profit and benifit cost ratio as affected by different treatments

Sr. No.	Treatments	Cost of cultivation (Rs/ha)	Total monetary returns (Rs/ha)	Net profit (Rs/ha)	Benefit cost ratio
1.	120 kg N/ha through fertilizer	7941	25583	17642	1:2.22
2.	90 kg N/ha through fertilizer	7767	24869	17102	1:2.20
3.	60 kg N/ha through fertilizer	7593	20952	13359	1:1.76
4.	120 kg N/ha through FYM	16844	17363	519	1:0.03
5.	90 kg N/ha through FYM	14444	15573	1129	1:0.08
6.	60 kg N/ha through FYM	12044	13944	1900	1:0.16
7.	120 kg N/ha through vermicompost	18355	19598	1243	1:0.07
8.	90 kg N/ha through vermicompost	15846	17669	1823	1:0.12
9.	60 kg N/ha through vermicompost	12799	15638	2839	1:0.22
10.	120 kg N/ha through fertilizer + 10 t FYM	13941	27060	13119	1:0.94
11.	45 kg N through fertilizer + 45 kg N through FYM	11105	21103	9998	1:0.90
12.	45 kg N through fertilizer + 45 kg N through vermicompost	11672	22071	10399	1:0.89
	Mean				

4.6 Chemical studies

The data on chemical studies are reported in Table 18 to 22.

4.6.1 Concentration of N, P and K in wheat grain

The data pertaining to N, P and K content in grain as affected by different treatments are presented in Table 18.

The mean N, P and K content in grain was 1.856, 0.484 and 0.457 per cent, respectively.

The nitrogen content differed significantly due to various treatments. The maximum N content in grain was observed with the application of 120 kg N/ha applied through chemical fertilizer + 10 t FYM/ha and it was significantly more than rest of the treatments except application of 120 kg N/ha applied through fertilizer and 90 kg N/ha of which 45 kg N through chemical fertilizer and remaining 45 kg N given through either FYM or vermicompost. Concentration of N in grain where N was supplied through vermicompost was on par with the 90 kg N applied through fertilizer. As regards 120 kg N supplied through vermicompost was superior to that of same quantity supplied through FYM.

Phosphorus and potassium content in wheat grain was not influenced significantly due to different treatments. However, maximum P and K content was observed with the application of 120 kg N/ha through fertilizer alone and in combination with 10 t FYM/ha, respectively.

Table 18 : Mean concentration of N, P and K in wheat grain as affected by different treatments

Sr. No.	Treatments	Percentage in grain			Protein percent in grain
		N	P	K	
1.	120 kg N/ha through fertilizer	2.067	0.528	0.500	12.93
2.	90 kg N/ha through fertilizer	1.820	0.480	0.488	11.38
3.	60 kg N/ha through fertilizer	1.785	0.450	0.438	11.16
4.	120 kg N/ha through FYM	1.750	0.469	0.438	10.94
5.	90 kg N/ha through FYM	1.680	0.457	0.425	10.50
6.	60 kg N/ha through FYM	1.680	0.448	0.413	10.50
7.	120 kg N/ha through vermicompost	1.820	0.485	0.475	11.38
8.	90 kg N/ha through vermicompost	1.820	0.471	0.425	11.37
9.	60 kg N/ha through vermicompost	1.820	0.457	0.425	11.38
10.	120 kg N/ha through fertilizer + 10 t FYM	2.150	0.538	0.500	13.44
11.	45 kg N through fertilizer + 45 kg N through FYM	1.960	0.528	0.475	12.25
12.	45 kg N through fertilizer + 45 kg N through vermicompost	1.925	0.499	0.488	12.03
	F test	Sig.	N.S.	N.S.	Sig.
	S.E. ±	0.087	0.023	0.025	0.545
	C.D. at 5 %	0.251	N.S.	N.S.	1.571
	Mean	1.858	0.484	0.457	11.805

The results are in conformity with the reports of Auti (1980), Sinha et al. (1981), Nikam (1985) and Dhuka et al. (1992).

4.8.2 Protein percent in grain

The data on mean protein percent in wheat grain as affected by different treatments are presented in Table 18.

It was clear from the data in Table 18 that the mean protein content in grain was 11.61 per cent. The differences in protein per cent as influenced by different treatments were significant.

Application of 120 kg N through fertilizer + 10 t FYM/ha recorded the highest protein per cent (13.44) and was significantly higher than all other treatments, except application of 120 kg N/ha through fertilizer alone and application of 90 kg N/ha of which 45 kg N applied through fertilizer and remaining 45 kg N either through FYM or vermicompost, which were on par. It could also be seen from the data that protein percentage in grain was more due to application of 120 kg N/ha through fertilizer and it was on par with the application of 120, 90 and 60 kg N applied through vermicompost and application of 90 kg N/ha through fertilizer alone. The application of nitrogen through vermicompost showed more protein percentage in grain than same dose applied through FYM.

The results are in conformity with the reports of Auti (1980), Nikam (1985), Jadhav and Koregave (1988), Patel et al. (1991), Pol et al. (1991), Singh et al. (1992), Chougule et al. (1993) and Patel and Upadhyaya (1993).

4.6.3 Concentration of N, P and K in wheat straw

The data pertaining to N, P and K content in straw as affected by different treatments are presented in Table 19.

It would revealed that the mean concentrations of N, P and K in straw were 0.359, 0.108 and 1.650, respectively.

The mean N and P content in straw was not significant. However, the maximum N and P percentage was observed with application of 120 kg N/ha through fertilizer with 10 t FYM/ha.

The K content in straw was significant. Maximum K percentage in straw was observed with application of 120 kg N/ha through fertilizer alone, and was significantly more than rest of the treatments except application of 120 kg N through fertilizer + 10 t FYM/ha, 90 kg N half of which through fertilizer and remaining either through FYM or vermicompost. It was observed that K content in straw with the application of 90 and 120 kg N/ha through vermicompost was on par with 90 kg N through fertilizer which was also superior than the same dose applied through FYM only.

Table 19 : Mean concentration of N, P and K in wheat straw as affected by different treatments

Sr. No.	Treatmetns	Percentage in straw		
		N	P	K
1.	120 kg N/ha through fertilizer	0.420	0.125	1.838
2.	90 kg N/ha through fertilizer	0.385	0.102	1.713
3.	60 kg N/ha through fertilizer	0.350	0.096	1.613
4.	120 kg N/ha through FYM	0.350	0.108	1.550
5.	90 kg N/ha through FYM	0.350	0.102	1.500
6.	60 kg N/ha through FYM	0.315	0.096	1.425
7.	120 kg N/ha through vermicompost	0.350	0.102	1.688
8.	90 kg N/ha through vermicompost	0.350	0.102	1.613
9.	60 kg N/ha through vermicompost	0.315	0.096	1.500
10.	120 kg N/ha through fertilizer + 10 t FYM	0.420	0.131	1.825
11.	45 kg N through fertilizer + 45 kg N through FYM	0.350	0.114	1.775
12.	45 kg N through fertilizer + 45 kg N through vermicompost	0.350	0.119	1.763
	F test	N.S.	N.S.	Sig.
	S.E. ±	0.57	0.011	0.046
	C.D. at 5 %	N.S.	N.S.	0.131
	Mean	0.359	0.108	1.650

4.6.4 Uptake of nitrogen by wheat grain, straw and total at harvest

The data in respect of uptake of nitrogen by wheat grain, straw and total uptake are presented in Table 20 and graphically dipicted in Fig. 8.

The data pertaining to mean uptake of nitrogen through grain, straw and total uptake by both differed significantly due to various treatments. The mean uptake of nitrogen through grain straw and total were 66.45, 16.55 and 83.43 kg/ha, respectively.

The mean uptake of nitrogen through grain differed significantly due to various treatments. The maximum uptake of nitrogen through grain (103.65 kg/ha) was due to application of 120 kg N/ha through fertilizer + 10 t FYM/ha and was significantly higher than rest of the treatments and was at par with application of 120 kg N/ha through fertilizer. Application of 120 kg N through vermicompost resulted significantly more N uptake in grain than same quantity through FYM.

As regards straw the similar trend was observed as that of grain. The maximum N uptake in straw was observed due to application of 120 kg N/ha through fertilizer + 10 t FYM/ha and was significantly higher than rest of the treatments and was on par with 120 kg N and 90 kg N/ha through fertilizer alone.

As regards the total N uptake through biomass it was observed that the mean maximum total N uptake (128.25 kg/ha) was noticed due to application of 120 kg N/ha through fertilizer

Table 20 : Mean uptake of nitrogen (kg) per hectae by wheat grain, straw and total as affected by different treatments

Sr. No.	Treatmetns	Grain (kg/ha)	Straw (kg/ha)	Total (kg/ha)
1.	120 kg N/ha through fertilizer	94.51	22.97	117.63
2.	90 kg N/ha through fertilizer	77.20	20.40	97.60
3.	60 kg N/ha through fertilizer	66.90	16.13	83.03
4.	120 kg N/ha through FYM	53.22	14.62	67.84
5.	90 kg N/ha through FYM	48.32	13.20	59.51
6.	60 kg N/ha through FYM	41.21	10.70	51.68
7.	120 kg N/ha through vermicompost	63.34	15.55	78.89
8.	90 kg N/ha through vermicompost	57.11	14.68	71.78
9.	60 kg N/ha through vermicompost	49.89	11.79	61.68
10.	120 kg N/ha through fertilizer + 10 t FYM	103.65	24.63	128.28
11.	45 kg N through fertilizer + 45 kg N through FYM	73.44	16.58	90.02
12.	45 kg N through fertilizer + 45 kg N through vermicompost	75.82	17.39	93.23
	F test	Sig.	Sig.	Sig.
	S.E. ±	4.69	2.06	4.75
	C.D. at 5 %	13.50	5.94	13.67
	Mean	66.88	16.55	83.43

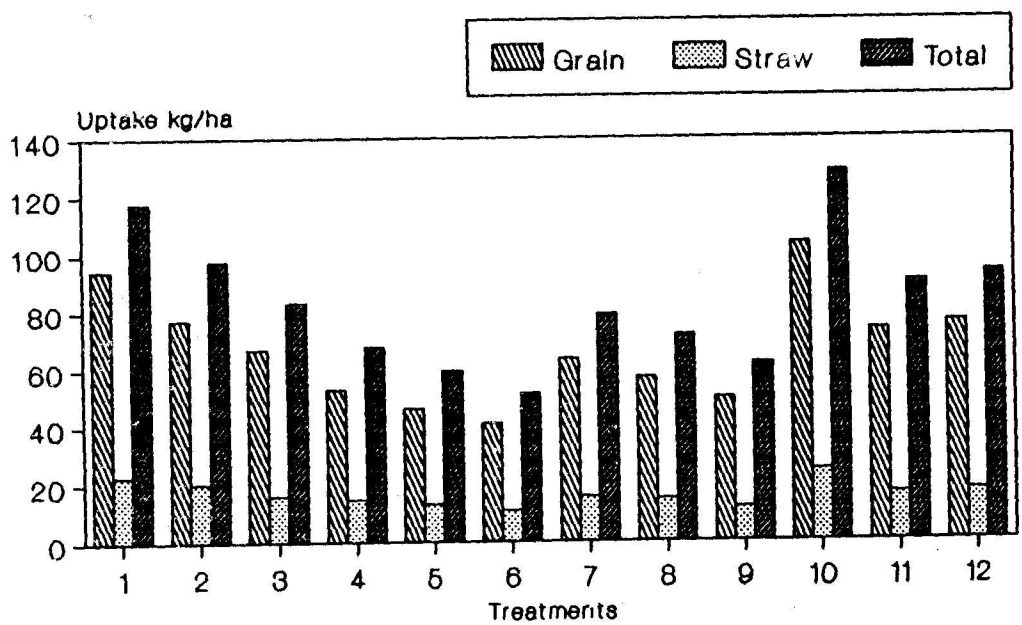


Fig.8:Mean uptake of nitrogen (kg/ha) by wheat grain, straw & total as affected by different treatments at harvest

+ 10 t FYM/ha and was significantly higher than rest of the treatments but was on par with application of 120 kg N/ha through fertilizer alone. Application of 120 kg N/ha given through vermicompost produced comparatively higher N uptake than its application through FYM.

Significantly less uptake of nitrogen by grain, straw and total was observed due to application of 60 kg N/ha through FYM. The results are in conformity with those obtained by Vaishy and Singh (1981), Singh (1981), Singh and Agarwal (1983), Nikam (1985), Raguwanshi et al. (1988), Pol et al. (1991), Naphade et al. (1993).

4.6.5 Phosphorus uptake by wheat grain, straw and total uptake at harvest

The data in respect of uptake of phosphorus by grain, straw and total uptake are presented in Table 21 and graphically shown in Fig. 9.

The mean uptake through grain, straw and total was 17.296, 5,038 and 22.336 kg/ha, respectively.

The maximum P uptake by grain and total uptake was observed due to application of 120 kg N/ha through fertilizer + 10 t FYM/ha which was significantly superior over rest of the treatments but on par with application of 120 kg N through fertilizer alone. However, P uptake through straw with application of 120 kg N/ha through fertilizer was on par with application of 90 kg N/ha through fertilizer and half of which through fertilizer and half through vermicompost or FYM.

Table 21 : Mean uptake of phosphate (kg) per hectare by wheat grain, straw and total as affected by different treatments at harvest

Sr. No.	Treatmetns	Grain (kg/ha)	Straw (kg/ha)	Total (kg/ha)
1.	120 kg N/ha through fertilizer	24.13	6.91	31.04
2.	90 kg N/ha through fertilizer	20.33	5.47	25.81
3.	60 kg N/ha through fertilizer	16.60	4.53	21.13
4.	120 kg N/ha through FYM	14.30	4.55	18.85
5.	90 kg N/ha through FYM	12.58	3.91	16.48
6.	60 kg N/ha through FYM	10.93	3.36	14.29
7.	120 kg N/ha through vermicompost	16.81	4.62	21.46
8.	90 kg N/ha through vermicompost	14.73	4.30	19.03
9.	60 kg N/ha through vermicompost	12.55	3.65	16.20
10.	120 kg N/ha through fertilizer + 10 t FYM	25.88	7.74	33.61
11.	45 kg N through fertilizer + 45 kg N through FYM	19.71	5.42	25.13
12.	45 kg N through fertilizer + 45 kg N through vermicompost	19.01	5.99	25.00
	F test	Sig.	Sig.	Sig.
	S.E. ±	1.109	0.633	1.470
	C.D. at 5 %	3.196	1.824	4.236
	Mean	17.296	5.038	22.336

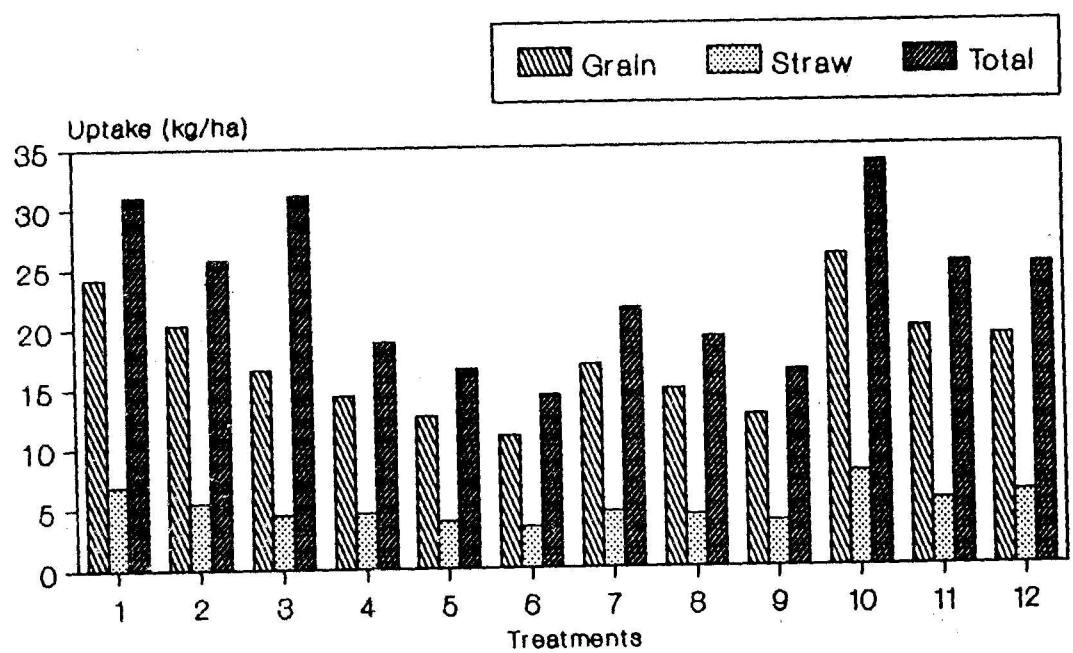


Fig.9:Mean uptake of Phosphorus (kg/ha) by wheat grain, straw and total affected by various treatments at harvest

Uptake of phosphorus through grain, straw and through both was maximum with 120 kg N/ha through vermicompost and its various levels were on par. The minimum uptake of phosphorus was observed due to application of 60 kg N/ha through FYM.

4.6.6 Potash uptake by wheat grain, straw and total at harvest

Data regarding mean uptake of potash by wheat grain straw and total uptake as influenced by various treatments are presented in Table 22 and graphically shown in Fig. 10.

The mean uptake of potash in grain, straw and total was 16.42, 76.14 and 92.85 kg/ha, respectively.

The maximum uptake of potash through grain, straw and total (24.11, 107.44, 131.55 kg/ha) was noticed with the application of 120 kg through fertilizer + 10 t FYM/ha. It was significantly superior over all other treatments except application of 120 kg N/ha through fertilizer.

Application of recommended dose of nitrogen through vermicompost produced more uptake of potash through grain, straw and both over its application through FYM but both these were at par. Application of 90 kg N/ha through organic fertilizer obtained more uptake of potash in case of wheat grain, straw and through both than its application half of which applied through inorganic source and remaining half either through vermicompost or FYM but all these were at par.

Table 22 : Mean uptake of potash (kg) per hectare by the wheat grain, straw and total as affected by different treatment at harvest

Sr. No.	Treatmetns	Grain (kg/ha)	Straw (kg/ha)	Total (kg/ha)
1.	120 kg N/ha through fertilizer	22.87	97.73	120.60
2.	90 kg N/ha through fertilizer	20.70	90.80	111.50
3.	60 kg N/ha through fertilizer	16.28	76.17	92.44
4.	120 kg N/ha through FYM	13.29	63.49	76.78
5.	90 kg N/ha through FYM	11.45	55.94	67.39
6.	60 kg N/ha through FYM	10.08	49.16	59.25
7.	120 kg N/ha through vermicompost	16.53	75.60	92.13
8.	90 kg N/ha through vermicompost	13.40	67.22	80.62
9.	60 kg N/ha through vermicompost	11.62	56.21	67.83
10.	120 kg N/ha through fertilizer + 10 t FYM	24.11	107.44	131.55
11.	45 kg N through fertilizer + 45 kg N through FYM	17.68	84.87	102.55
12.	45 kg N through fertilizer + 45 kg N through vermicompost	19.08	89.06	108.14
	F test	Sig.	Sig.	Sig.
	S.E. ±	1.018	3.782	3.887
	C.D. at 5 %	2.932	10.897	11.199
	Mean	16.422	76.140	92.854

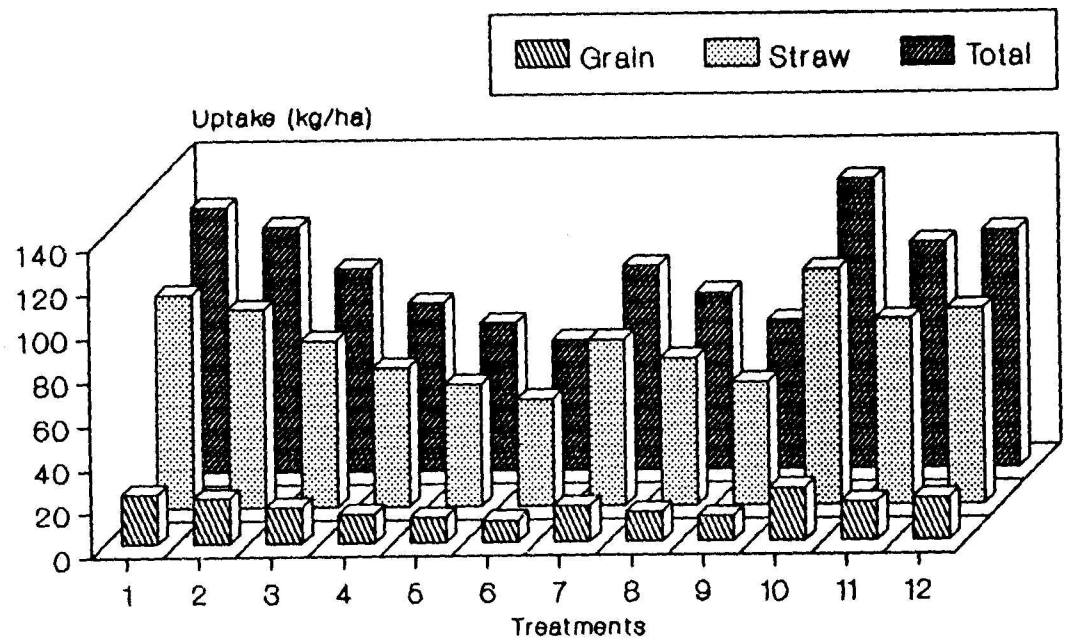


Fig.10:Mean uptake of Potash (kg/ha) by wheat grain, straw and total as affected by various treatments at harvest

4.7 Chemical studies of soil

The data pertaining to chemical studies of soil after harvest of wheat crop are presented in Table 23 and 24.

4.7.1 Organic carbon percent

The data regarding soil organic carbon content as influenced by different treatments are presented in Table 23.

The data given in Table 23 revealed that the mean soil organic carbon per cent after harvest of wheat crop was 0.62 per cent and differed significantly due to various treatments.

The maximum organic carbon (0.69 %) was accumulated due to application of 120 kg N + 10 t FYM/ha and was significantly higher than rest of the treatments except application of 120 and 90 kg N/ha applied through FYM. While, the low organic carbon content in soil was in different levels of nitrogen applied through fertilizers.

4.7.2 Mean total nitrogen per cent

The data pertaining to total nitrogen per cent in soil after harvest of wheat was presented in Table 23.

The total nitrogen per cent was significantly influenced due to different treatments. The mean total nitrogen per cent was 0.052. The mean maximum total nitrogen per cent of 0.057 was observed due to application of 120 kg N through fertilizer + 10 t FYM/ha. It was significantly more than rest of the treatments except with application of 120 kg N and 90 kg N/ha applied through FYM only which were on par.

Table 23 :Mean organic carbon (%), total nitrogen (%) in soil and C:N ratio after harvest of wheat as affected by different treatments

Sr. No.	Treatmetns	Organic carbon (%)	Total nitrogen (%)	C:N ratio
1.	120 kg N/ha through fertilizer	0.58	0.048	11.99
2.	90 kg N/ha through fertilizer	0.56	0.046	12.08
3.	60 kg N/ha through fertilizer	0.53	0.045	11.82
4.	120 kg N/ha through FYM	0.67	0.056	11.98
5.	90 kg N/ha through FYM	0.66	0.055	11.87
6.	60 kg N/ha through FYM	0.62	0.052	12.03
7.	120 kg N/ha through vermicompost	0.64	0.053	11.99
8.	90 kg N/ha through vermicompost	0.63	0.053	12.09
9.	60 kg N/ha through vermicompost	0.63	0.052	12.03
10.	120 kg N/ha through fertilizer + 10 t FYM	0.69	0.057	11.98
11.	45 kg N through fertilizer + 45 kg through FYM	0.62	0.052	11.99
12.	45 kg N through fertilizer + 45 kg N through vermicompost	0.60	0.051	11.95
	F test	Sig.	Sig.	N.S.
	S.E. ±	0.010	0.001	0.325
	C.D. at 5 %	0.030	0.002	N.S.
	Mean	0.62	0.052	11.98

4.7.3 Carbon to nitrogen ratio

The data regarding carbon to nitrogen ratio is presented in Table 23.

The carbon to nitrogen ratio was not influenced significantly due to various treatments. The mean C:N ratio of soil after harvest of wheat crop was 11.98. The C:N ratios remains unchanged due to graded levels of nitrogen given through various sources was also reported by Sharma et al. (1989).

4.7.4 N, P and K status of soil after harvest of wheat

The data pertaining to the available N, P and K status of soil after harvest of wheat crop as influenced by different treatments are presented in Table 24 and graphically shown in Fig. 11.

The mean available N, P and K was 127.83, 20.78 and 389.40 kg/ha, respectively.

The mean maximum available nitrogen in soil after wheat harvest was 141.75 kg/ha due to application of 120 kg N/ha + 10 t FYM/ha and was significantly higher than rest of the treatments except application of 120 kg N and 90 kg N/ha through inorganic sources. Application of 120 kg N/ha either through vermicompost or FYM had similar available N in soil.

As regards the available phosphorus and potassium in the soil the differences were not significant due to graded levels of nitrogen given through various sources. The results corbororate with the results obtained by Chaudhari (1981), Prasad et al. (1983), Acharya et al. (1988) and Raghuwanshi et al. (1988).

Table 24 : Mean N, P and K content in soil at harvest of wheat as diffected by different treatments

Sr. No.	Treatmetns	Available N, P and K in soil (kg/ha)		
		N	P	K
1.	120 kg N/ha through fertilizer	138.00	21.43	397.50
2.	90 kg N/ha through fertilizer	134.50	20.68	375.25
3.	60 kg N/ha through fertilizer	123.75	20.58	389.25
4.	120 kg N/ha through FYM	123.00	20.84	392.25
5.	90 kg N/ha through FYM	120.75	19.99	391.75
6.	60 kg N/ha through FYM	126.00	20.28	386.25
7.	120 kg N/ha through vermicompost	123.00	20.79	397.50
8.	90 kg N/ha through vermicompost	121.50	19.83	378.00
9.	60 kg N/ha through vermicompost	122.25	20.42	386.75
10.	120 kg N/ha through fertilizer + 10 t FYM	141.75	22.28	411.50
11.	45 kg N through fertilizer + 45 kg N through FYM	127.75	21.43	400.50
12.	45 kg N through fertilizer + 45 kg N through vermicompost	131.75	20.79	386.25
	F test	Sig.	N.S.	N.S.
	S.E. ±	3.029	0.687	13.556
	C.D. at 5 %	8.728	N.S.	N.S.
	Mean	127.83	20.78	389.40

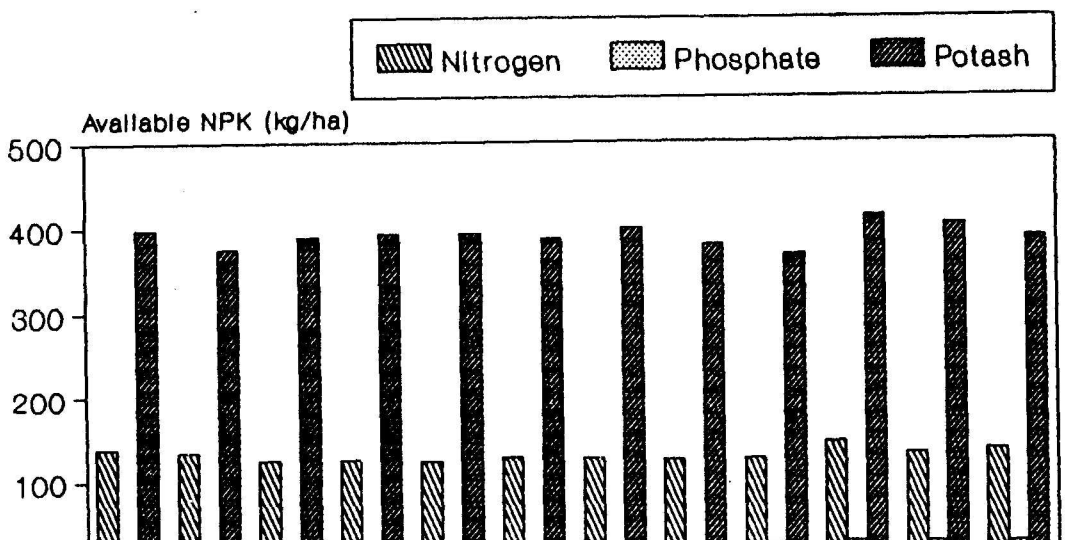


Fig.11:Mean available N,P and K (kg/ha) as influenced by various treatments after harvest of wheat

4.8 Balance sheet of available nitrogen in bajra-wheat sequence

The data presented in Table 25 indicated that there was overall loss of nitrogen at the end of bajra-wheat cropping system. The study revealed that there was gain in available nitrogen if it is applied through inorganic sources. The graded levels of nitrogen applied through FYM had lost more nitrogen than the same levels applied through vermicompost. It indicates that amongst organic sources vermicompost is better source.

The study further revealed that the combinations of inorganic and organic sources reduced the loss of nitrogen than the whole quantity of nitrogen applied through either of the organic sources. Amongst the combinations of inorganic and organic sources at particular N level it was observed that combinations of inorganic and vermicompost was better than same N applied through inorganic sources and FYM.

Further, it was observed that the maximum gain of nitrogen was with recommended dose of N supplemented with 10 t FYM/ha.

Table 25 : Balance sheet of available soil nitrogen in various treatment in bajra-wheat sequence

Treatments	Initial available soil N	Addition of nitrogen through fertilizer (kg)			Removal of nitrogen by crop (kg)			Expected balance of nigrogen (kg)	Actual balance (kg)	Net loss or gain in nigrogen (kg)
		Kharif	Rabi	Total	Kharif	Rabi	Total			
1	125	60	120	180	57	118	175	130	138	+ 8
2	125	45	90	135	54	98	152	108	135	+ 27
3	125	30	60	90	49	83	132	83	124	+ 41
4	125	60	120	180	17	68	85	220	123	- 97
5	125	45	90	135	12	60	72	188	121	- 67
6	125	30	60	90	11	52	63	152	126	- 26
7	125	60	120	180	24	79	103	202	123	- 79
8	125	45	90	135	21	72	93	167	122	- 45
9	125	30	60	90	17	62	79	136	122	- 14
10	125	60	120	180	61	128	189	116	142	+ 26
11	125	45	90	135	36	90	126	134	128	- 6
12	125	45	90	135	42	93	135	125	132	+ 7
Total	1500	555	1110	1665	401	1003	1404	1761	1536	-225

ble 26 : Balance sheet of available soil phosphorus in various treatment in bajra-wheat sequence

eatment	Initial available soil P	Addition of phosphorus through fertilizer (kg)			Removal of phosphorus by crop (kg)			Expected balance of P (kg)	Actual balance (kg)	Net loss or gain in P (kg)
		Kharif	Rabi	Total	Kharif	Rabi	Total			
	12.91	30	60	90	13.17	31.04	44.21	58.7	21.43	-37.27
2	12.91	30	60	90	10.03	25.81	35.84	67.07	20.68	-46.39
3	12.91	30	60	90	8.52	21.13	29.65	73.26	20.58	-52.68
4	12.91	30	60	90	5.34	18.85	24.19	78.72	20.84	-57.88
5	12.91	30	60	90	3.17	16.48	19.65	83.26	19.99	-63.27
6	12.91	30	60	90	1.73	14.29	16.02	86.89	20.26	-66.63
7	12.91	30	60	90	8.07	21.46	29.53	73.38	20.79	-52.59
8	12.91	30	60	90	5.02	19.03	24.05	78.86	19.83	-59.03
9	12.91	30	60	90	4.19	16.20	20.39	82.52	20.42	-62.10
10	12.91	30	60	90	15.65	33.61	49.26	53.65	22.28	-31.37
11	12.91	30	60	90	6.24	25.13	31.37	71.54	21.43	-50.11
12	12.91	30	60	90	8.90	25.00	33.90	69.01	20.79	-48.22

.9 Balance sheet of available phosphorus in bajra-wheat sequence

The data presented in Table 26 showed that there as overall loss of phosphorus at the end of bajra-wheat crop equence. The loss in the available soil phosphorus in the bajra-heat crop sequence with the various treatments was in the range f 31.37 to 66.63 kg/ha. The maximum loss was in the treatment here 60 kg N/ha was applied through FYM, while the mimimum was in he treatment where 120 kg N/ha through fertilizer + 10 t FYM/ha as added.

le 27 : Balance sheet of available soil potassium in various treatment in bajra-wheat sequence

atment	Initial available soil K	Addition of potassium through fertilizer (kg)			Removal of potassium by crop (kg)			Expected balance of K (kg)	Actual balance (kg)	Net loss or gain in K (kg)
		Kharif	Rabi	Total	Kharif	Rabi	Total			
	450	---	60	60	---	120.60	120.60	407.40	397.50	-9.90
	450	---	60	60	---	111.50	111.50	398.50	375.25	-23.25
	450	---	60	60	---	92.44	92.44	417.56	389.25	-28.31
	450	---	60	60	---	76.78	76.78	433.22	392.25	-40.97
	450	---	60	60	---	67.39	67.39	442.61	391.75	-50.86
	450	---	60	60	---	59.25	59.25	450.75	386.25	-64.50
	450	---	60	60	---	92.13	92.13	417.87	397.50	-20.37
	450	---	60	60	---	80.62	80.62	429.38	378.00	-51.38
	450	---	60	60	---	67.83	67.83	442.17	366.75	-75.42
0	450	---	60	60	---	131.55	131.55	378.45	411.50	+33.05
1	450	---	60	60	---	102.55	102.55	407.45	400.50	-6.95
2	450	---	60	60	---	108.14	108.14	401.86	386.25	-15.61

10 Balance sheet of available potassium in bajra-wheat sequence

The data presented in Table 27 indicated that there as overall loss of potassium at the end of bajra-wheat crop equence. However, the gain in potash was only observed in the reatment 120 kg N/ha + 10 t FYM/ha. The loss in the available oil potassium in the bajra-wheat crop sequence with the various reatments was in the range of 6.95 to 75.42 kg/ha. The maximum oss was in the treatment where 60 kg N/ha was applied through ermicompost, while the mimimum was in the treatment 45 kg N hrough fertilizer + 45 kg N through vermicompost was added.

Summary and Conclusions

5. SUMMARY AND CONCLUSION

5.1 Summary

The present investigation on the 'Nitrogen substitution through organic sources and their effects on irrigated wheat in bajra-wheat sequence' was carried out at Post Graduate Institute, Central Campus Farm in 'B' block of Mahatma Phule Krishi Vidyapeeth, Rahuri in Ahmednagar district during rabi season of 1993-94. The experiment was laid out in randomised block design with twelve treatments replicated four times. The first nine treatments consisted of three levels of nitrogen viz., 60, 90 and 120 kg N/ha through various sources viz., chemical fertilizer (urea) and organic sources such as FYM and vermicompost. The common basal dose of 60 kg P_2O_5 and 60 kg K_2O/ha were applied to all the treatments at sowing. In addition there were three treatments viz., recommended dose of 120 kg N with 10 t FYM/ha and 90 kg N of which half through inorganic source and remaining half through either FYM or vermicompost. The gross and net plot sizes were 4.50 x 3.60 m^2 and 3.60 x 2.70 m^2, respectively.

The soil of experimental field was clayey in texture low in available nitrogen medium in available P_2O_5 and fairly rich in available K_2O content. In general the season was normal for the growth of wheat.

Besides yield data, the periodical growth attributes and the yield contributing characters of wheat were

recorded. The data regarding economics, N, P and K content in grain and straw were recorded and uptake of these nutrients was also worked out. The protein content in grain was determined. The fertility status before start of experiment and balance sheet of nitrogen in bajra-wheat sequence after harvest was also worked out.

The growth characters viz., plant height, number of tillers, leaf number, leaf area per plant, dry matter accumulation were determined periodically. The chemical studies viz., N, P and K content in soil at initial stage and after harvest, its concentration in grain, straw and in both, uptake of these nutrients in grain, straw and both were determined.

5.1.1 Growth characters

The growth contributing characters viz., plant height, number of tillers, number of leaves, leaf area and dry matter accumulation per plant were influenced significantly due to graded levels of nitrogen given through both organic and inorganic sources. The mean maximum plant height (90.08 cm), green leaves (4.90), highest number of productive tillers (1.11/plant) were observed with 120 kg N through fertilizer supplemented with 10 t FYM/ha and was significantly higher over rest of the treatments. It was also observed that amongst the sources of nitrogen, application of nitrogen through inorganic source was better than both the organic sources in case of growth attributes.

Similarly maximum leaf area (9.15 dm^2/plant) more dry matter accumulation (9.07 g/plant) were obtained due to 120 kg N/ha through fertilizer supplemented with 10 t FYM/ha and was significantly better than rest of the treatments.

5.1.2 Yield contributing character

The studies on the magnitude of yield attributes such as number of productive tillers per plant, panicle length, number of spicklets, number of grains per plant, grain weight were significant. The maximum number of productive tillers (1.11/plant), more panicle length (8.45 cm), highest number of spikelets per panicle (22.83) and higher number of grains per panicle (46.43) were observed with 120 kg N through fertilizer supplemented with 10 t FYM/ha and all these yield attributes were significantly more than rest of the treatments except application of 120 kg N/ha through inorganic source.

The higher number of grain weight (2.28 g) per plant, the maximum test weight (46.78 g) were noticed due to application of 120 kg N through fertilizer supplemented with 10 t FYM/ha and both these yield attributes were significantly superior over rest of the fertilizer treatments. As regards the economic yields, it was seen that maximum grain (48.22 q/ha) and straw (58.89 q/ha) yields were obtained due to 120 kg N/ha supplemented with 10 t FYM/ha. The grain to straw ratio was wider due to 60 kg N/ha applied through FYM while, it was narrow (1:1.21) due to 120 kg N/ha through fertilizer.

5.1.3 Chemical studies

The chemical study indicated that the maximum N content in grain (2.15 %) and protein (13.44 %) were observed due to 120 kg N through fertilizer supplemented with 10 t FYM/ha. As regards the uptake of major nutrients, the maximum uptake of N (125.27 kg/ha), P (33.61 kg/ha) and K (131.55 kg/ha) through total biomass was due to application of 120 kg N/ha through fertilizer with 10 t FYM/ha and each was significantly higher than rest of the fertilizer treatments.

5.1.4 Economic study

The maximum gross returns (Rs. 27066/ha) were obtained due to 120 kg N/ha through fertilizer supplemented with 10 t FYM/ha followed by 120 kg N/ha through fertilizer. However, maximum net profit (Rs. 17642/ha) was obtained due to application of 120 kg N/ha through fertilizer alone. It was followed by application of 90 kg N/ha (Rs. 17102/ha) through fertilizer.

The net profit (Rs. 13119/ha) was obtained due to 120 kg N/ha through fertilizer supplemented with 10 t FYM/ha and it was at higher order. The margin of net profit was reduced due to organic sources particularly through FYM. The maximum benefit cost ratio (1.22) was obtained due to application of 120 kg N/ha through fertilizer. It was followed by application of 90 kg N/ha (1.20) through fertilizers.

5.1.5 Nutrient status of soil

The study revealed that the organic carbon content in soil improved after bajra-wheat sequence. The maximum organic carbon content (0.69 %) was with 120 kg N/ha through fertilizer supplemented with 10 t FYM/ha. It was interesting to note that with the application of Nitrogen through inorganic source reduced the status of organic carbon content in the soil. However, combinations of organic and inorganic nitrogen sources help in maintaining the organic carbon eontent in soil at higher level (0.62 %). The available nitrogen status of the soil improved due to combine application of both inorganic and organic nitrogen sources.

5.1.6 Nitrogen balance study

It was observed that the available nitrogen status of soil was reduced due to nitrogen application through organic means than inorganic source. However, combine application of inorganic and organic sources improve the available nitrogen status (142 kg N/ha) to greater extent. The overall gain in available nitrogen status was higher (26 kg N/ha) due to 120 kg N/ha through fertilizer supplemented with 10 t FYM/ha.

5.2 Conclusions

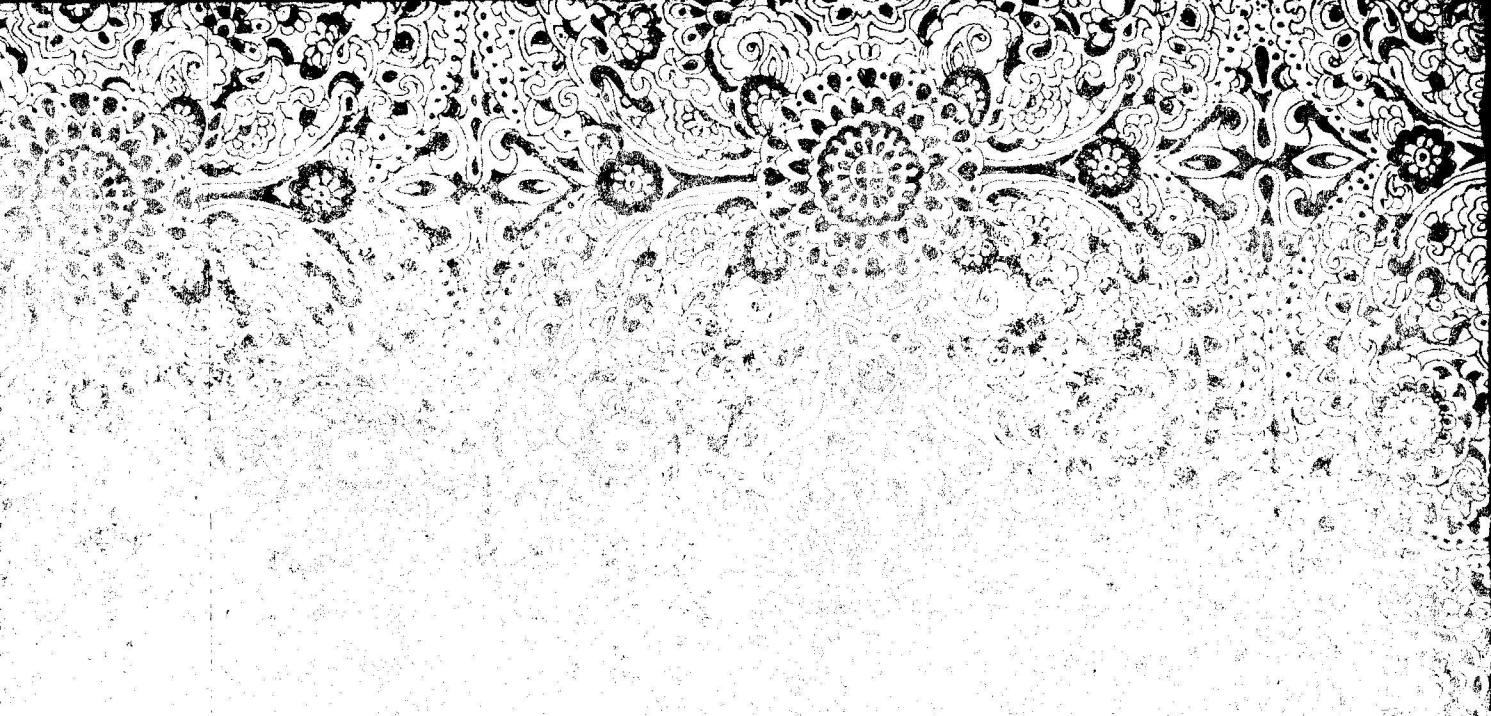
On the basis of results of present investigation following broad conclusions can be drawn.

1. For obtaining good yields of cropping sequence and to maintain better nutrient status of soil it is necessary to

apply recommended dose of fertilizer supplemented with FYM for both the crops.

2. For high production and productivity of cropping sequence such as bajra-wheat and to maintain the soil health combined application of 120 kg N/ha through urea + 10 t FYM/ha to wheat crop should be applied.

3. Among both the organic sources of nitrogen vermicompost was better than FYM.



6. LITERATURE CITED

Acharya, C.L., Boshnoi, S.K. and Yaduwanshi, M.S. 1988. Effect of long term application of fertilizer and orgainc and inorganic amendment under continuous cropping on soil physical and chemical properties. Indian J. Agri. Sci. 58 (7) : 509-516.

Anonymous, 1984. A report on wheat physiology by Wheat Specialist, Agricultural Research Station, Niphad (Nasik), M.P.K.V., Rahuri. pp. 13.

Anonymous, 1993. A report on the research work done on Agricultural Microbiology by Bacteriologist A.C. Pune, M.P.K.V., Rahuri, MD. 18-24.

Antil, R.S., Rahul, D.S. and Mahendra Singh. 1985. Effect of long term application of FYM and nitrogen II mineral P reactions. Haryana agric. Univ. J. Res. XV (2) : 200-205.

A.O.A.C. 1975. Offical method of analysis. Association of Agricultural Chemists. 12th Edn. Washington, D.C. pp. 564-596.

Auti, K.D. 1980. Effect of sowing dates, seed rates and fertilizer doses on the growth and yield of late sown wheat C Triticum aestivum L.) variety Sonalika, grown in the field vacated by sugarcane. Thesis submitted to M.P.K.V., Rahuri.

Badiyala, D. and Verma S.P. 1991. Intergrated nitrogen management in maize + soyabean-wheat cropping sequence under midhills of Himachal Pradesh. Indian J. Agron. 36 (4) : 496-501.

Balasubramanian, V. and Singh, L. 1982. Effeciency of nitrogen fertilizer use under rainfed maize and irrigated wheat at Kadawa, Northern Nigeria, Fertil. Res. 3 (4) : 315-324.

Balyan, J.S. and Jagdish Seth. 1989. Organic recycling in bajra + cowpea-wheat crop sequence. Indian J. Agron. 34 (3) : 290-292.

Balyan, J.S. and Jagdish Seth. 1991. Effect of planting geometry and nitrogen on pearlmillet + clusterbean intercropping system and their after effect on suceeding wheat. Indian J. Agron. 36 (4) : 513-517.

Bhaliya, P.J., Parmar, M.T. and Patel, J.C. 1983. Response of wheat to irrigation based on JW/CPE ratio under different nitrogen levels. Indian J. Agron. 36 (4) : 513-517.

Bhandari, A.L., Anid Sood, Sharma, K.N. and Rana, D.S. 1992. Integrated nutrient management in a Rice-Wheat system. J. Indian Soc. Soil Sci. 40 : 742-747.

Bhatia, K.S. and Shukla, K.K. 1982. Effect of contineous application of fertilizer and manure on some physical properties of eroded alluvial soil. J. Indian Soc. Soil Sci. 30 (3) : 33-36.

Bhriguvanshi, S.R. 1988. Long term effect of high doses of FYM on soil properties and crop yield. J. Indian Soc. Soil Sci. 36 (4) : 784-786.

Borse, C.D. and Mahajan, V.K. 1980. Studies on the effect of sowing depth, seeding rates and nitrogen levels on growth and yield of wheat variety Sonalika. Indian J. Agron. 25 (1) : 45-50.

Chahal, R.S., Singh, J.P. and Khera, A.P. 1984. Cumulative, direct and residual effect of phosphorus, potassium and farmyard manure on crop yield and soil characteristics. J. Indian Soc. Soil Sci. 32 : 92-96.

Chaudhary, M.L., Singh, J.P. and Narvl, R.P. 1981. Effect of long term application of P, K and FYM on some soil chemical properties. J. Indian Soc. Soil Sci. 29 (1) : 81-85.

Chougule, B.A., Kotecha, P.M., Adsule, R.N. and Manke, B.S. 1993. Effect of fertilizers, irrigations and sowing dates on quality of wheat. J. Maharashtra agric. Univ. 18 (2) : 226-228.

* Cisse, L. 1988. Effect of organic matter application on millets and groundnut on degraded soil in North Senegal II plant development and nutrient uptake. Agronomie. 8 (5) : 411-417.

Dahatonde, B.N. 1981. Effect of varying levels of nitrogen and phosphorus on late sown wheat varieties. P.K.V. Res. J. 5 (1) : 91-92.

Deshpande, M.S. 1990. National agricultural and earthworms. Proceedings of National Seminar on organic farming organised by M.P.K.V., A.C. Pune (M.S.). pp. 29.

Dhuka, A.K., Sadaria, S.S., Patel, J.C. and Vyas, M.N. 1991. Response of irrigated late sown wheat to nitrogen application. Indian J. Agron. 36 (2) : 276-277.

Dhuka, A.K., Sardaria, S.S., Patel, J.C. and Patel, B.S. 1992. Effect of rate and time of nitrogen application on late sown wheat. Indian J. Agron. 37 (2) : 354-355.

* Edward, C.A., Burrows, I., Fletcher, K.E. and Jone, B.A. 1985. The use of earthworms for composting farm wastes. In Composting of Agricultural and Other Wastes. Edn. by J.K.R. Gasser. pp. 229-242.

Gajendra Giri. 1993. Direct and residual effect of nitrogen and phosphorus fertilization on groundnut-wheat cropping system. Indian J. Agron. 38 (1) : 6-12.

Gill, H.S. and Meelu, O.P. 1982. Studies on substitution of inorganic fertilizers with organic manures and their effect on soil fertility in rice-wheat rotation. Fertilizer Research. 3 : 303-304.

Girothia, O.P., Nema, M.L. and Sharma, A.K. 1987. Response of wheat cultivars to sowing time and fertility levels. Indian J. Agron. 32 (1) : 34-36.

Gogoi, H.N. and Sandhu, H.S. 1984. Fertilizer requirement of wheat grown after different kharif crops. Indian J. Agron. 29 (1) : 15-19.

Gunjal, S.S. and Nikam, T.B. 1992. Grape cultivation through earthwarm farming. Proceedings of the National Seminar on Organic Forming organised by M.P.K.V., A.C. Pune (M.S.). pp. 48-49.

Gupta, A.P., Antil, R.S. and Narwai, R.P. 1988. Effect of FYM on organic carbon, available N and P contents of soil during different periods of wheat growth. J. Indian Soc. Soil Sci. 36 (2) : 269-273.

Hanway, J. and Heidal, H.S. 1967. Soil analysis method as used in IOWA State College, Soil Testing Lab. IOWA Agri. 57 : 1-31.

Hapse, D.G. 1993. Organic farming in the light of reduction in use of chemical fertilizers. D.S.T.A. 43rd Annual conven part-I. pp. SA 37-51.

Hapse, D.G., Murkute, S.B. and Zende, N.A. 1993. Effect of vermicompost on sugarcane yield and sugar recovery 10th Annual State level sugarcane development workshop on low cost technology for cane and sugar production, organised by V.S.I. Manjri (Bk), Pune (M.S.).

Hegde, D.M. and Dwivedi, B.S. 1993. Integrated nutrient supply and management as a strategy to meet nutrient demand. Fertil. News. 38 (12) : 49-59.

Hooda, I.S., Faroda, A.S., Mundra, M.C. and Gupta, S.C. 1991. Nutrient management in bajra-wheat cropping system. Haryana J. Agron. 7 (2) : 140-145.

Jackson, M.L. 1973. Soil Chemical Analysis, Prentice Hall of India Pvt. Ltd., New Delhi. 37-87.

Jadhav, A.S. and Koregave, B.A. 1988. Effect of N and P fertilizers on N and P uptake and quality of wheat under sequence cropping. J. Maharashtra agric. Univ. 13 (3) : 274-277.

Jadhav, A.S. and Koregave, B.A. 1988. Effect of N and P fertilizers on wheat yield and its economics under sequence cropping J. Maharashtra agric. Univ. 13 (3) : 270-273.

Jadhav, A.S. 1989. Pattern of leaf area and dry matter production in wheat under sequence cropping J. Maharashtra agric. Univ. 14 (3) : 283-287.

Jadhav, A.S. 1990. Influence of wheat based cropping system on physio-chemical properties of soil. J. Maharashtra agric. Univ. 15 (1) : 1-5.

Jadhav, S.B., Jadhav, M.B., Joshi, V.A. and Jagtap, P.B. 1993. Organic farming in the light of reduction in use of chemical fertilizers. DSTA, 43rd Conven. pp. SA 53-68.

Jambhekar, H.A. 1990. Effect of vermicompost as a Biofertilizer on grape-vines, proceedings of VIIIth Southern Regional Conference on microbiol inoculants. Organised by M.P.K.V., A.C. Pune (M.S.). pp. 79-81.

Jambhekar, H.A. 1991. Development and communication with rural mases Ph.D. Thesis submitted to Pune University, Pune.

Jambhekar, H.A. 1992. Use of earthworms as a potential source to decompose organic wastes. Proceeding of National Seminar on Organic farming. Organised by M.P.K.V., A.C. Pune (M.S.). pp. 51-53.

Jambhekar, H.A., Desai, K.R. and Jasani, K.P. 1993. Organic farming in the light of reduction in use of chemical fertilizer. D.S.T.A. 43rd Annual conven part-I. pp. SA 1-5.

* Kale, R.D. and Krishnamurthy, K.V. 1981. Enrichment of soil fertility by earthwarm activity. Soil biology and ecology in India G.K. Veeresh (Ed.) U.S.A. Tech. Series. 87. pp. 64-68.

* Kale, R.D. and Bano, K. 1986. Field trials with vermicompost (Vec comp. E 83 VAS) an organic fertilizer. Proc. NAT. SEM. ORG. WASTE. UTILIZ. VERMICOMP. PART.B. VERMS AND VERMICOMPOSTING, M.C. DASM, B.K. Senapati and P.C. Mishra (EDS) : 151-156.

* Kale, R.D., Bano, K., Sreenivasan, M.N. and Bagyraj, D.J. 1987. Influence of wormcast (Vec. comp. E. UAS-83) on the growth and mycorhizel colonization of two ornomental plants. South Indian Horticulture. 35 (5) : 433-437.

Kasole, K.E., Kalke, S.D., Kareppa, S.M. and Khade, K.K. 1993. Production potential and economics of sorghum followed by wheat under integrated nutrient management practices. Paper presented in seminar on fertilizer economy through, Agronomic manipulations held at M.P.K.V., Rahuri on 23rd May, 1993.

Khan, I.A., Rawal, D.R. and Bhatia, S.K. 1982. Effect of economising nitrogen as fertilizer through application of organic manures in a bajra-wheat-moong crop sequence. Indian. J. Agron. 27 (3) : 207-210.

Khanday, B.A., Thakur, R.C. and Khushu, M.K. 1990. Effect of nitrogen, FYM and zink application on yield and yield attributes and nutrient uptake of maize. Haryana J. Agron. 6 (12) : 113-117.

Malik, C.V.S. 1981. Response of wheat varieties to different levels of nitrogen. Indian J. Agron. 26 (1) : 93-94.

Mishra, B., Sharma, A. and Sarkar, A.K. 1992. Efficiency of organic manures for groundnut-wheat sequence in acid alfisol of Ranchi. Proc. Nat. Sem. On organic farming, M.P.K.V., A.C. Pune. 1-3.

Mishra, C.M. and Vyas, M.D. 1992. Response of groundnut-wheat cropping sequence to fertilizer application. Indian J. Agron. 37 (3) : 440-443.

Naphade, K.T., Deshmukh, V.N., Rawatkar, S.R. and Solanke, B.V. 1993. Grain yield and nutrient uptake by irrigated wheat grown on vertisol, under various nutrient levels. J. Indian Soc. Soil. Sci. 41 (2) : 370-371.

Negi, S.C., Singh, K.K. and Thakur, R.C. 1988. Response of maize-wheat cropping sequence to phosphorus and FYM. Indian J. Agron. 33 (3) : 270-273.

Negi, S.C., Singh, K.K. and Thakur, R.C. 1992. Economics of phosphorus and FYM application in wheat-maize sequence. Indian J. Agron. 37 (1) : 30-33.

* Nighwan, S.D. and Kanwar, J.S. 1952. Physico-chemical properties of earthwarm casting and their effect on the productivity of soil. Indian J. agric. Sci. 22 (4) : 357-372.

Nikam, B.T. 1985. Studies on the effects of different sources and levels of fertilizers on growth, yield and quality of wheat (HD. 2189) (Triticum aestivum L.) in rabi season. Thesis submitted to M.P.K.V., Rahuri.

Olsen, R.A. 1954. Estimation of available phosphorus in soil by extraction with sodium bicarbonate U.S.D.A. Cir. pp. 939.

Panse, V.G. and Sukhatme, P.V. 1985. Statistical method for agricultural worker ICAR, New Delhi. pp. 359.

Patel, B.A., Patel, R.H., Patel, M.V. and Amin, A.V. 1992. Effect of combined application of organic sources and inorganic fertilizers on wheat. Indian J. Agron. 37 (1) : 52-54.

Patel, N.M., Patel, R.B. and Patel, K.K. 1991. Response of wheat varieties to nitrogen and phosphorus. Indian J. Agron. 36 : 255-258.

Patel, R.M. and Upadhayaya. 1993. Response of wheat to irrigation under varying levels of nitrogen and phosphorus. Indian J. Agron. 38 (1) : 113-115.

Patil, B.P., Bhakare, B.D., Joshi, A.C. and Umrani, N.K. 1993. Supplementation of nitrogen through organic manures in sorghum-wheat crop sequence. J. Maharashtra agric. Univ. 18 (1) : 7-10.

Piper, C.S. 1966. Soil and plant analysis. Indian Edn. Hans, publication Bombay. pp. 19-136.

Pol, P.S., Nikam, B.T. and Shinde, S.H. 1991. Yield, quality parameters and nutrient removal of wheat as influenced by levels and sources of fertilizers. J. Maharashtra agric. Univ. 16 (2) : 273-274.

Prasad, B., Singh, R.P., Roy, H.K. and Sinha, H. 1983. Effect of fertilizer, lime and manure on some physical and chemical properties of a red loam soil under multiple cropping. J. Indian Soc. Soil Sci. 31 (4) : 601-603.

Raghu, J.S., Koshta, L.D., Coubey, S.D. 1983. Effect of kharif legumes on nitrogen economy of wheat crop. JNKVV. Res. J. 17 (1 and 2) : 148-150.

Raghuwanshi, R.K.S., Nema, M.L., Dubey, D.D., Umat, R. and Thakur, N.S. 1988. Manurial requirement of long term hybrid sorghum-wheat cropping sequence. Indian J. Agron. 33 (3) : 295-299.

Rahul, D.S. and Mahendra Singh. 1982. Effect of long term application of FYM and nitrogen I Crop yields and accumulation of organic carbon. Haryana agric. Univ. J. Res. XII (2) : 272-281.

Raj, M., Nath, J., Malik, B.S. and Batra, M.L. 1984. Studies to evaluate wheat yield in fallow-wheat and bajra-wheat rotations and its response to applied nitrogen. Haryana agric. Univ. J. Res. XIV (3) : 310-312.

Ramshe, D.G. and Patil, B.R. 1987. Studies on nutrient status of soil in different crop sequences. J. Maharashtra agric. Univ. 12 (2) : 214-216.

Ramshe, D.G. and Patil, B.R. 1987. Effects of precceding crops on yield and nitrogen requirement of wheat. J. Maharashtra agric. Univ. 12 (2) : 214-216.

Rao, Y.G. and Bhardwaj, R.B.L. 1981. Consumptive use of water, growth and yield of aestivum and durum wheat varieties at varying levels of nitrogen under limited and adequate irrigation situation. Indian J. Agron. 26 (3) : 243-250.

Reddy, M.R. and Prasad, R. 1980. Effect of nitrogen and row direction on yield and yield components in pure and systematic mixed stand of wheat varieties differing in plant height. Indian J. Agron. 25 (3) : 332-341.

Reddy, S.A. and Baradwaj, R.B.L. 1983. Uptake of nitrogen, phosphorus and potassium by wheat as influenced by irrigation frequenccies, nitrogen and phosphorus fertilization. Indian J. Agron. 28 (4) : 398-402.

Roshan, Lal and Hooda, I.S. 1993. Effect of preceeding crop on yield of wheat in Bajra-Wheat cropping system. Haryana J. Agron. 9 (1) : 68-73.

Sambasiva, A., Reddy, A. and Bharadwaj, R.B.L. 1982. Leaf area index and leaf area ratio as influenced by irrigation frequencies, levels of nitrogen and phosphorus in wheat. Indian J. Agron. 27 (4) : 454-456.

Sambasiva, A., Reddy, A. and Bharadwaj, R.B.L. 1984. Effect of nitrogen and phosphorus on growth and yield of wheat under limited and adequate irrigation. Indian J. Agron. 29 (4) : 505-509.

Sharma, J.P. 1981. Role of FYM in economising the use of fertilizers in a cropping sequence (wheat-moongbean). Indian J. Agron. 26 (2) : 171-174.

* Sharma, V.K., Sharma, N. and Madan, M. 1989. Organic recycling and earthworms. International reviews. Energy Resources and Technology. 1 : 142-150.

Shinde, P.B. 1992. Influence of organic manures on improvement of soil health, Proc. Nat. Sem. on Organic Farming, M.P.K.V., A.C. Pune. 14-16.

Shinde, S.H., Dhonde, P.W., Patil, B.B. and Umrani, N.K. 1984. Kharif legumes helps to economising nitrogen of suceeding wheat crop. J. Maharashtra agric. Univ. 9 (2) : 153-155.

Singh, B.P., Chahal, R.S. and Singh, M. 1981. Fertilizer management through organic and inorganic fertilizer in bajra-wheat crop sequence. Fertil. News. 26 (8) : 18-19.

Singh, B.P., Mahendra Singh and Chahal, R.S. 1982. Response of N,P and K fertilization under optimum and constraint doses, conditions in Bajra-Wheat crop sequence. Haryana agric. Univ. J. Res. XII (4) : 577-582.

Singh, B.P. and Gulani, R.S. 1983. Effect of row spacing and nitrogen on late sown wheat. Indian J. Agron. 28 (3) : 305-306.

Singh, B. and Awasthi, O.P. 1983. Comparitive performance of yield and quality components of three wheat genotypes in solid and interrow mixed stands of different levels of nitrogen. Indian J. Agron. 28 (4) : 369-375.

Singh, B., Sharma, K.N., Rana, D.S., Sodhi, J.S. and Kapur, M.L. 1983. Available phosphorus and potasssium and soil organic matter content as influenced by long term application of fertilizers and FYM to wheat maize rotation. J. Indian Soc. Soil Sci. 31 (4) : 491-494.

Singh, H. and Agarwal, J.P. 1983. Studies on nitrogen fertilization and weed management in wheat. Indian J. Agron. 28 (1) : 23-29.

Singh, S.M., Taneja, K.D. and Sharma, M.C. 1983. Residual effect of quality of irrigation water, nitrogen and phosphorus applied to pearlmillet on suceeding wheat. Indian J. Agron. 28 (4) : 477-478.

Singh, S., Singh, G. and Vasisht, R. 1984. Chemical weed control to economise fertilizer use in wheat II. Yield attributes, response and economic of production. Indian J. Agron. 29 (4) : : 424-428.

Singh, R.S. and Dubey, S.D. 1987. Direct, residual and cumulative effect of FYM and NPK application on yield and nutrient uptake in wheat. J. Indian Soc. Soil Sci. 35 : 745-747.

Singh, R.V., Dubey, V.K. and Vyas, M.D. 1992. Effect of seedrate, nitrogen level and method of fertilizer placement on wheat, under late sown condition. Indian J. Agron. 37 (1) : 43-46.

Singh, G., Singh, O.P., Yadav, R.A. and Singh, R.S. 1993. Response of wheat to planting method, seed rate and fertility in late sown condition. Indian J. Agron. 38 (2) : 195-199.

Sinha, N.P., Prasad, B. and Ghosh, A.R. 1981. Effect of contineous use of fertilizers on yield and nutrient uptake in a wheat-soybean-potato cropping system. J. Indian Soc. Soil Sci. 29 (4) : 537-542.

Soni, P.N. and Sikarwar, H.S. 1983. Nitrogen substitution with FYM in rice wheat sequence. Indian J. Agron. 28 (4) : 392-396.

* Tomati, V., Grapelli, A., Galli, E. and Rossi, W. 1983. Fertilizer from vermiculture as an option for organic waste recovery. Agrochemica. 27 : 244-251.

Upadhayaya, S.P. and Dubey, O.P. 1991. Response of wheat genotypes to varying fertility levels under limited and adequate water supply. Indian J. Agron. 36 (2) : 290-293.

Vaishya, R.D. and Singh, V. 1981. Effect of seedrate, row spacing and nitrogen on yield and uptake of nitrogen in late sown wheat. Indian J. Agron. 26 (1) : 53-58.

Yadav, D.S. and Singh, S.B. 1984. Studies on nitrogen economy in legume based cropping system. Indian J. Agron. 31 (4) : 380-383.

Zope, R.E. 1981. Physiological analysis of growth and yield of two wheat varieties (Triticum spp) as influenced by plant densities and nitrogen levels. Thesis submitted to the M.P.K.V., Rahuri.

* Originals not seen

Appendix

7 - APPENDIX

APPENDIX-I

Mean grain and fodder yield of bajra N and P uptake by pearlmillet as influenced by different treatments at harvest

Sr. No.	Treatments	Grain yield (q/ha)	Fodder yield (t/ha)	N uptake (kg/ha)			P uptake (kg/ha)		
				Grain	Fodder	Total	Grain	Fodder	Total
1.	60 kg N + 30 kg P_2O_5/ha through fertilizer	35.78	4.36	34.27	22.39	56.66	8.78	4.39	13.17
2.	45 kg N + 30 kg P_2O_5/ha through fertilizer	33.12	3.93	32.71	21.22	53.93	6.99	3.04	10.03
3.	30 kg N + 30 kg P_2O_5/ha through fertilizer	31.06	3.47	29.46	19.92	49.38	6.07	2.45	8.52
4.	60 kg N/ha through FYM alone	27.70	2.82	12.31	5.07	17.38	3.48	1.86	5.34
5.	45 kg N/ha through FYM alone	24.80	2.31	8.41	3.93	12.34	2.32	0.86	3.17
6.	30 kg N/ha through FYM alone	22.00	2.26	7.46	3.31	10.77	1.38	0.35	1.73
7.	60 kg N/ha through vermicompost alone	30.94	3.21	17.84	6.54	24.38	5.49	2.58	8.07
8.	45 kg N/ha through vermicompost alone	28.14	2.86	15.85	5.55	21.40	4.22	1.40	5.62
9.	30 kg N/ha through vermicompost alone	24.48	2.64	12.95	4.53	17.48	3.30	0.89	4.19
10.	60 kg N + 30 kg P_2O_5/ha through fertilizer + 10 t FYM	40.47	4.62	36.51	24.16	60.67	10.31	5.34	15.65
11.	22.5 kg N through chemical fertilizer + 22.5 kg N through FYM	25.83	2.70	21.30	14.24	35.54	4.14	2.10	6.24
12.	22.5 kg N through chemical fertilizer + 22.5 kg N through vermicompost	30.64	3.05	26.30	16.07	42.37	5.95	2.95	8.90
	S.E. ±	0.863	0.161	0.454	0.12	---	0.077	0.037	---
	C.D. at 5 %	3.34	0.623	1.41	0.38	---	0.24	0.11	---
	Mean	29.58	3.19	21.37	12.24	33.52	5.20	2.35	7.55

APPENDIX-II

Following prices were considered for calculating cost of cultivation

Particulars	Rates (Rs.)
1. Man and women	Rs. 20.10/day
2. Bullock pair	Rs. 75.00/day
3. Wheat grain	Rs. 500.00/q
4. Wheat straw	Rs. 50.00/q
5. Urea	Rs. 2.64/kg
6. Single superphosphate	Rs. 3.03/kg
7. Murate of potash	Rs. 4.80/kg

8. VITA

RAMCHANDRA DATTATRAYA NIGADE

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRONOMY

1995

Title of thesis : Nigrogen SUBSTITUTION through organic sources in irrigated wheat (Triticum aestivum L.) and their effects in bajra-wheat sequence

Major field : Agronomy

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