Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P.

Thesis

Submitted to the

Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut- 250110 (U. P.), India

By

Nishant
Id. No. 2014

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Doctor of Philosophy

in

Agronomy

February, 2016

Dr. Vivek
Professor

Department of Agronomy
Sardar Vallabhbhai Patel
University of Agric. & Tech.,
Meerut - 250 110 (U.P.), India

CERTIFICATE

This is to certify that the thesis entitled **"Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P."** submitted in partial fulfilment of the requirements for the degree of **Doctor of Philosophy** with major in **Agronomy** and minor in **Soil Science** of the college of Post-Graduate studies, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, is a record of *bona-fide* research carried out by **Mr. Nishant, Id. No. - 2014**, under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation and source of literature have been acknowledged.

(Vivek)
Chairman
Advisory Committee

CERTIFICATE

We, the undersigned, members of the advisory committee of **Mr. Nishant, Id. No. - 2014,** a candidate for the degree of **Doctor of Philosophy** with major in **Agronomy** and minor in **Soil Science,** agree that the thesis entitled **"Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P."** may be submitted by **Mr. Nishant,** in partial fulfilment of the requirements for the degree.

(Vivek)
Chairman
Advisory Committee

(Raghuvir Singh)	**(B. P. Dhyani)**	**(Ravindra Kumar)**
Member	Member	Member

Contents

List of Tables

List of Illustrations

Abbreviations

%	:	percent	Sci.	:	Science
@	:	At the rate	mm	:	Millimetre
^{0}C	:	Degree celsius	Maxi.	:	Maximum
l	:	Litre	Mini.	:	Minimum
ANOVA	:	Analysis of variance	NS	:	Non-significant
B:C	:	Benifit cost ratio	SEm±	:	Standard error of mean
BSS	:	Bright sun-shine	t	:	ton
CD	:	Critical difference	Temp.	:	Temperature
cm	:	Centimetre	VC	:	Vermicompost
LAI	:	Leaf area index	B	:	Bio fertilizer
DAS	:	Days after sowing	FYM	:	Farm yard manure
df	:	Degree of freedon	N	:	Nitrogen
FAO	:	Food and agriculture organisation	P	:	Phosphorus
m^{-1}	:	Per metre	K	:	Potassium
g	:	Gram	EC	:	Electric conductivity
GOI	:	Government of India	CEC	:	Cation exchange capacity
q ha-1	:	Quintal per hectare	RDF	:	Recommended dose of fertilizer
RH	:	Relative humidity			
hr	:	Hours			
ha	:	hectare			
ha^{-1}	:	Per hectare			
j.	:	Journal			

ACKNOWLEDGEMENT

My debts are great and too many, which I can never dare to acknowledge especially an unseen power of almighty God, who bestowed upon me the courage to carryout this research work.

I gratefully aware of this opportunity to express my humble and deep sense of gratitude to my respected teacher and chairman of my advisory committee ***Dr. Vivek****, Professor Agronomy, and chairman advisory committee Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, for not only his innate guidance throughout this study period but also exposing me to the panorama of field of unexplored knowledge. Whatever I can do in this study might not have been possible without his persistent encouragement, splendid cooperation, moral boosting, untiring supervision and constructive criticism. I am extremely indebted to him for being meticulous throughout the investigation and preparation of this manuscript.*

I highly grateful to members of my advisory committee ***Dr. Raghuvir Singh Professor, Deptt. of Agronomy, Dr. B. P. Dhyani Professor, Deptt. of Soil Science and Dr. R. Kumar Professor, Deptt. Of Biotechnology****, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, for their kind cooperation, encouragement and valuable suggestions during the tenure of my present investigation.*

I am highly indebted to ***Dr. H. S. Gaur****, Hon'ble Vice-Chancellor and* ***Dr. N. S. Rana,*** *Dean PGS, Collage of Agriculture, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh (U.P.) for providing all the necessary facilities for the completion of the experiment.*

I felt prickly conscience to remain with a single word of gratitude for the pivotal role played by Dr, M. K. Kaushik, Dr. R. K. Naresh, Dr. Rajvir Singh, Dr. R. B. Yadav, Dr. Sandeep Singh Tomar and Dr. Adesh Singh, of Agronomy, during investigation and throughout my studies.

From the core of my heart uncountable words of cordial veneration and gratitude are dedicated to pious feet's of my father & mother ***Shri Avadh Raj Yadav*** *and* ***Smt. Rama Yadav*** *for their love, affection, good wishes, blessings, constant encouragement and inspiration showered upon me for the achievement of my present educational assets.*

I wish to record my profound sense of respect and gratitude to my grand Father Late. ***Shri Daya Ram Yadav*** *grandmother Late* ***Smt. Bansraji Devi*** *for their blessings, good wishes, cooperation and financial support during my whole study period.*

My sincere thank goes to my Uncle ***Late Shri Ram Ajor Yadav, Shri R.B. Yadav, Late Dr. Y.N. Yadav, Shri Virendra Yadav, Shri N.B. Yadav*** *and* ***Shri Rahul Yadav*** *for their constant help during the present study.*

I also indebted to my elder brother ***Vivek, Anurag, Abhishake, Himanshu, Sudhanshu, Surendra, Sitanshu*** *and My younger brother* ***Rajan, Shashank, Divyank, Krishna, Amit & Harry,*** *elder sister* ***Abha, Nidhi, Priyanka, Neha, Divyanka,*** *and my* ***Younger Sister Neha, Khusboo, Anshuma, Himanil, Shreya,*** *and who extended moral support and love without which this dream would not be materialized.*

*It is indeed a pleasure to acknowledge the love affection, and co-operation rendered by my Seniors **Dr.Raja Ram Yadav, Dr. Darmendra Dubey**, **Dr. Virendra Kumar, Dr. Dinesh Kumar,** their caring eyes and helping hands were always there to share my ecstasies and sorrows.*

*I am getting short of words to express my special regards to my sweet friend **Vanshi Dhar Yadav, Jugal Kishore Verma, Krishna Mohan Prasad, Rajesh kumar, Siddhartha, Dharmendra Kumar Gautam, Pawan Kumar, Anurag Mishra, Manoj Sharma, Jay pal Singh Tomar, Ravi kant Singh, Dileep Gupta, Neeraj kumar,** who co-operated me in my bad times and helped me to overcome my mental tiredness and distress.*

I would really miss if do not express my indebtness to my such jovial and friendly juniors, Kamlesh Yadav, Sanvjeev Rao, Ista dev, Raju, Sudheer Yadav, Ashish Dwivedi and Vineet Singh for their kind cooperation.

I am also thankful to Smt. Archna, Lab Assistant, Soil Science, Mr. Amit Kumar, Clerk, computer operator and all the staff members of Department of Agronomy of S.V. P. University of Agriculture & Technology for their help during the experimentation.

Heart full thanks and extended to officer member, University Library Mr. Sudesh and Smt. Sangeeta Sharma, Asst. Librarian for providing me better library facility.

A special word of appreciation goes to Mr. Pranish Yadav for showing enormous support.

*I shall be failing in my task if I do not express my heartily thanks to my senior **Dr. Raja Ram Yadav and Dr. Manoj for** analyzing the data.*

Lastly the co-operation provided by the entire staff of Agronomy Department and all the respondents of the study area who help me directly or indirectly are greatly acknowledged .

*Its like drop in the ocean by me all regards to **Maa Saraswati ji** for providing me energy and patience without which it would have been none.*

Meerut — ***Nishant***

Febrauary, 2016 — *(Author)*

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important cereal crop of the world after rice, both in terms of area and production. In India wheat is the second most important food crop next to rice and it contributes nearly 35% to the national food basket. Among winter crops, it contributes about 49% of the food grains in 2012–13. It meets 20 per cent of the total food, 19 per cent of calories and 20 per cent of protein requirements of the global population besides being a major source of dietary fiber in human nutrition since decades. In India, the area, production and productivity of wheat jumped up from 12.8 to 29.65 m ha, 11.4 to 93.5 m tons and 887 to 3153 kg ha^{-1} by 1966-67 to 2013-14 (FAO, 2013). Yet, Productivity of wheat is very low in India in comparison to major wheat producing countries *viz.,* UK (7.9 t ha^{-1}), Germany (7.8 t ha^{-1}), France (7.5 t ha^{-1}) China (4.7 t ha^{-1}) etc. The three states namely U. P., Punjab and Haryana are agriculturally important in north-western plain zone and contribute 68.29 per cent towards India wheat production. The state of U. P. is the major player with almost 50 per cent share but the productivity is very low being 2.85 t ha^{-1} as against 4.36 t ha^{-1} in Punjab (FAO, 2013). The total area of wheat in the world is around 222.6 m ha with production of 716.16 m t. The normal world productivity is 32.17 q ha^{-1} (FAO, 2014). It is grown across a wide range of environments around the world and has the highest adaptation among all the crop species. Worldwide more land is devoted to the production of wheat than any other contributes about 60% of daily protein requirement and more calories to world human diet than any other food crop. In Uttar Pradesh, wheat is grown in typical semiarid climate which is characterized by high temperature during crop growth.

Wheat is the most important winter crop grown in India during *rabi* (November to April). This golden grain winter cereal is a major contributor to the food security system and provides more than 50 per- cent calories to the people who are mostly dependent on this staple food. Wheat is cultivated in almost every state except Kerala. Based on the agro- climatic condition and varying agro- ecological production conditions, the country is broadly divided into six wheat growing zones. The maximum wheat growing duration is in Northern Hill Zone and minimum in Peninsular Zone. Based on the present rate of population growth of 1.5 per cent and per capita consumption of 180 g of wheat per day in the country, the demand for wheat is expected to be around 109 million tonnes by 2020 (Anon. 2009). Wheat contributes nearly one third of the total food grain production. It is consumed mostly in the form of bread as ‘Chapatti’. Wheat is responsible for the success story of green revolution as its increased many folds due to availability of input responsive high yielding varieties of the crop. There are several inputs which made it possible to raise the productivity of wheat but fertilizer is the main contributor and responsible for about 40 percent of increases productivity of wheat. Wheat straw is used for feeding the cattle. The approximate chemical composition of the wheat kernel is starch 63-71%, protein 10-15%, water 8-17%, cellulose 2-3%, fat 1.5-2%, sugar 2-3% and mineral matter 1.5-2%.

The common bread wheat occupies more than 90% of total wheat area along with 10% area under *Triticum durum* (Anonymous, 2012). Its cultivation is common under rainfed condition only, on account of higher susceptibility to rusts. A large area has come in Punjab under irrigated condition due to high yielding varieties developed to obtaining the foreign exchange. The crop is mostly grown under irrigated condition. It could be sown late in December and January without much fear of heat injury during grain filling even in the south zone. Rice and wheat is the hub of food security of the global population.

In 21 st century, there will be a need of about 250 million tones to feed the rapidly increasing population. Wheat is grown in India in different cropping sequences, among them rice-wheat is important one. Rice (*Oryza sativa*) - Wheat (*Triticum aestivum* L.) system play a significant role in food security contributing 76% to the total food grain production of the country. Enhancement of wheat production from limited land area is great challenge for Indian agriculturist. Apart from developing high yielding wheat varieties, integrated nutrient management will be required to boost wheat production.

Plant nutrient plays an important role in growth and productivity of a crop. As wheat crop is highly responsive to applied nutrient through various sources, a proper fertility management is an important parameter for optimizing the productivity of wheat crop. Wheat is generally grown in intensive cropping system with higher use of inorganic especially nitrogenous fertilizers. This condition is adversely affected and therefore it is needed to supply the nutrient to the crop in combination with organic sources. Indian soil are generally deficient in nutrient particularly nitrogen. It has been universally observed that the nitrogen use efficiency which is low as about 30-37% is utilized while the rest is lossed through volatilization, denitrification and leaching. The phosphorous use efficiency is 15-20% while rest is fixed in the soil and not available to the plant easily. Nitrogen is required by wheat crop in large amount and most of the soils in wheat growing areas are deficient in nitrogen availability. Nitrogen is an important metabolic element for growth and development of plant. It is considered essential for synthesis of Protein and other bio chemical products of plants such as protoplasm which is the basis of life. Therefore, nitrogen is directly concerned with physiological process occurring with in the plants. Although nitrogen is the most important element which play the vital role in wheat nutrition as it is required the growing period of the crop. Nitrogen fertilization always results in an increase in above ground dry matter and root biomass production which results into higher productivity as well as higher residue left in soil after the harvest of the crop which helps in improving the fertility of soil. The nitrogen use efficiency value become high with combination of FYM and Azosprillum.

It is believed that inorganic fertilizers give good response & high yield of crop but after sometimes leaves some deleterious effect on soil, ultimately damaging its fertility. However, inorganic fertilizers have their own utility in a system of soil fertility maintenance and they now to come to form an essential part of all system of scientific agriculture practised in many countries and India also. In recent years increasing fertilizer input cost, soil health, sustainability and pollution consideration have led to renewed interest in the use of organic manure. The crop yield in spite of balance use of nitrogen, phosphorus and potassium fertilizer are declining year to year. The use of vermicompost along with chemical fertilizers play an important role in maintenance of Physico-chemical properties and fertility of soil.

Long time studies carried out at several locations in India indicate that application of all the needy nutrients through chemical fertilizers have effect on soil health leading to unsustainable yield. Organic manure is also important source of nutrient addition to soil but contain low amount of nutrient and therefore, whole crop requirement can not be fulfilled by their application. Chemical fertilizers on the other hand are available in fixed grades, hence, all nutrients are not supplied in balanced quantities. Therefore, for maintaining soil fertility, there is a need of integrate the two sources of nutrients. During the decade, the concept of integrated nutrient management has emerged as an important tool for maintaining soil fertility and crop productivity. The research findings on various aspects of the integrated nutrient management on wheat are reviewed. Thus, integrated use of organic manures with optimal levels of NPK fertilizers is the need of the day that will not only improve the nutrient status but has also shown greater potential in stabilizing crop yields over a period of time. The basic concept underlying the principle of integrated nutrient management is to maintain or adjust plant nutrient supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients. The basic objectives of INM are to reduce the inorganic fertilizers requirement and to restore organic matters (O.M.) in soil to enhance the nutrient use efficiency and to maintain soil health in terms of physical, chemical and biological properties. The integrated use of organics and chemical fertilizers at optimum levels as determined by soil tests in long-term fertilizer experiments indicate the build-up of micronutrient and secondary nutrient reserves such as Zn, Cu, Mn, Ca, Mg and S. Therefore, INM in sustainable cropping systems is of paramount importance.

The three most vital nutrients that a plant can receive are nitrogen (N), phosphorous (P) and potassium (K). The use of organic manure along with chemical fertilizer to play an important role for maintence of physico-chemical properties and fertility of soil (Pandey *et al.*, 2009).

Indian soil are generally deficient in nutrient particularly nitrogen. The reduction of N retarted growth and development of plants, turn foliage to pale green colour and reduces the crop yield. It has been universally observed that the nitrogen use efficiency which is low as about 30-37% is utilized which the rest is lossed through volatilization, denitrification and leaching. Nitrogen is an important metabolic element for growth and development of plant. Nitrogen is considered as essential for synthesis of protein and others biochemical products of plant such as protoplasm which is the life. The nitrogen use efficiency value become high with combination of FYM, vermicompost, pressmud and Azosprillium. Therefore, nitrogen is directly concerned with physiological process occurring with in the plants. Although nitrogen is the most important element which plays the vital role in wheat nutrition as it is required throughout the growing period of the crop. Nitrogen aids in the plant's growth above ground.

Phosphorus is second most important major plant nutrient after nitrogen for crop production. It has been called as the "key of life for the plants". It is a structural component of cell membranes, chloroplast and mitochondria. It is necessary for such life process of plant as photosynthesis, development of plant cell as well as synthesis and breakdown of carbohydrates and transfer of energy with in the plants. It also strengthens the stem of cereal plants, reducing their tendency to lodge. Phosphorous enhances plant cell division. It also helps in flower and seed production and in the development of a strong root system.

Potassium plays an important role in the maintenance of cellular organization by regulating the permeability of cellular membranes and keeping the protoplasm in a proper degree of hydration by stabilizing the emulsion of high colloidal properties. Potassium has a great buffering action and stabilize various enzymes system. It plays role in photosynthesis and translocation of food from leaves to seeds. It also enhance the plants ability to resist pest attack, moisture stress and cold condition. Adequate supply of this nutrient promotes the formation of fully developed grain with a high starch contents.

Due to energy crisis the use of chemical fertilizer in crop has become not only costly but also short in supply. The country in thus, in great need for alternate source which can supplement partially or wholly the use of chemical fertilizers. Since ancient time, farmer in India have been using FYM in their farms. Since, ancient time farmers in India have been using FYM in their farms, there has been several times increase in demand of manures and fertilizers for maintaining optimum productivity. The quantity of FYM available to the farmers could cover only 5- 10 per cent of the area every year which means that a field can receive FYM application after a gap of 8- 10 years. Therefore, for making integrated nutrient management more effective, there is a need to increase the availability of organic manures. The use of organic manure like FYM, Vermicompost, Preesmud with fertilizer is receiving great attention in intensive agriculture. Application of organic along with inorganic source not only improve soil health but with also improve the produce quality and fertilizer use efficiency and there by reducing the cost of cultivation. Use of organic manure have been found to be promising in arresting the decline in productivity through correction of deficiencies of secondary and micronutrient (Kumar and Tripathi, 1999). Organic source of nutrient applied to preceding crop benefit the succeeding crop to great extent (Singh *et al.*, 1996).

FYM is also important component of sustainable agriculture. It contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O respectively. Besides its manorial properties it has valuable physical effect on soil texture and improve water holding capacity of the soil. The quality of FYM available to the farmer could cover only 50 to 10% of the area every year which means that a field can receive FYM application after a gap of 8 to 10 years. The recent concept of integrated nutrient management (INM) is very important for sustaining the production and improved soil health. The basic concept underlying the principal of integrated nutrient management is to maintain or adjust plant nutrient supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients. The basic objectives of INM are to reduce the inorganic fertilizers requirement and to restore organic matters in soil to enhance the nutrient use efficiency and to maintain soil health in terms of physical, chemical and biological properties. Therefore making of integrated nutrient management (INM) more effective, there is a need to consider the organic manures. Some organic manure *viz.* farmyard manure and vermicompost and Preesmud are important constituents of integrated plant nutrient management system. However, one of the demerits of the FYM is that it may a carry weed seeds although its nutrient content is quite low. Whereas vermicompost is free from weed seed. Incorporation of vermicompost, farm wastes as well as practices of green manuring are viable alternative to FYM and compost for improving soil fertility and sustaining productivity of crops.

Recently, vermicompost technique has been developed for increasing the availability of organic sources of nutrients. Vermicompost being a major component of organic manure has attracted attention of scientist word wide since it is an entirely nature product which maintain the soil ecosystem and leaves no adverse effect on it. Vermicompost is the compost that is prepared with the help of earth worms during the process of vermicompost a strong heat is not generated so the soil holds nutrients, beneficial bacteria, valuable enzymes and vitamins. This helps in better vegetative growth, heavy flowering and insect. In U.P., vermicompost is emerging as a major practice for recycling of residues and wastes. Vermicompost is a rich mixture and minor plant nutrients. It contains 3 % Nitrogen, 1% Phosphorous and 1.5% Potash. Vermicompost is an excellent base for the establishment of beneficial free living and symbiotic microbes. Application of vermicompost increase the total microbial population of nitrogen fixing bacteria. The use of vermicompost has been advocated as a part of integrated nutrient management (INM) in various field crops. Vemicomposting has been developed for increasing the availability of organic resources of nutrients. Recycling of organic wastes through biological agents such as microbes and earthworms is well established practices. It is also advantageous in conserving soil moisture, nutrients, bacteria and valuable enzymes and in preventing leaching of nutrients.

Bio- fertilizers are recognized as important component of sustainable agriculture. These bio fertilizers are used to inoculate cereal crop for increasing the growth, yield attributes and yield. Azosprillium is a associative (non- symbiotic) aerobic nitrogen fixing bacteria commonly found in close association with vegetable crops. If the seed is inoculated with the Azosprillium and sown in favourable weather condition at proper sowing time with suitable varieties it shall become possible to fetch good yield of wheat. The yield of wheat increased due to inoculation with Azosprillium as alone and in combination. (Singh *et al.*, 2004, Kachrao and Razdan 2006).

Hypothesized that the applications of different organic sources in conjution supply plant the plant nutrients in optimum amount during the growth period. Therefore keeping these things in mind present experiment "Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P." was undertaken at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, with the following objectives.

1. To assess the effect of nutrient management options on growth, yield and quality of wheat.
2. To assess the impact of nutrient management options on nutrient content and uptake by wheat.
3. To work out the economic feasibility of different nutrient management strategies.
4. To assess the organic carbon and N, P, K availability in soil under nutrient management options.

In the ensuing text an attempt has been made to review the relevant research work carried out by various workers in different agro climatic conditions in India and abroad. "Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P." have been presented below:

2.1 Effect of organic manures on wheat

Over the past century, many of the basic scientific principles of plant nutrition and soil fertility have been developed and documented. During last few decades, inorganic chemical fertilizer have been widely accepted as major source for improving and maintaining the soil fertility with the advent of these abundant and relatively inexpensive chemical fertilizer, farmers developed a thinking that agricultural manures are agricultural wastes of last, it has been realized that it is not possible through chemical fertilizers to add every nutrient in natural balanced manure. The traces of micronutrients which are essential for plants are not supplied by chemical fertilizers but organic manures supply micronutrients (Hesse 1984). Application of organic manures increase the organic matter content in the soil which increase the water holding capacity in sandy soil and drainage in clay soils which results in improving the soil fertility (Gupta *et al.,* 1990).

The beneficial impact of organic manures on physical, biological and chemical properties of soils is widely known but the full appreciation for the some remains largely ignored in commercial chemical agriculture. Organic manures also increase the nutrient holding capacity of soil and minimize the effect of toxicants. Organic manures make the soil biologically active as these are good source of food and energy for soil micro-organisms and increase the activity of microbes which bring non-available plant nutrients into available from (Yawalkar *et al.,* 1992) thus improving the growth, yield and quality of crop plants.

Nayak and Gupta (1995) reported that available P increased with the application of organic matter and there was also an increase in the dry matter yield of tops and roots of the crop. The beneficial effect of organic manures on soil health and crop production has been extensively reviewed by various other workers (Yawalkar *et al.*, 1992 and Verma, 1995). Yadav *et al*. (2003) observed that build up in organic carbon and P content of the soil after 2 years application of organic sources of nutrients in wheat. Significantly higher organic carbon was obtained in the plots supplied with 10 tonnes FYM ha^{-1} either alone or in combination with the control. Slow mineralization of organic matter leads to build up of organic carbon.

Dhaliwal and Walia (2008) reported that incorporation of FYM, G.M and CRI in the soil has beneficial effect on soil health by improving physico-chemical properties besides supplying the macronutrients like N, P and K and increasing the availability of the micronutrient like Zn, Cu, Fe and Mn in the soil. Moreover, the results obtained the addition of these manures decreased the bulk density and increased the level of organic carbon, field capacity, permanent wilting point and available soil moisture.

2.1.1 Effect of Growth

Farmyard manure (FYM) is an important source of nutrients and has direct influence on soil properties and plant growth. Sharma (1981) observed that the panicle length, number of panicles m^{-2}, under of grains per panicle and test weight of wheat increased with the application of FYM at 12 t ha^{-1} in conjunction with each NPK level up to N_{60} P_{30} K_{30} only as compared to some fertilizer level alone. The application of FYM with higher fertilizer levels that N_{60} P_{30} K_{30} however, did not significantly affect the above said growth and developmental characters of wheat because of higher and readily availability of nutrients from the higher fertilizer doses as compared to FYM to meet out the requirements of the plants.

Ranwa *et al.* (1999) revealed that application of organic manures improved yield attributes and grain, straw and biological yield of wheat. Application of vermicompost at the rate 7.5 or 10 t ha^{-1} yielded higher than 10 t ha^{-1} FYM. Increasing dose of nitrogen improved significantly the yield attribute and yields of the crop. Integration of vermicompost at 10 t ha^{-1} or 7.5 t ha^{-1} or FYM 10 ha^{-1} with 100 kg N ha^{-1} produced grain, straw as well as biological yields at par to recommended dose of fertilizer during both the years.

Pang and letay (2000) reported that conventional fertilizer management to organic farming has been proposed as a means to reduce ground water degradation or these factor lead to better establishment and better growth of crop plant supreme position of FYM over the inorganic fertilizer had a significant effect on the crop yield of wheat which was 7.05% higher as compared with the control application of FYM had a positive influence on roots development, tillering and flowering, hence resulted in betterment of yield and quality.

Ranwa *et al.* (2001) reported that the application of vermicompost at 10 t ha^{-1} significantly improved the number of tillers, dry matter accumulations, LAI.

Nehra (2001) revealed that application of vermicompost at 15 t ha^{-1} recorded maximum value for all the growth parameters and significantly more yield as compared to other organic manures.

Agarwal *et al.* (2003) resulted that treatment with 75% vermicompost + 25% farmyard manure gave the greatest plant height at 105 days after sowing (DAS) and also leaf attributes number at 90 DAS, dry weight at 105 DAS and number of seeds per spike, test weight grain yield per plot and harvest index at 105 DAS.

Yadav *et al.* (2005) observed that plant height and effective tillers m^{-1} row increased significantly with each successive increment of N from 120 to 180 kg ha^{-1}. Effective tillers m^{-1} row length increased by 29.3% with 180 kg N ha^{-1} over 120 kg N 120

N ha^{-1}. This might be due to the fact that nitrogen plays a vital role in cell division and cell enlargement as well as increased sink size.

Tulsa Ram and Mir (2006) reported that application of FYM @ 10 t ha^{-1} + 120 kg N ha^{-1} significantly increased plant height, effective tillers/m row length, grain/spike, grain and straw yields over the control and FYM @ 10 t ha^{-1} + 100 kg N ha^{-1}.

Singh *et al.* (2007) observed that application of FYM to wheat induced better growth of plant which resulted in taller plant, more tiller m^{-2}, length of spike, grain weight per spike, test weight, yield of grain and straw over the control.

Singh *et al*. (2008) showed that application of FYM 7.5 t ha^{-1} + 50% RDF + biofertilizers recorded the highest plant height, effective tillers m^{-2}, grains/spike and 1000 seed weight during both the years. The highest grain yield of wheat was also recorded with the combined application of FYM 7.5 t ha^{-1} + 50% RDF + bio-fertilizers.

Gowda Channabasana *et al*. (2008) a field experiment was conducted during rabi season of 2006-07 on red loamy soil of main Agricultural Research Station, University of Agricultural Sciences, Dharwad to study the effect of organic manures on growth of wheat. Application of vermicompost @ 3.8 t ha^{-1} + poultry manure @ 245 t ha^{-1} recorded plant height (86.30 cm) than other treatments.

Yadav *et al.* (2009) reported that growth and yield components of rice and wheat were not affected to level of significance during the first year. The tallest plant and highest dry matter production of rice and wheat were recorded with the treatment in situ incorporation of wheat/rice straw+GM+PM @ 5T ha+PSM .

Sepat *et al.* (2010) reported that integrated use of fertilizers with FYM and bio-fertilizers increased the number of spikes m^{-2}, grains/spike and the test weight. The enhanced early vegetative growth in terms of higher leaf area index, dry matter accumulation and vigorous root system resulted in more spikes which consequently increased the number of spike bearing tillers significantly. The combined application of 75% RDF or RDF along with FYM, bio-fertilizer and zinc also increased the grain/spike.

Rajhans *et al.* (2011) the investigation was aimed to determine the characteristics of different composts prepared by using wheat straw adopting suitable techniques, the maximum content of nutrients in compost, whereas content of these nutrients were very less in NADEP and Local composting methods. The maximum content of ash and higher production of compost in NADEP composting method is associated with the content of 40% soil with wheat straw.

Fecondo *et al.* (2012) reported that the use of the compost generally improved the growth and production of the crops and increased soil organic matter and nutrients content.

Chaplot and Sumeriya (2013) reported that the application of organic manures effective, however, both significantly improved growth, chlorophyll content and dry matter accumulation by plant parts at successive stages, over no manure i.e. farmyard manure (FYM) @ 10 t ha^{-1} and biogas slurry (BGS) @ 3.33 t ha^{-1} proved equally.

2.1.2 Effect on yield and yield attributes

Hasan and Kamal (1998) found that grain, straw yield and protein contents were higher in wheat with N in 4 splits + 10 t FYM. There is a positive effect of applying FYM and various amounts of N fertilizers on soil N balance, crude protein content.

Sharma *et al.* (1999) conducted on experiment at different growth stages in late sown wheat in an acid alfisoil of Himalayan region, reported that an application of 8 t FYM and 90 kg P_20_5 ha^{-1} considered at optimum, gave a grain yield of 3.87 t ha^{-1}. The uptake of Ca and Mg increased with application of FYM and P.

Ranwa and Singh (1999) reported that the application organic manures improved yield attributes and grain, straw and biological yields of wheat.

Ranwa (1999) in an investigation at Hisar reported that application of vermicompost at the rate of 10 t ha^{-1} remaining at par with 7.5 t ha^{-1} significantly increased number of effective tillers, length of spike, number of grains per spike, grain weight per spike, grain and straw yield of wheat over 5 t ha^{-1}.

Pang and Letay (2000) reported that conventional fertilizer management to organic farming has been proposed as a means to reduce ground water degradation. All these factor lead to better establishment and better growth of crop plant. Super imposition of FYM over the inorganic fertilizer had a significant effect on the crop yield of wheat which was 7.05% higher as compared with the control. Application of FYM had a positive influence on roots developments tillering and flowering, hence resulted in betterment of yield and quality.

Nehra and Hooda (2000) studied the integrated use of organic manures with NPK fertilizers for wheat production. Among organic manures, 15 t vermicompost ha^{-1} gave the best results and 2.5 t press mud (filter cake) the worst. Among fertilizer treatments, 60 kg N ha^{-1} gave lower yield than higher N rates or NPK fertilizer.

Negi *et al*. (2000) conducted an experiment on rainfed wheat with application of 10 t FYM ha^{-1} caused a significant increase in grain (by 3.52 q ha^{-1}) and straw (by 3.37 q ha^{-1}) yield.

Hati *et al*. (2000) reported that grain yield of wheat increased significantly with integrated application of fertilizers of organic manure (FYM) up to 138.5% and 123% by recommended dose of NPK+ FYM @ 10 t ha^{-1} over the control, respectively. The combined use of inorganic and organic manure enhanced the inherent nutrient supplying capacity of soil.

Bhardwaj *et al.* (2000) reported that wheat cultivars were sown with vermicompost at 5, 10 and 20% of NPK. Among the treatment, 20% of vermicompost produced the highest wheat yield.

Sushila and Giri (2000) observed that application of nitrogen up to 90 kg ha^{-1} increased the grain yield significantly by increasing yield attributes, e.g. Number of spike, length of spike, 1000- grain weight of wheat.

Yonglin *et al*. (2001) to investigate the application of fertilizer NPK combined with OM had a better yield-increase effect than the application of fertilizer NPK alone, especially combined with farmyard manure at a higher dose. It is concluded that the application of fertilizer NPK combined with O.M. might not only make good use of resources, but also enhance wheat yield.

Singh and Agarwal (2001) reported that the plant height dry matter accumulation, effective tillers, grains per spike, grain straw and biological yield increased significantly with the graded levels of FYM up to 20 t ha^{-1} but the response decreased with the increase of FYM from 20 to 30 t ha^{-1}.

Patil and Bhilare (2001) results showed that all treatments recorded significantly higher values for yield and yield components over the control. The 1/2 PMC + 1/2 FYM treatments recorded the highest values for plant height, number of tillers per plant, weight of grains per earhead, 1000-grain weight, grain yield, straw yield and protein content of grain.

Dikshit *et al*. (2001) observed that when the application of NPK recommended dose was associated with organic manures, higher yield levels were obtained. The highest grain yield, straw yield and energy yield were recorded in 100% NPK and compost treatment which accounted for the highest cost of cultivation but the highest gross returns.Maximum net profit and cost benefit ratio were achieved in NPK + FYM treated plot which indicated that economic yield can be obtained with integrated plant nutrient supply.

Babita *et al.* (2001) revealed that the application of higher level of fertility 150 kg N, 150 kg P_2O_5, 75 kg K to wheat crop gave the maximum grain and straw yield with significantly higher content of N, P in grains and straw and also significantly higher content of K and S in grain and straw were recorded under lower level of fertility (100 kg N, 50 kg P_2O_5) during both the years.

Chaudhary *et al.* (2001) reported that the highest grain yields were obtained with N at 90 kg ha^{-1} (3877 kg ha^{-1}) and 120 kg ha^{-1} (3871 kg ha^{-1}) + FYM on late sown wheat.

Rawat and Pareek (2003) reported that the yield and N, P, K content of wheat grain and straw increased with increasing rates of FYM and NPK uptake of the crop also increased with increasing rates of FYM and NPK. The treatments had no significant effects on the organic carbon and available N, P and K content in the soil at harvest.

Thakaral *et al.* (2003) revealed that recommended dose of N and P along with 5 t ha^{-1} of vermicompost produced highest grain yield but it was non significant during both the years. Yield improvement was attributed to the higher number of effective tillers, more number of grains per spike and bolder seeds of wheat crop under integrated nutrient supply system.

Singh *et al.* (2003) reported that Farm Yard Manure (FYM) resulted in the highest wheat yield. The application of FYM, Vermicompost or GM reduced the NPK rate by 1/3 without reducing wheat yield.

Agrawal *et al.* (2003) reported that treatment with 75% vermicompost+ 25% manure gave the significantly higher no of seed per spike, test weight, grain yield per plot and harvest index.

Maiti *et al.* (2003) revealed that the results confirm that favorable effects of NPK with Farm Yard Manure. Jan *et al.* (2003) to study the wheat sown after pearl millet was inferior in terms of emergence rate, number of plants per m^{-2} and spike emergence. The N fertilizer enhanced emergence. The legume residue (soybean) resulted in greater plant emergence per m^{-2} and taller plants, but delayed flowering. The results indicated the beneficial effect of leguminous residue, particularly soybean plant material on wheat production.

Singh and Agarwal (2004) observed that application of 10, 20 and 30 t FYM ha^{-1} enhanced the agronomic efficiency by 4.4, 7.1 and 7.9 kg grain added kg^{-1} N. Application of 10 t FYM ha^{-1} substituting 34.1 kg N requirement compared to without FYM.

Singh and Singh (2005) observed that the increase in the grain yield was 29.91, 18.81, 35.45 and 45.21 % owing to FYM application at 15 t ha^{-1} and vermicompost at 7.5, 10 and 15t ha^{-1} over no organic manure respectively. The harvest index was not influenced significantly by the application of organic manures since recommended dose of NWA applied to all plots including control, the incensement in grain yield owing to vermicompost decreased correspondingly with the decrease in the amount of vermicompost used.

Swarup and Yaduvanshi (2005) suggested that gypsum or FYM / press mud along with recommended dose of fertilizer must used to sustain the productivity of rice-wheat cropping system in areas having sodic ground water for irrigation.

Singh and Singh (2005) observed that the increase in the grain yield was 29.91, 18.82 and 35.45 and 45.21% sowing to FYM application at 15 t ha^{-1} and vermicompost at 7.5, 10 and 15 t ha^{-1} over no organic manure respectively. The harvest index was not influenced significantly by the application of organic manures. Since recommended dose of N was applied to all plots including control, the increment in grain yield owing to vermicompost decreased correspondingly with the decrease in the amount of vermicompost used. It means that the supply of nutrients to the crop, including phosphorus, potassium, zinc and other nutrients was a function of amount of vermicompost used.

Singh and Yadav (2006) found that with the application of 150 kg ha^{-1} N produced 34.9, 27.3 and 5.1% more spike m^{-1}, and 27.8, 26.7 and 8.0% more grain/spike than that of 0, 50, and 100 kg N ha^{-1} respectively.

Singh *et al*. (2006) observed that complete dose of NPK fertilizer with and without organic amendment increase or maintained the sustainability to rice-wheat cropping system. The residual effect of the organic materials application of rice on the succeeding wheat crop during all the years was positive and increase in wheat grain yield range from 4 to 8%.

Shah and Ahmad (2006) reported that integrated use of urea and FYM performed better than the use of urea of FYM alone in term of improving crop performance and grain yield of wheat despite the fact that the level of applied N was same i.e. 120 kg N ha^{-1} either alone from urea, FYM or combination of both the combination of inorganic (urea) and organic FYM at 75:75 or 50:50 ratio based on result and is therefore recommended for optimum wheat production.

Reddy *et al.* (2006) observed that the application of 50% inorganic + poultry manure @ 1 t ha^{-1} + Azospirillium resulted in higher grain yield, straw yield, number of effective tiller/unit area and grains per panicle in wheat.

Kumar *et al.* (2007) recorded higher yield of rice-wheat with the use of organic manure. They also reported that bio-fertilizer have added advantage in wheat production. Singh *et al.* (2007) observe that application of FYM to wheat significantly increased length of spike, grain weight per spike, test weight, grain and straw yield over the control.

Chaudhary *et al.* (2007) the field was conducted at Iglas, Aligarh, Uttar Pradesh, India. Treatment include combination of vermicompost and N at recommended (120 kg ha^{-1} as urea), half of recommended dose as urea or FYM (farm yard manure) and 100 kg N ha^{-1} as urea. Application of vermicompost at the rate of 10 t ha^{-1} 120 kg N ha^{-1} and Farmyard manure 15 t ha^{-1} + 120 kg N ha^{-1} increased the grain yield by 202.4 and 155.5% straw yield by 182.0 and 178.2% and biological yield by 190% and 184.7% respectively over control.

Behra *et al.* (2007) application of available organic sources, particularly FYM and poultry manure along with full recommended doses of NPK fertilizer to wheat was essential for improving productivity grain quality, profitability, soil health and sustainability.

Gupta and Sharma (2007) Observed that increasing fertilizer dose from 75 to 100% of recommended dose significantly increased yield attributes, such as spikes m^{-2} grains per spike, spike length and 1000-grains weight and grain and straw yields. However, upon further increase in the fertilizer dose 125% of recommended dose, the various yield attributes and grain and straw yield did not exhibit significant variation.

Mukherjee (2008) reported that the grain and biological yields of wheat increased significantly with the inclusion of bio fertilizers and maximum benefit was recorded with the combined application of the 3 sources.

Gowda *et al*. (2008) reported that the application of vermicompost @ 3.8 t ha^{-1} + poultry manure @ 2.45 t ha^{-1} recorded significantly higher plant height (86.30 cm), number of leaves (40.50) and higher number of tillers (94.60) at 90 DAS and it also recorded higher number of ear heads per meter square (160.10), 1000 seed weight (42.73 g) and seed yield (3043 kg ha^{-1}) seedling dry weight (311.27 mg) and protein content (13.41%) compared to other treatments. RDF also accounted at par yield and yield parameters with that of former treatment. Application of organic manures in combinations with each other recorded at par B: C ratio with that of RDF.

Gopinath *et al.* (2008) a transition period of at least two years is required for annual crops before the produce may be certified as organically grown. The purpose this study was to evaluate the effects the three organic amendments on yield of wheat. The organic amendments there composted FYM, vermicompost and lantana, compost applied to soil at four application rates 60 kg N ha^{-1}, 90 kg N ha^{-1}, 120 kg N ha^{-1} and 150 kg N ha^{-1}. The grain yield of wheat in all the treatments involving organic amendments was markedly lower (36.55% and 23.54%) less in the first and second year of transition respectively than with the mineral fertilizer treatment.

Dahiya *et al.* (2008) reported that integration of vermicompost or farm yard manure with chemical fertilizers exhibited beneficial effect on yield attributes and yield of wheat.

Pandey *et al.* (2009) reported that the application of FYM 10 t ha^{-1} with RDF produced similar grain yield (3.4-3.6 t ha^{-1}) as the yield obtained under 150% RDF alone (3.3-3.6 t ha^{-1}).

Pandey *et al.* (2009) reported that application of 150% RDF together with 10 tones FYM although produced maximum grain yield (3.8-3.9 t ha^{-1}), however, highest benefit: cost ratio (1.5-1.7) was obtained with 10 t FYM ha^{-1} together with RDF only. Addition of 10 t ha^{-1} FYM with fertilizers levels significantly increased the nutrient uptake by the crop, improved the organic carbon content, N, P and K status and significantly reduced the bulk density of the soil as compared to chemical fertilizer alone.

Shalaby *et al.* (2010) reported that a highly significant effect of application rates for compost on both grain and straw yield of wheat and weight of 1000 grains were obtained. The rate 10 ton compost ha^{-1} + 50% NPK showed the highest beneficial effect wherever, compost a surpassed the other compost B and C on the detrimental parameter. While the highest rate of compost (20 ton ha^{-1}) gave the lowest effect on plant growth and yield.

Hakeem *et al*. (2010) study on the Application of inorganic + organic sources increased plant height, no. of tillers, grain yields and test weight and showed marked response on grain yield and 1000 seed wheat.

Ghanshyam *et al*. (2010) to evaluate available N and P in soil after green gram harvest, increased significantly over no organic manure application of FYM and vermicompost in green gram. NPK uptake by green gram as well as succeeding wheat crop increased significantly with 9 kg P ha^{-1} over control. Application of 75% RDF (113, 20 and 40 kg ha^{-1} N, P and K) to wheat grown on residual fertility of manures and P applied to green gram, gave significantly higher productivity and net return of wheat as well as in green gram-wheat cropping system.

Tahir *et al*. (2011) to checks the results of this experiment indicate that organic matter along with recommended dose of synthetic fertilizers could be helpful in increasing the stagnant grain yield of wheat in our country.

Zahedifar *et al.* (2011) study was conducted to determine the number of tillers, grains/spike, spike-length, grain-yield, and 1000-grain weight increased with P and OM applications.

Singh *et al*. (2011) reported that the growth parameter viz. number of tillers $hill^{-1}$ and plant height significantly increased due to presence of nitrification inhibitors in nimco fertilizer, they slowly supplied nitrogen to plant and decreased the looses of nutrients resulting more nitrogen available to plant. Combined application of organic manures and inorganic fertilizers increased the dry matter accumulation, number of grains $spike^{-1}$, grain yield, straw yield and NPK uptake by wheat crop compare to treatment T_2 where full dose of NPK applied through urea, single superphosphate and manure of potash. Application of 50% N through nimco and 50% through Bhu amrit showed maximum number of tillers hill^{-1}, plant height, number of grains spike^{-1}, dry matter accumulation and test weight. The highest grain and straw yield of wheat to the extent of 44.9 and 69.56 q ha^{-1} respectively was obtained where recommended dose of nitrogen was applied in ratio of ½:$^1/_2$ through nimco and Bhu amrit, respectively.

Dadhich *et al.* (2011) a field experiment was conducted at Udaipur to study the direct effect of fertilizer P, FYM and biofertilizers alone and in combinations on soybean and their residual effect on subsequent wheat. Result obtained that the application of increasing levels of P, FYM and biofertilizers significantly enhanced the seed/grain yield of soybean and subsequent wheat.

Meena *et al*. (2012) reported that wheat crop also, integrated use of NPK and FYM (7.5 t ha^{-1}) gave significantly higher grain yield (5.23 t ha^{-1}) as compared with general recommended dose of NPK (4.28 t ha^{-1}). Conjoint use of fertilizer NPK and FYM, improved soil physical health as revealed by a significant decrease in soil bulk density (BD) and an increase in water holding capacity vis-à-vis sole fertilizer treatments or unfertilized control during the years of experimentation. Soil BD decreased from 1.50 Mg m^{-3} in NPK to 1.40 mg m^{-3} in NPK + FYM + ID plots. Water holding capacity increased from 36.1% in NPK to 39.4% in NPK + FYM plots. Among biological parameters of soil health, microbial biomass C, microbial biomass N (MBN) and de hydrogenise activity were measured, which varied from 178 to 373 mg kg^{-1}, 22.8 to 65.8 mg kg^{-1} and 43.7 to 61.0 µ TPF/24 h/g of soil, respectively in different treatments. In general highest values of these parameters were recorded in treatments that received NPK + FYM with or without ID.

Kumar and Pannu (2012) to study increase in dose of organic manures from 75 to 150 and 225 kg N ha^{-1} by any sources increased the grain yield of wheat significantly increased during both the year. The increase in level of poultry manure increased the N, P and K uptake from T_9 (80.5, 83.2, 18.9, 19.5, 81.0 and 81.7 kg ha^{-1}) and from T_{10} (93.2, 96.6, 21.6, 22.6, 89.0 and 90.4 kg ha^{-1}) in T_{11} treatment during both the years of study, respectively.

Davari *et al*. (2012) the results of this study show that VC+RR+B was the most productive treatment, while FYM+RR+B was the most economical treatment with respect to increasing net profit. This was because of the higher price of vermicompost compared with FYM. Both of these combinations resulted in improved grain quality and nutrient uptake by grain. The present study thus indicates that a combination of FYM+RR+bio fertilizers or VC+RR +bio fertilizers hold promise for organic wheat farming.

Ahmad *et al*. (2013) reported that the combinations of NPK+PM 50 kg ha^{-1} having high plant height (102.53) while number of (343) tillers ha^{-1} was obtained high in combination with NPK+ city compost 300 kg ha^{-1} which was at par with combination (NPK+ press mud 500 kg/acre) having plant height 100.90 Spike length, number of grains/spike, 1000 grains weight, grain yield t ha^{-1} was 13.35 cm, 61.85, 40.60 grams and 3.14 t ha^{-1} respectively, obtained in treatment (NPK+press mud 500 kg/acre). While minimum amount of plant height (94.80), number of tillers m^{-2} (223), spike length (10.35 cm), number of grains/ spike (43.43), 1000 grains weight (35.33 g), grain yield t ha^{-1} (38. 41) was found in control where no dose of organic and inorganic fertilizer were applied.

2.1.3 Effect on nutrient content uptake and quality

Jadhav *et al.* (1997) in a pot experiment on rice observed that dry matter production and uptake of the most major nutrients were highest from 75 kg N ha^{-1} as urea + 25 kg N ha^{-1} as vermicompost.

Prasad and Prasad (1998) reported that the major portion of the nutrients through organic sources and almost available to wheat, while the remaining will be available to succeeding crop in the cropping system. Sushila and Giri (2000) found that grain yield, quality and water use efficiency of wheat increased due to application of FYM. An application of FYM recorded the saving at 45 kg N ha^{-1}.

Kathuria *et al.* (2004) found that application of organic manure significant increased the content and uptake of N and P in wheat grain and straw significantly.

Singh *et al.* (2008) reported that application of FYM, vermicompost, green manuring and rice residue incorporation alone or in combination with bio-fertilizers supplemented by NPK fertilizers improved the soil fertility besides maintaining higher sustainable productivity.

Ibrahim (2008) to evaluate the partial replacement of N fertilizers by additional of equivalent level of organic fertilizers to wheat production could be a useful way to save the amount of irrigation water used in wheat production by prolonging the irrigation interval and enhancement of plant growth and increasing nutrients uptake by plants and to avoid nitrate leaching especially under sandy soils and consequently reducing pollution problems.

Verma and Mathur (2009) found that integrated use of FYM with chemical fertilizers or use of FYM alone exerted significant effect on the active pools of soil carbon. The C/N ratio was highly and significantly correlated with soil microbial biomass carbon, soil microbial biomass nitrogen, water soluble carbon, water soluble carbohydrates and dehydrogenise activity under maize crop.

Verma *et al.* (2010) significant improvement in the physico-chemcial properties of the soil was observed by the addition of FYM alone or in combination with inorganic over 100% NPK. Addition of organic matter through FYM alone or along with recommended dose of NPK further improved the properties of soil. The beneficial effects of fertilizers with FYM application on soil properties are due to incorporation of larger amount of plant residue through roots and stubbles due to better plant growth in the fertilizers and manures plot. However, when compared with initial status, significant decrease in bulk density, no change in pH and increase in EC and CEC.

2.2 Effect of inorganic fertilizers on wheat

The role of fertilizers in boosting crop production has already been proved and they have become so essential that the cultivation of present day wheat crop without them is rather a dream. Use of chemical fertilizers has increased the crop yield, but caused many environmental problems including soil, air and water pollution and finally human health hazards and making the crop productivity unsustainable (Eid *et al.* 2006). Fertilizers play vital role in production and productivity of any crop but continuous and imbalanced use of high analysis chemical fertilizers badly influences production potential and soil health use of chemical fertilizer in combination with organic manure is essentially required to improve the soil health (Bajpai *et al.* 2006). Behara (1995) reported that the use of optimum quantity of fertilizer and their suitable method of application are essential for improving the productivity level and finally the income. Behara *et al.* (2007) observed that the optimum dose of nutrients and their sours play an important role in increasing the productivity of these crops. Due to prolonged cultivation of crops with recommended dose of inorganic fertilizers alone, the productivity of soil has gone down and time has come to supplement their inorganic fertilizers with organics and micronutrient to sustain the fertility and productivity of the soils.

2.2.1 Effect on growth

Prasad *et al.* (1982) reported that increasing rate of N application from 150 to 170 kg ha^{-1} along with other nutrients significantly enhance the growth parameters viz., plant height, number of shoots and dry matter accumulation.

Singh and Brar (1994) found that the N application at 60, 90, 120 and 150 kg N ha^{-1} influenced growth as well as yield attributing characters significantly. All these characters except 1000 grain weight increased with each increment in nitrogen dose.

Pal *et al*. (1996) reported that leaf area index, dry matter accumulation and CGR increased significantly with recommended level of fertilizers (N_{100} P_{50} K_{25} kg ha^{-1}) over 50% of recommended fertilizers maintained 33-35% more green leaf area, dry matter accumulation at faster rate and produced 39% more at maturity that 50% of recommended level which accumulated dry matter at faster rate per unit leaf area, per unit time by reducing death of tillers and senescence of leaf.

Banga *et al.* (1996) reported that both N and P content in grain and straw improved with the addition of each fertilizer unit.

Kataria and Bassi (1997) recorded that the application of 120 kg N ha^{-1} to wheat crop produced significantly taller plants, more number of tillers and dry matter.

Azad and singh (1997) reported that grain yield increased with application of 100 kg N ha^{-1} and no significant further increase with 125 kg N ha^{-1} fertilizer application has always-beneficial effect on growth and development of plant.

Gwal *et al. (*1999) studied on a field experiment which conducted on Sehore, Madhya Pradesh, India to determine the effect of different levels of fertilizer on growth of late-sown wheat reported that, averaged over the cultivars, plant height, number of tillers $plant^{-1}$ increased with NPK rate.

Maqsood *et al.* (1999) reported that a field experiment which conducted at Faisalabad, Pakistan to determine the growth and yield response of wheat to N, P and K application in different combinations and resulted that the highest grain yield was achieved from plot fertilized at the rate of 140-75-50 kg NPK ha^{-1} which was significantly higher than control and other treatments.

Yadav *et al.* (2000) experiment conducted at Hissar and reported that the 75% of recommended N dose with bio-fertilizer gave similar yield to the recommended rate without bio-fertilizer inoculations of wheat.

Singh and Agarwal (2001) found that application of graded levels of nitrogen and recommended dose of N, P and Zn fertility significantly enhanced number of tillers at 45 days after sowing, plant height, dry matter accumulation, effective tillers per meter row length, grain per spike, straw and biological yield. Pandey *et al.* (2003) observed that plant height, effective tiller per meter row length, ear length, grain per ear, test weight, grain yield, straw yield, harvest index, grain protein content, net return and nitrogen uptake was highest with 180 kg N ha^{-1}.

Hussain *et al.* (2002) Investigations on the effect of three NPK levels (35-25-25, 70-50-50 and 105-75-75 kg ha^{-1}) on growth and quality of wheat cultivars, were carried out at Faisalabad, Pakistan. Different NPK levels significantly affected plant height, number of tillers.

Kumar and Arora (2003) studied at New Delhi, India and reported that the effects of N with or without P and K on the growth and spectral response of wheat were the normalized difference vegetation index (NDVI) increased up to 70-80 days after sowing then decreased thereafter. At 80 DAS, the highest NDVI was recorded for 125 kg N ha^{-1} without P and K; when P and K were supplied, NDVI was highest at 150 kg N ha^{-1}. The results suggest that 40-90 DAS may be the most suitable growth stage for spectral assessment in wheat.

Yadav *et al.* (2005) observed that plant height and effective tillers/m row increased significantly with each successive increment of N from 120 to 180 kg ha^{-1}. Effective tillers/m row length increased by 29.3% with 100 kg N ha^{-1} over 120 kg N ha^{-1}. This might be due to the fact that nitrogen plays a vital role in cell division and cell enlargement as well as increased sink size. Singh *et al*. (2006) reported that complete dose of N, P, K fertilizer with and without organic amendment increase or maintained the sustainability of rice-wheat cropping system. The residual effect of the organic materials application of rice on the succeeding wheat crop during all the years was positive and increase in wheat grain yield range from 4 to 8 per cent.

Jakhar *et al.* (2006) a study was conducted in Hisar, Haryana, India, during the rabi season to determine the effect Nitrogen on Crop physiological parameters and dry matter accumulation increased with the increasing nitrogen rate from 100 to 125 kg ha^{-1}. Treatment with 150 kg N ha^{-1} was statistically at par with 125 kg N ha^{-1}.

Shou *et al.* (2006) reported that a field experiment conducted at Yinchuan, Ningxia, China to determine the effect of NPK on wheat, the NPK application remarkably increased dry matter weight and NPK concentration and accumulation in the plants.

Singh and Yadav (2006) study that application of nitrogen significantly increase the growth parameters. 150 kg N ha^{-1} produced significantly taller plants and dry matter than all other treatments.

Laghari *et al.* (2010) field investigations were conducted at Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan and reported that Fertilizer application significantly enhanced growth of wheat. Application of 120-60-60 NPK kg ha^{-1} to TD-1 recorded maximum tillers, dry matter, leaf area index, crop growth rate and NPK uptake. Further increase in NPK rate had a non-significant response on these traits.

However, application of 180-60-60 NPK kg ha^{-1} or higher fertilizer regimes produced tall plants, maximum nodes $stem^{-1}$, internodes length, prolonged maturity days.

Rehman *et al.* (2010) reported that a field experiment which conducted at KPK Agricultural University, Peshawar, Pakistan to determine Phenology, leaf area index and of rain fed wheat influenced by organic and Inorganic fertilizer resulted different levels of NPK and FYM alone or in combination had significant effect on tillers m^{-2}, days to 50% heading, days to maturity, leaf area index, and plant height. Maximum tillers m^{-2} (330), days to 50% heading (117), days to maturity (151.1) and plant height (82.4) were recorded at 80-60-60 kg NPK ha^{-1}. Maximum leaf area index (2.50) was recorded at 80-60-30 kg ha^{-1}, while minimum leaf area index (2.23) was found at low level of 40-30-30 kg NPK ha^{-1}.

Bhaduri and Gautam (2012) found that highest grain and straw yield of 46.6 and 67.6 q ha^{-1} respectively were obtained at 200 kg N ha^{-1}. The higher magnitude of response up to 150 kg N ha^{-1} levels may be due to the favourable effect of N on plant vegetative growth. Application of P and K also had such type of effect on grain yield.

Ashutosh Barthwal *et al.* (2013) reported that at 90 days offer sowing NPK application at 170 N, 60 P_2O_5 and 120 K_2O kg ha^{-1} recorded the highest value of growth parameters. The magnitude of increase in plant height was 12.4 and 18.8%, number of shoots/m^2 was 17.8 and 18.4% and dry matter accumulation was 15.98 and 18.04% over farmer fertilizer practice (N_{120} + P_{40} + K_0) and recommended practice (N_{150} + P_{60}+K_{40}), respectively. Plant height, number of shoots/m^2 and dry matter accumulation was superior under higher dose of NPK due to better nutrient availability and reduced inter-plant competition in the community.

2.2.2 Effect on yield and yield attributes

Singh and Prasad (1998) showed that test weight of wheat was significantly increased with the application of 80 kg N ha^{-1}, while the grain yield increased by 24.9 and

47.4% by the application of 40 and 80 kg N ha $^{-1}$, respectively, Over control. Hasan and Kamal (1998) found that grain, straw yield and protein contents were higher in wheat with N in 4 splits + 10 t FYM. There is a positive effect of applying FYM and various amounts of N fertilizers on soil N balance, crude protein content.

Kumar *et al.* (1999) found that application of N at 0 to 180 kg N ha^{-1} increased plant height, length of spike, and 1000 grain weight and the entire attributes registered significantly higher yield.

Gwal *et al.* (1999) studied on a field experiment which conducted on Sehore, Madhya Pradesh, India to determine the effect of different levels of fertilizer on yield and quality of late-sown wheat reported that averaged over the cultivars, spike length, grain protein content increased with NPK rate.

Maqsood *et al.* (1999) reported that a field experiment which conducted at Faisalabad, Pakistan to determine the yield response of wheat to N, P and K application in different combinations and resulted that the highest grain yield was achieved from plot fertilized at the rate of 140-75-50 kg NPK ha^{-1} which was significantly higher than control and other treatments.

Singh and Singh (2000) studies the effect of potassium application in rice-wheat cropping system and reported that the highest value of yield attributes were recorded at K_{6o} irrespective of the K_o application in the two crops.

Sushila and Giri (2000) observed that application of nitrogen upto 90 kg ha^{-1} increased the grain yield significantly by increasing yield attributes, e.g. number of spike, length of spike, 1000- grain weight of wheat.

Kaur *et al.* (2001) from Ludhiana, Punjab reported that all yield attributes increased with increasing nitrogen rate except 1000 grain weight in 1998-99, nitrogen at 150, 180 and 210 kg ha^{-1} resulted significantly higher grain yield over 120, 150 and 180 kg ha^{-1}was superior over to 210 kg N ha^{-1}.

Shama and Vyas (2001) obtained that the significant improvement in effective tillers m^{-2}, ear length, 1000-grain weight and grain yield of wheat was found during residual effect of increased level of P fertilization at 90 kg P_2O_5 ha^{-1}.

Dikshit *et al.* (2001) observed that when the application of NPK recommended dose was associated with organic manures, higher yield levels were obtained. The highest grain yield, straw yield and energy yield were recorded in 100% NPK and compost treatment which accounted for the highest cost of cultivation but the highest gross returns. Maximum net profit and cost benefit ratio were achieved in NPK + FYM treated plot which indicated that economic yield can be obtained with integrated plant nutrient supply.

Sharma and Manohar (2002) reported that application of 120 kg N ha^{-1}enhanced the grain and straw yield of wheat by 63.5 and 30.1% respectively over 30 kg N ha^{-1}.

Maqsood and Ali (2002) observed that the application of N increased the yield and yield attributes of wheat, giving the highest no. of productivity tillers (871.73 m^2), number of grains per spike (44.28), 1000 grain weight (36.57 gm) when N was applied @ 160 kg ha^{-1}.

Hussain *et al.* (2002) investigations on the effect of three NPK levels (35-25-25, 70-50-50 and 105-75-75 kg ha^{-1}) on yield attributes of wheat cultivars, were carried out at Faisalabad, Pakistan. Different NPK levels significantly affected number of fertile tillers, 1000-grain weight, and grain protein content of wheat.

Panday *et al.* (2003) observed that plant height, effective tillers per metre row length, ear length, grain per ear, test weight, grain yield, straw yield, harvest index, grain protein content, net return and nitrogen uptake was highest with 180 kg N ha^{-1}.

Parihar (2004) reported that the yield attributing character like effective tillers/m row length increased significantly with application of 120 kg N ha^{-1}.

Pandey *et al.* (2004) showed significantly effect on growth characters is height of plant and number of tillers per plant at different growth stages and number of grain par ear and test weight of 1000 gain of harvest with addition of K. The yield significantly increased with increasing levels of potassium up to 60 kg K_2O ha^{-1}.

Ram *et al.* (2005) an experiment was conducted in Hissar, Hariyana, (India) during Rabi season and observed that the crop yield increased with increasing Nitrogen rates.

Yadav *et al.* (2005) reported that application of 150 kg and 180 kg N ha^{-1} was at par significantly increasing the grain yield. Hussain *et al.* (2005) reported that application of 150 kg and 180 kg N ha^{-1} was at par significantly increasing grain yield.

Kulkami *et al.* (2005) reported that significant increase in yield and straw yield were increased with application of potassium up to 120 kg K_2O ha^{-1} beyond this marginal decrease in yield. Yadav *et al.* (2005) reported that application of 150 kg and 180 kg N ha^{-1} was at par significantly increasing the grain yield.

Duhan *et al.* (2006) conducted a pot experiment and reported that the application of N significantly increased the wheat grain yield over the control and the extent of increase was 2.18 g pot^{-1} with 200 mg N kg^{-1} soil over the control. Kachroo and Razdan (2006) found that the increase in N levels lead to significant increase in yield attributing characters and grain yield in wheat.

Shukla *et al.* (2006) observed that the maximum grain yield of 38.48 and 40.28 q ha^{-1} was obtained with 180 kg N ha^{-1} which was at par with 150 kg N ha^{-1} (37.85 and 37.54 q ha^{-1}) and significantly higher than that of 120 kg N ha^{-1} (32.94 and 34.57 q ha^{-1}) during 1999-2000 and 2000-2001 respectively. A similar trend was also observed for straw yield. Number of ear heads/m^2 increased with increasing nitrogen up to 180 kg N ha^{-1}.

Singh and Yadav (2006) an experiment conducted at Faizabad (U.P.) observed that application of 150 kg N ha^{-1} increase the yield attributes and yield of wheat if increased the grain yield by 96.6, 65.0 and 37.7% compared to 0, 50 and 100 kg N ha^{-1}.

Singh (2006) observed that increase in the levels of NPK applied both to rice and wheat increased their grain and straw yield significantly. Giving the additional values at 150% recommended dose i.e. 6.42 and 3.38 q ha^{-1} compared with 100% NPK (34.67 and 41.18 q ha^{-1}) in rice and wheat respectively.

Deshmukh *et al.* (2007) reported that all the growth and yield attributing characters and straw yield and grain yield were significantly higher due to the application of 150 kg N ha^{-1} while it was at par with 120 kg N ha^{-1}.

Kumar *et al.* (2007) a field experiment was conducted in Varanasi, U.P. (India) during *rabi* season observed that N at 200 kg ha^{-1} gave the maximum number of spike-lets/ear, number of grains/ear, test weight, grain yield and straw yield.

Shirpurkar *et al.* (2007) a field experiment was conducted at the Niphad (India) reported that the grain and straw yield (13.29 and 27.65.q ha^{-1}) of wheat increased with significantly with the application of 80 kg N ha^{-1}. It might be reduce to significantly highest number of ear heads/m^2 (196.08) and number of grains per ear head (32.41).

Gupta *et al.* (2007) observed that increasing fertilizer dose from 75 to 100% of recommended dose significantly increased yield attributes, such as spikes/m^2, grain per spike, spike length and 1000 – grain weight and grain and straw yields. However, upon further increase in the fertilizer dose 125% of recommended dose, the various yield attributes and grain and straw yield did not exhibit significantly variation.

Kumar *et al.* (2007) observed that N at 200 kg ha^{-1} gave the maximum number of spike-lets/ear, number of grains/ear, test weight, grain yield and straw yield. Alam and

Sinha (2008) reported that optimum nitrogen doses l50 kg N ha^{-1} for maximum yield and yield attributing characters in wheat.

Panchal *et al.* (2008) observed that crop fertilized with 160 kg N ha^{-1} yield significantly higher grain yield than 120 kg N ha^{-1}, but it was at par with 140 kg N ha^{-1}. Kazemeini *et al.* (2008) reported that nitrogen level from 0 to 40 and 40 to 80 kg ha^{-1} wheat yield increase significantly number of spikes/m^2 increased significantly only when nitrogen level was increased from 0 to 80 kg ha^{-1}.

Srivastava *et al.* (2008) reported that a field experiment was conducted at Banaras Hindu University, Varanasi, India to assess the effect of organic manures (FYM, green leaf manure cleric and biogas slurry) under various fertility levels on yield of wheat crop.

Choudhary *et al.* (2009) reported that a field experiment conducted on a western Himalayan soils to study the effect of organic manures and inorganic fertilizers on productivity, nutrient uptake and soil fertility in rice (*Oryza sativa)*-wheat (*Triticum aestivum* L.) crop sequence in western Himalayas and resulted in consistent and significant improvement in grain yield of wheat with increase in fertilizer levels with significantly highest grain yield in wheat (4.89 t ha^{-1}) in FYM supplied plots @ 10 t ha^{-1}+150% NPK dose.

Gupta *et al.* (2009) results indicated that increasing nitrogen levels from 120 to 150 kg ha^{-1} significantly increased ear heads/m^2 and the mean grain (40.04 q ha^{-1}) and straw (124.4 q ha^{-1}) yield and further increase in nitrogen level to 180 kg ha^{-1} decreased the ear heads/m^2 and grain yield. Application of 150 Kg N ha^{-1} showed mean increase of 16% in grain yield over 120 kg N ha^{-1}.

Pareta *et al.* (2009) reported that maximum grain and straw yield (45.03 and 58.54 q ha^{-1}) were observed with the 140 kg N ha^{-1} in wheat.

Polara *et al.* (2009) a pot experiment conducted under net house condition to study the effect of four level of potassium K_o, K_{6o}, K_{90}, and K_{120} kg ha^{-1} on grain yield. The grain yield of wheat was significantly increased due to application of potassium up to K_{90} treatment and further it was decreased with increased in level of K.

Barar *et al.* (2009) reported that the grain yield of wheat crop increased significantly with the application of phosphorus, by increasing the dose of phosphorus additional grain yield to the tune of 2.7 and 3.2 q ha^{-1} were achieved at PAU Farm and farmers field respectively.

Laghari *et al.* (2010) field investigations were conducted at Department of Agronomy, Sindh Agriculture University, Tandojam, Pakistan and reported that Fertilizer application significantly enhanced yield components of wheat. Application of 120-60-60 NPK kg ha^{-1} to TD-1 recorded spike length, grains $spike^{-1}$, biological yield, grain yield, harvest index, and NPK uptake. Further increase in NPK rate had a non-significant response on these traits.

Rahim *et al.* (2010) reported that fertilizer P doses 0, 47, 81 and 111 kg P_2O_5 ha^{-1} were calculated by using adsorption isotherms and applied by broadcast and band placement. Wheat grain yield increased from 1.58 mg ha^{-1} to 3.94 mg ha^{-1} with the use of P @ 81 kg P_2O_5 ha^{-1}.

Rehman *et al.* (2010) reported that a field experiment which conducted at NPK Agricultural University, Peshawar, Pakistan to determine Phenology, and grain yield of rain fed wheat influenced by organic and Inorganic fertilizer resulted different levels of NPK and FYM alone or in combination had significant effect on grain yield. Maximum grain yields (2505 kg ha^{-1}) were recorded at 80-60-60 kg NPK ha^{-1}. However, maximum grain yield was recorded at 80-60-60 kg NPK ha^{-1} and 30t FYM ha^{-1}.

Singh *et al.* (2010) reported that a field experiment was conducted at NDUA&T, Kumarganj, Faizabad, during *rabi* season to study the effect of irrigation levels and fertility sources on grain yield. The highest grain and straw yield was obtained under 100% RD of NPK (F_1) through fertilizer which was found significantly superior over other sources of fertility.

Khan *et al.* (2011) reported that application of P had a positive influence on growth and grain yield of wheat. However the maximum growth and yield wheat was recorded at 120 kg ha^{-1} P_2O_5 application.

2.2.3 Effect on nutrient content, uptake and quality

Robinson et al. (1992) reported that the nutrient present in vermicompost and readily available to the plants. P uptake by plant is enhanced due to increase in phosphate activity induced by earthworms. Vermicompost was beneficial for sugarcane yield also.

Banga *et al.* (1996) reported that both nitrogen and phosphorus contents in grain and straw were improved with the addition of each fertilizer dose. However uptake both in grain and straw increased significantly only upto 120 kg N + 60 kg P_20_5 ha^{-1}.

Laxminarayana and Patiram (2006) reported that application N, P and K either alone or in combination and graded doses of N, P and K recorded significantly higher uptake of N, P and K in rice over that of control. Gupta *et al.* (2007) found that nutrient uptake (except P uptake) in wheat increased significantly with increase in fertility level from 75 to 100% of recommended fertilizer dose. Further increase in fertility level to 125% of recommended fertilized dose could not being about significant increase in N, P and K uptake. The increase in nutrient content was in consonance with higher grain and biological yields and increase in nutrient content in plant tissue with increase in fertility levels.

Pandey *et al.* (2009) observed that uptake of N, P and K increased with progressive increase in the supply of N, P and K nutrients to the crop. Probably because of high available of these nutrients and higher grain and straw yield at higher fertility levels.

Application of FYM with fertilizer levels significantly increases the NPK uptake by the crop than the application of fertilizer alone.

Bhaduri and Gautam (2012) reported that nitrogen application of 150 to 200 kg ha^{-1} increased the uptake from 112.3 to 130.4 kg ha^{-1}. However, for the production of grain yield higher uptake of N was useful only up to 150 kg N ha^{-1} and the rest could have been used for the vegetative growth.

Jat *et al.* (2013) found that the maximum uptake of N, K, S and Zn in wheat was recorded at 9 kg Zn ha^{-1}. Uptake of N, S, K and Zn in wheat grain was 49.3, 50, 51.4 and 53.7% higher and in straw was 44.08, 50, 41.8 and 48.2% higher under 9 kg Zn ha^{-1} over control, respectively. Significantly response of wheat to Zn by the application of 9 kg Zn ha^{-1} could be directly attributed to an enhanced availability of Zn ha^{-1} could be directly attributed to an enhanced availability of Zn in soil at a level below where the optimum requirement of crop is fulfilled. This showed that enhancement in Zn levels not only increased the yields but also increased the nutrient concentration and ultimately their uptake.

Ashutosh Barthwal *et al.* (2013) reported that application of NPK at 170, 60 and 120 kg N, P_2O_5 and K_2O ha^{-1} resulted in more uptake of N, P and K. This may be attributed to increased grain and straw yield of crop and their respective nutrient contents owing to increased availability of nutrients to the crop as a result of improved soil fertility.

2.3 Effect of various organic and inorganic sources on nutrient content and uptake of wheat.

Singh (1999) reported that the wheat cv. VL421 was given 0, 5 or 10 t farmyard manure (FYM) ha^{-1} or 40 kg N ha^{-1}, 80:60 kg NP ha^{-1} or 40:30:30 or 60:30:30 kg NPK ha^{-1}. Yield and N, P and K uptake increased with increasing rates of FYM. Yield was highest with NPK among the inorganic treatments.

Singh *et al*. (2002) reported that the effect of organic and inorganic N sources on the quality of wheat (UP2338) and soil nutrient balance. Treatments comprised farmyard manure (0, 10, 20 and 30 t ha^{-1}) in the main plots and N fertilizers (0, 60, 120 and 180 kg ha^{-1}) and a recommended fertilizer (120 kg N+ 26.2 kg ZnSO4 ha^{-1}) in the subplots, farmyard manure at 10 t ha^{-1} with the recommended fertilizer or 20 t farmyard manure + 120 kg N ha^{-1} enhanced grain yield, improved grain quality, and resulted in a positive soil nutrient balance after 2 crop cycles.

Agarwal *et al.* (2003) resulted that treatment with 75% vermicompost + 25% farmyard manure gave the greatest plant height at 105 days after sowing (DAS), and also leaf attributes number at 90 DAS, dry weight at 105 DAS and number of seeds per spike, test weight grain yield per plot and harvest index at 105 DAS.

Khalil *et al*. (2004) results revealed that all manure treatments whether combined with or without bio fertilizers led to a significant increase in wheat dry weights. The weight of the plants grown on a clay soil was higher than that grown on sandy or calcareous soils. The response of wheat to organic manure treatments was more pronounced in sandy and calcareous soils than in the clay one. Although N, P and K contents of wheat were higher in the clay soil, yet the response to organic manuring was more obvious in sandy and calcareous soils.

Kathuria *et al.* (2004) the organic manures significantly increased the content and uptake of N and P in grain and straw. In both years, the highest N contents of grain and straw were obtained with 160 kg N ha^{-1} and 100% NPK on soil test basis, whereas the highest P contents of grain and straw were obtained with 120 kg ha^{-1}, 160 kg N ha^{-1}, 90 kg ha^{-1} + Azotobacter and 100% NPK on soil test basis. N and P uptake by grain and straw increased with the increased in the N fertilizer rate, and with the application of 90 kg ha^{-1} + Azotobacter and 100% NPK on soil test basis.

Sharma *et al.* (2005) reported that the highest grain, straw and biological yields of wheat and maximum nutrient uptake were recorded when lantana Vermicompost along with 67 and 100% recommended dose of fertilizers (120, 60 and 30 kg ha^{-1} NPK) was applied. Hence, 67% of recommended dose of NPK along with lantana vermicompost at 10 tones ha^{-1} was considered to be best treatment. Among organic manures lantana vermicompost was found to be superior over carrot grass vermin compost followed by farm yard manure in increasing the nutrient uptake and wheat yield.

Singh and Singh (2005) reported that the application of all organic manures significantly increased the uptake of N, P and K in grain and straw and their total uptake, grain and straw yields and protein content in grain over the no organic manure treatment during both years. Among various organic sources, FYM at 15 t ha^{-1} recorded the highest N, P and K uptake in straw yield and protein content in grain. Application of recommended dose of fertilizer resulted in the maximum total uptake of N, P and K grain and straw yields and protein content in grain which was significantly higher over no fertilizer, 25 , 50 and 75% of the recommended dose of fertilizers .

Chaturvedi (2006) the data revealed that the analysis for respective years of experimentation further revealed that the maximum plant height (91.9 cm), total number of tillers m^{-2} (1798), leaf number m^{-2} (1070), leaf weight (275 g m^{-2}), leaf area index (2.48), dry matter accumulation (18.34 tones ha^{-1}), number of grains per spike (47.5), 1000 grain-weight (45.2 g), seed yield (5.05 tones ha^{-1}), straw yield (7.0 tones ha^{-1}) and N, P and K uptake (49.3, 7.2 and 50.1 kg ha^{-1}), were recorded in the plots receiving phosphorus in combination with phosphate-solubilising bacteria (P. strata) and farmyard manure indicating that the combined application of phosphorus and farmyard manure with phosphorus-solubilising bacteria had highest degree of influence on growth, yield and nutrients uptake of wheat thus emphasizing the need for P application in conjunction with solubilise and organic source (farmyard manure) to wheat and other crops.

Stalenga (2007) to determine the nitrogen (N) and potassium (K) nutrient status of wheat cultivated in the organic system was lower compared with the other farming systems. Assuring sufficient supply of nitrogen to cereals under the conditions of organic farming is particularly difficult in early growth stages. In the integrated and conventional systems wheat was sufficiently supplied with NPK. Cobra cv. proved to be more adapted to the organic system than the other cultivar. Results indicate that classical nutrient status indices are of lesser use for organic farming.

Thakral and Madan (2008) reported that different organic and inorganic sources of wheat nutrition.The experiment comprised four treatments, application of recommended dose of nitrogen through inorganic sources proved best with 11.84% protein content in grain. Maximum nitrogen content in grain (1.82%) was recorded with recommended dose of nitrogen through inorganic source during all the years under study. The N, P and K uptake in grain and straw was highest, when nitrogen was applied through inorganic sources in comparison to organic source.

Kajla *et al*. (2008) the results showed that the application of recommended dose of nitrogen fertilizer through inorganic sources proved to be the best with 11.94% protein content in the grains. The N, P, K uptake in grains and straw was highest when the recommended dose of N fertilizer through inorganic sources was applied.

Maitra *et al.* (2008) reported that the increase in N, P and K uptake with 60 kg P_2O_5 ha^{-1} were 20.5, 44.0 and 54.9% respectively, over the P treatment. Grain and straw yield of wheat increased significantly with farmyard manure at 5 and 7.5 t ha^{-1} applied in sun hemp over the FYM treatment, although the yield recorded with 5 and 7.5 t FYM ha^{-1} were at par. The increase in grain and straw yield less than 5 t FYM ha^{-1} was 6.60 and

14.05 respectively. A combined dose of 60 kg P_2O_5 with 7.5 t FYM ha^{-1} applied in sun hemp recorded the highest grain yield of wheat (4.55 t ha^{-1}), which was 21.3% higher than that without P and FYM. The N, P and K uptake by wheat increased significantly due to the residual effect of FYM and P applied in sun hemp crop. The application of P and FYM had significantly improved the organic carbon and available N, P and K status in post harvest soil after 2 years of cropping.

Nitika *et al.* (2008) the results of study revealed that nutrient composition of both organic and inorganic wheat varieties is comparable and protein digestibility is higher in wheat varieties grown under organic conditions. The people of North India, where wheat is a staple cereal, can therefore be encouraged to use organically grown wheat varieties as they are free from hazardous effects of synthetic pesticides fertilizers. Mandal *et al.* (2009) the results indicate that in the background of long-term fertility management regimes, crop growth (rhizospheric feed back) stages have significant impact on the nutrient dynamics in soil and nutrient concentration in growing plants.

Randhe *et al.* (2010) to study Nitrogen, phosphorus and potassium uptake were significantly increased in grains and straw with the incorporation of organic and inorganic fertilization. The N, P and K increased with increasing levels of recommended dose of fertilizer. Maximum nutrients uptake (192.30 kg N, 20.65 kg P and 176.99 kg K ha^{-1}) was observed with the application of 100% RDF. Among organic manures, 125% recommended N through vermicompost (16.48t ha^{-1}) influenced significantly uptake of nitrogen, phosphorus and potassium, maximum being 165.99 kg N, 18.29 kg P and 157.68 kg K ha^{-1} respectively.

Singh and Kumar (2010) reported that the treatment 75% NPK+ vermicompost at 3 t ha^{-1} + foliar spray of $ZnSO_4$ (0.5%) at 30 DAS and other treatment 75% NPK+ FYM at 10 t ha^{-1} + foliar spray of $ZnSO_4$ (O.5%) at 30 DAS observed highest values for the growth, yield and quality parameters as well as for the nutrient content and uptake of wheat.

Zahedifar *et al*. (2011) the results confirmed that wheat-plants required much more P at early stages. The tentative conclusion is that flag-leaf P analysis, instead of stem, may be used to evaluate the nutritional status of winter wheat.

Akhtar *et al*. (2011) reported that the use of NEC (200 mg kg^{-1} soil) for wheat production could be a useful tool to improve the efficiency of commercial N- fertilizer.

Singh *et al.* (2013) reported that the maximum protein content was observed under the recommended dose of nitrogen through inorganic source which was at par with inorganic source based on soil test value.

2.4 Integrated Nutrient Management in Wheat

Modern agriculture largely depends on the use of high input technologies viz., high yielding varieties, chemical fertilizers, pesticides, herbicides and labour saving but energy intensive farm machinery. Although high input chemical agriculture has certainly resulted in spectacular gains in productivity, it has degraded some of the natural bases on which this system rests. Heavy withdrawal of nutrients from the soil is one of such problems. The fertilizer use is not only inadequate but also highly imbalanced because of fertilizer to be used by an average Indian farmer depends on its availability and price and is rarely decided by local recommendation or soil tests. Under present day situation it is not possible to completely revert back to organic farming but integrated use of organic manures and fertilizers has been found to be promising not only in maintaining higher productivity but also for providing mobility in crop production Lal and Mathur, 1988.

Yadav *et al.* (2003) reported that integration of farm yard manure (FYM) along with chemical nitrogen significantly increased the yield of wheat as well as of succeeding green gram. Kumar *et al*. (2005) field studies indicated that application of FYM, green manure, crop residues, bio-fertilizers and other wastes either alone or along with inorganic fertilizers enhanced the organic carbon and other plant nutrients in soil.

Jat *et al.* (2006) found that integrated nutrient management aims and improved the physical, chemical and biological health of soil and enhances the availability of both applied and native soil nutrients during growing season of the crops.

Verma *et al*. (2010) reported that application of 20 t FYM ha^{-1} and combined use of NPK and 10 t FYM ha^{-1} recorded significant differences in the soil properties.

Mubarak and Singh (2011) observed that combined application of recommended fertilizer dose, farmyard manure 15 t ha^{-1} and bio-fertilizer significantly improved wheat yield and soil nutrient status. Increase over the alone application of chemical fertilizer during 2004-05 and 2005-06 respectively. Wheat yield and nitrogen uptake showed significant increase when grown after pulses. Integrated nutrient management is very essential which not only sustains high crop production over the years but also improved soil health and ensures safe environment.

2.4.1 Effect on growth

Nambiar and Abrd (1992). The major components of integrated nutrient supply system are fertilizer, FYM, compost, crop residues, farm or industrial wastes such as rice or wheat straw, rice husk, sugarcane trash etc. and bio-fertilizers like *Azotobacter, Rhizobium* and blur green algae. Gill *et al*. (1994) showed a positive response of wheat to applied N in combination of FYM.

Rao *et al*. (1998) found that integrated use of 16 t FYM (to soybean) + 44 kg P ha^{-1} (to both wheat and soybean) produced the maximum wheat grain yield. In combination with FYM fertilizer P recovery was greater at all increasing rates compared with those of no manure.

Hati *et al*. (2000) found that grain yield increased significantly with integrated application of fertilizer and organic manure (FYM) upto 138.5 and 123% by recommended dose of NPK + FYM @ 10 t ha^{-1} over the control, respectively. The combined use of inorganic and organic manure enhanced the inherent nutrient supplying capacity of soil.

Patil and Bhilare (2001) showed that all treatments recorded significant higher values for growth and yield component over the control the ½ PMC + ½ FYM treatments recorded the highest values for plant height, number of tiller per plant, weight of grain per year head, 1000- grain weight, yield, straw yield and protein content of grain.

Thakaral *et al.* (2003) Revealed that recommended dose of N and P_2O_5 along with 5 ton ha^{-1} of vermicompost produced highest grain yield but it was non significant during both the year, yield improvement was attribute to the higher no of effective tiller, plant height more no of grain per spike and bolder seed of wheat crop under integrated nutrient supply system.

Upadhyay *et al.* (2004) reported that application of biodynamic product CPP improved the soil fertility, percent organic carbon, available phosphorus and available potassium were increased by 0.04%, 41.2 kg and 8.2 kg ha^{-1} respectively.

Singh *et al.* (2006) observed that all the growth and yield parameters improved significantly due to Integrated Nutrient Management practice treatment over the rest of treatments. integrated use of inorganic fertilizer either 25% or 59% of RDF through FYM, press a mud and packing straw and the rest RDF through inorganic fertilizer give significantly increased plant height, dry matter, high grain and straw yields of both rice and wheat over 75% of RDF through organic sources and 25% RDF through inorganic fertilizer. The maximum grain yield (3.67 t ha^{-1}) and straw yield (5.24 t ha^{-1}) were produced in the higher level of nitrogen (120 kg ha^{-1}). The grain yield being the function of cumulative effect of yield attributes increased significantly by 0.31 t ha^{-1} due to additional application of 60 kg N ha^{-1}. The increase in yield attributes might be ascribed to supply of nitrogen at higher level, resulting into increased photosynthetic activities and translocation of photosynthetic, which promote the growth, better partitioning of photosynthetic in yield attributes and eventually produced more yield (Sen *et al.* 2003).

Sharma *et al.* (2007) reported that application of 187.5 kg N ha^{-1} + FYM 10 t ha^{-1} + *Azotobactor* recorded significantly more plant height. The enhancement in growth with increase in fertility was owing to rapid conversion of synthesized photosynthates into protein to form more protoplasm, thus increasing the number and size of cell which might have increased the plant height.

Verma *et al.* (2009) reported that application of FYM alone or in combination with chemical fertilizers (which were at par with each other) increased soil organic content after harvest of maize and wheat crops. Reason attributed is the direct incorporation of organic matter, better root growth and more plant residues addition after harvest of crops.

Singh and Pal (2011) found that the tallest plant were observed at application of RDF + FYM seed treatment with *Azotobactor*, followed by 75% RDF + FYM seed treatment with *Azotobactor* during both years. The plant height was increased by application FYM and seed treatment with *Azotobactor* along with chemical fertilizers. Total plant dry matter accumulation was recorded significantly highest at integrated application of RDF + FYM Seed treatment with *Azotobacto*r during both years but it was found at par with 75% RDF + FYM Seed treatment with *Azotobactor*.

Usadadiya and Patel (2013) reported that application of 120 kg N ha^{-1} showed its significant superiority over lower level of nitrogen, it has recorded significantly the higher plant height, number of effective tillers, grains per spike, test weight, chlorophyll content in leaves and protein content in grain and the harvest index as compared to 60 kg N ha^{-1}.

2.4.2 Effect on yield and yield attributes

Banwasi and Bajpai (2001) observed that 50, 75 and 100 percent of the recommended NPK rate (100:50:30 kg ha^{-1}) were used and highest yield of wheat were obtained with the 100% NPK. Jadho *et al.* (2001) a field experiment was conducted in

Akola, Maharashtra observed that 100% recommended dose of NPK to wheat resulted in the highest yield of Sorghum-wheat cropping system (67.05 q ha^{-1}).

Bhagat (2001) observed that highest yield of wheat (34.56 q ha^{-1}) were obtained with the treatment 50% NPK + 50% FYM in Groundnut-wheat cropping system. Pandey *et al.* (2004) reported that application of 150, 75, 50 kg N, P and K ha^{-1} recorded significantly higher values of yield attributing characters, grain and straw yield by the crop than the lower levels of fertilizer.

Singh *et al.* (2005) reported that grain yield of wheat *(Triticum aestivum* L.*)* was significantly higher under various organic manure (FYM, pressmud, vermicompost and green manures) than no organic manure applied to the proceeding kharif fodder crop. Application of 100% NPK on soil test basis, being at par with 120 and 160 kg N ha^{-1} produced significantly higher grain yield of wheat than the control.

Kathuria *et al.* (2005) revealed that grain yield of wheat *(Triticum aestiuum* L.*)* was significantly higher under various organic manures (FYM, green manure, press mud and vermicompost). Application of 100% NPK on soil test basis, being at par with 120 and 160 kg N ha^{-1} produced significantly highest grain yield of wheat than the control (no fertilizer), 60 kg N ha^{-1} and 90 kg N ha^{-1} + Azotobacter.

Bindia *et al.* (2005) reported that grain and straw yields increases with biofertilizer inoculation and application of FYM and N fertilizer, grain yields obtained with 75% of the recommended N rate FYM (32 q ha^{-1}) or biofertilizer (29.71 q ha^{-1}) and 100% of the recommended N rate (29.76 q ha^{-1}) were on at par, sustaining that the application of biofertilizers or FYM could reduce the N fertilizer rates by 25%.

Kumar *et al.* (2005) reported 100% NPK (120 kg N + 26.2 kg P + 49.8 kg K ha^{-1}) with farm yard manure 10 t ha^{-1} increase the yield attributes and yield wheat.

Sharma and Sharma (2006) reported that integrated nutrient management involving FYM and NPK fertilizer is a must for the sustainability of cropping system. Tulasa and Mir (2006) observed that the application of 10 t FYM + 120 kg N ha^{-1} significantly increased plant height, effective tillers/m row length, number grains per spike, grain and straw yields over the control and 10 t FYM + 100 kg N ha^{-1} in wheat.

Kamla *at el.* (2006) field experiments were conducted in Dhaulakuan, Himachal Pradesh, India, during the 2003-04 and 2004-05 cropping seasons, to monitor the combined use of green manures, crop residues, compost and fertilizers on the yield and N uptake in a rice-wheat cropping system.

Behar *et al.* (2007) found that application of available organic sources, particularly FYM and poultry manure along with full recommended doses of NPK fertilizer to wheat was essential for improving productivity, grain quality, profitability, soil health and sustainability.

Sharma *et al*. (2007) observed that application of 187.5 kg N ha^{-1} + FYM 10 t ha^{-1} and 150 kg N ha^{-1} + FYM 10 t ha^{-1} + Azosprillium recorded significantly higher grain and straw yields.

Mamta *et al.* (2007) was reported through a field experiment which was conducted at Hisar, Haryana, India, to determine the effects of organic and inorganic fertilizers on the growth and yield of wheat. The highest values for yield, leaf area index, crop growth rate and relative growth rate were recorded in the treatment with the recommended dose of N through inorganic source. The minimum values were observed in the treatment where the recommended dose of N through organic source was applied.

Muhammad *et al.* (2008) the impact of organic manure and compost on productivity of wheat (*Triticum aestivum* L.) was investigated in sandy clay loam soil. The amounts of various organic manures to supplement the inorganic fertilizers must be optimized to increase crop yield. Changes in growth and yield parameters of wheat relative to inorganically fertilized controls were measured. Organic amendments had positive but variable effects. The organic manures application increased the wheat yield by 11.13 (105%) to 13.53 (128%) g pot^{-1}, relative to the control. The wheat plant height, number of tillers, spike length, straw yield, grain yield and 1000-grain weight all were statistically different from that of control.

Billore *et al.* (2009) the results occurred revealed that the integrating poultry manure @ 2.5 t ha^{-1} followed by farm yard manure @ 5 t ha^{-1} with recommended 50% of the recommended dose of fertilizers improved the yield of wheat.

Lakhdar *et al.* (2009) observed that the risks related to municipal solid waste compost application in comparison to farmyard manure and mineral fertilizers on durum wheat were investigated on a short-term experiment. Compost was applied at 40 t ha^{-1} and 80 t ha^{-1} with or without chemical fertilizers. Analogously, farmyard manure was applied at 40 t ha^{-1}. Both compost and farmyard manure improved plant growth and nutrient uptake. Pandey *et al.* (2009) reported that application of FYM and FYM at varying fertility levels produced significantly higher values for yield attributing characters, i.e. effective tillers per meter row length, number of grain per ear heads and test weight in both the years than the application of chemical fertilizers alone. Application of FYM with 150% RDF recorded higher values of yield indices and was found to be at par with the application of FYM with 125% RDF and significantly surpassed over RDF with FYM.

Rathor and Sharma (2010) reported that the significant improvement sowing to appropriate combination of NPK, VC, FYM, Zn and PSB was observed for the nutrient uptake by the crop and the maximum nutrient uptake was noticed due to 100% RDF of NPK+VC+Zn+PSB and minimum with control.

Rehman *et al.* (2010) reported that a field experiment which conducted at KVK Agricultural University, Peshawar, Pakistan to determine Phenology, leaf area index and of rain fed wheat influenced by organic and Inorganic fertilizer resulted different levels of NPK and FYM alone or in combination had significant effect on tillers m^{-2}, days to 50% heading, days to maturity, leaf area index, and plant height. Maximum tillers m^{-2} (330), days to 50 % heading (117), days to maturity (151.1), and plant height (82.4) were recorded at 80-60-60 kg NPK ha^{-1}. Maximum leaf area index (2.50) was recorded at 80-60-30 kg ha^{-1}, while minimum leaf area index (2.23) was found at low level of 40-30-30 kg NPK ha^{-1}.

Shalaby *et al.* (2010) reported that the effect of compost and mineral fertilizers on yield and nutrients uptake by wheat plant. The experiment included three main plots as type of rice straw and maize stalk with different activators, compost (farmyard manure) and (mineral activator). Five sub plots were fertilization treatments (100% recommended NPK, 5 ton compost/fed+75% recommended NPK, 10 ton compost/fed+50% recommended NPK, 15 ton compost/fed+25recommended NPK and 20 ton compost/fed). A highly significant effect of application rates for each compost on both grain and straw yield of wheat and weight of 1000 grains were obtained grain surpassed that straw.

Singh *et al.* (2010) reported that a field experiment was conducted at NDUA&T, Kumarganj, Faizabad, during *rabi* season to study the effect of irrigation levels and fertility sources on yield attributes. The 100% RDF of NPK through fertilizers recorded significantly higher spikelet's $spike^{-1}$, spike length, grains $spike^{-1}$, over F_3 and F_4 and it was statistically on par with 75% RD of NPK (F_2) through fertilizers +25 % RDF through FYM.

Sepat *el al.* (2010) revealed that treatment where RDF was applied in combination with FYM, bio-fertilizers produced the highest grain yield. This was closely followed by treatment receiving 75% RDF + FYM + Bio-fertilizer +INM (RDF + FYM + Bio-fertilizer) on average gave 23% higher grain yield than RDF alone showing the beneficial effect of combined use of fertilizers with FYM and bio-fertilizers.

Meena *et al.* (2012) reported that the treatment where recommended dose of fertilizers (RDF) were applied in combination with FYM, bio-fertilizers produced the highest grain yield of 50.39 and 52.73 q ha^{-1} during 2007-08 and 2008-09, respectively. The treatment was followed by the treatment receiving RDF + FYM + BF during 2007-08 which recorded grain yield of 49.28 q ha^{-1} and application of RDF + FYM during 2008-09 i.e 51.22 q ha^{-1} during both the years of study, the treatments RDF + FYM and RDF + FYM + BF were statistically at par with RDF + FYM + BF also produced significantly at par grain yield during 2008-09 to the RDF + FYM + BF.

Agamy *et al.* (2012) reported that a field experiment was conducted at the Experimental Farm of Faculty of Agriculture, Fayoum University to study the effect of the application of biofertilizers farm yard manure and mineral fertilizer (NPK) singly or in combination on yield, anatomical structure and physiological analysis of wheat plant. The results showed that, the application of Bio-fertilizer and FM in combination with NPK significantly increased the growth characters were reflected in yield.

Singhal *et al.* (2012) conducted with integrated nutrient management on wheat at IARI research farm New Delhi. Grain yield of wheat with 50% NPK fertilizer + NPK enriched compost was significantly higher than that of 100% NPK fertilizer, it was at par with 50% NPK fertilizer + NP enriched compost. The treatment 50% NPK fertilizer along with NPK enriched compost recorded maximum N uptake (105.0 kg ha^{-1}). A better correlation was observed between amino sugar-N with grain yield N uptake by wheat.

2.4.3 Effect on nutrient content, uptake and quality

Kumar and Yadav (1995) showed that manuring with FYM increased the NPK uptake by grain and straw of wheat. A small amount of nutrient substituted by the organic source proved to be beneficial for plant growth. FYM applied with chemical fertilizer results in better uptake of nutrients.

Jadhav *et al.* (1997) in a plot experiment on rice observed that dry matter production and uptake of the most major nutrients were highest from 75 kg N ha^{-1} as urea + 25 kg N ha^{-1} as vermicompost.

Singh (1999) revealed that application of 10 t FYM ha^{-1} yielded significantly higher grain and straw yields of wheat over 5 t ha^{-1} and control (no FYM). Incorporation of FYM and application of N, P and K also exhibited significantly effect on uptake of NPK by grain and straw, FYM @ 10 t ha^{-1} with 60 kg N + 30 kg P_2O_5+ 30 kg K_20 ha^{-1} was found optimum level to get the maximum yield in wheat under low valley situation of U. P. hills.

Dwivedi and Thakur (2000) application of FYM together with 150% RDF recorded higher nutrients uptake in both the years and K uptake in second year by the crop at 125% RDF with FYM alone. This might be due to increased efficiency of fertilizers in the presence of FYM resulting in increased uptake.

Srrenivash *et al.* (2000) reported that available N in soil increased significantly with increasing levels of vermicompost at all the growth stages ridge gourd while N contain increased significantly with increased level of vermicompost. The highest N uptake was observed with vermicompost @ 10t ha^{-1} + 50:25:25 kg NPK through chemical fertilizer.

Gupta and Sharma (2006) observed that application of 100% NPK to both crops attained the maximum N (214.1 kg ha^{-1}) and P (43.0 kg ha^{-1}) uptake by the rice-wheat cropping system. However, 50% NPK + 50% N through FYM to rice followed by 100% NPK to wheat attained the maximum K uptake (208.4 kg ha^{-1}) by the whole system along with highest positive N (35.5 kg ha^{-1}) and P a balance (78.5 kg ha^{-1}) in the soil. While, in case of K, positive nutrient balance in soil was only recorded by application of 50% NPK + 50% N through wheat straw to rice followed by 100% NPK to wheat crop (54.5 kg ha^{-1}).

Sharma *et al*. (2007) observed that application of 187.5 kg N ha^{-1} integrated with FYM 10 t ha^{-1} and bio-fertilizer (*Azosprillium*) being at par with 187.5 kg N ha^{-1} + FYM 10 t ha^{-1} and 150 kg N ha^{-1} + FYM (10 t ha^{-1}) + *Azosprillium* recorded significantly higher N, P and K uptake than rest of the treatment. Such results are obvious, as application of fertilizer N in combination with organic manure and bio-fertilizer is known to improve various physico-chemical properties resulted in enhance nutrient absorption or uptake these finding confirm those of Singh (2006).

Singh *et al.* (2008) reported that green manuring *in-situ* or application of FYM (10 t ha^{-1}) or vermicompost (5 t ha^{-1}) one in a year, during kharif, were equivalent to 60 kg N, 13 kg P and 25 kg K fertilizer ha^{-1}. Integrated application of bio-fertilizers like *Azotobactors*, BGA and PSB, along with organic manures, reduced the N and P fertilizer requirement further by 60 kg N and 13 kg P ha^{-1}.

Srivastava *et al.* (2008) reported that a field experiment was conducted at Banaras Hindu University, Varanasi, India to assess the effect of organic manures (FYM, green leaf manure and biogas slurry) under various fertility levels on yield and NPK uptake by rice and their residual effect on wheat crop. Increased fertility levels from 25 to 75% of RFD in rice resulted maximum nutrient uptake by rice as well as residual wheat crop.

Pandey *et al.* (2009) to study the long term effect of fertilizer on the uptake of nitrogen phosphorus, potassium and sulfur by rice and wheat. Nutrient removal by rice at higher level of NPK was relatively higher than that of the lower levels of NPK fertilizer. The uptake of N, P, K and S by rice under control increased to 168.66, 156.84, 138.87 and 406.01% at 150% NPK+compost+crop residue treatment. The nutrient uptake was enhanced by the integrated use of compost+crop residue with chemical fertilizer at all levels of NPK.

Rathor *et al.* (2009) a pot culture experiment was conducted in the pot house at Lakhaoti, Bulandshahr, U.P. to study the effect of integrated use of Vermicompost, *Azosprillium* and inorganic fertilizers on nutrient content and their uptake by wheat. Significant improvement sowing to appropriate combination of NPK, VC and *Azosprillium* was observed for the nutrient content and their uptake by the crop and the maximum nutrient content and their uptake was noticed due to 100% RFD of NPK+ VC and *Azosprillium* and minimum with control.

Pandey *et al.* (2009) found that maximum NPK uptake by the crop was recorded at 150% RDF with FYM together and was similar to the NPK uptake by the crop at 125% RDF with FYM together, but significantly higher than the RDF with FYM together, although,

Sepat *et al.* (2010) reported that increased N, P and K contents along with higher grain and straw yield of wheat from treatments receiving combined application of NPK fertilizers, FYM, bio-fertilizers resulted in higher NPK uptake by wheat as compared to the treatments were no fertilizer or manures was applied or only NPK fertilizers were applied which recorded low N, P and K content in grains and straw on one hand and also lower grain and straw yield on the other.

Mubarak and Singh (2011) found that combined application of RDF + FYM 15 t ha^{-1} + bio-fertilizer recorded significantly higher nitrogen uptake followed by application of FYM 15 t ha^{-1} along with RDF. This may be attributed to the increased grain and straw yield of crop and their respective nutrient contents owing to increased availability of nutrients to the crop as a result of improved soil fertility. Farmyard manure acts as a nutrient reservoir and releases nutrients slowly, expected to be more closely matched with supply and demand by the crop. There results confirm the findings of Patidar and Mali (2001) and Brar *et al.* (2001).

Meena *et al.* (2012) reported that integrated use of NPK and FYM (7.5 t ha^{-1}) gave significantly higher grain yield (5.23 t ha^{-1}) as compared with general recommended dose of NPK (428 t ha^{-1}). Conjoint use of fertilizer NPK and FYM, improved soil physical health as revealed by a significant decrease in soil bulk density (BD) and an increase in water holding capacity (WHC) vis-à-vis soil fertilizer treatments or unfertilized control during the years of experimentation soil BD decreased from 1.50 mg/m^3 in NPK to 1.40 mg/m^3 in NPK + FYM + ID plots. Water holding capacity increased from 35.1% in NPK to 39.4% in NPK + FYM plots.

2.5 effect of Azospirillum

2.5.1 Effect on growth

Alvarez *et al.* (1996) reported the effect of *Azospirillum* in wheat seed promoting caleoptile growth in wheat seedling was under water stress.

Panwar and Singh (2000) have found that significant effect on wheat growth with use of *Azospirillum*.

Amooaghaie *et al.* (2002) in laboratory experiment conducted to determine the suitable strains and optimum concentration of *Azospirillum brasilense* reported that inoculation with *Azospirillum* strain (106-107 CFO) increased the growth of wheat.

Singh et al. (2006) conducted experiment for 2 crop season (1998-99 and 1999-2000) in Ludhiana, Punjab to determine the effect of *Azospirillum* seed inoculation and found significant effect on growth of wheat.

2.5.2 Effect of yield and yield attributes

Elanchezhion and Panwar (1997) had observed significant effect on yield attributes like dry No of grains and test weight.

Shivankar and Joshi (2000) studied the effect of *Azospirillum* and phosphate stabilizer on yield of irrigated wheat at Akola, India during 1995-97 and pointed that the grain yield increased significantly as treated with bio-fertilizer ranged from 12.15 to 12.79 % or 11.39 to 13.34 % as compared to untreated crops. same result was found Panwar and Singh (2000).

Aradakani *et al.* (2001) on an experiment conducted to investigate the effect of bio-fertilizer (*Azospirillum*) on yield components and result showed that it increases 1000-grain weight of wheat significantly. Ardakani *et al.* (2001) had been showed that individually, *Azospirillum* caused significant increase in grain yield of wheat.

Creus *at al.* (2004) reported in Argentina that a better water studies and an additional elastic adjustment in *Azospiriltum* inoculated wheat plant could be crucial in promoting higher grain yield significantly.

Singh *et al.* (2006) pointed out that the grain yield increased significantly due to seed treated with Azospiriltum. Geus *at al.* (2009) in an experiment conducted in Argentina and observed that the yield component is higher due to *Azospirillum* inoculation over control.

2.6 Economics of treatments

Singh and Uttam (1994) reported that a field experiment which conducted at Kanpur, UP, India to determine the effect of plant growth regulators and fertility levels on economics of wheat resulted highest net returns were obtained with 120 kg N + 60 kg P + 60 kg K ha^{-1}.

Patra *et al.* (1998) found that combining 125 per cent NPK and FYM gave the highest number of spike m^{-2} and net returns.

Singh *et al*. (2010) reported that a field experiment was conducted at NDUA&T, Kumarganj, Faizabad, during *rabi* season to study the effect of irrigation levels and fertility sources on net return. The 100% RD of NPK through fertilizers recorded significantly higher net return over F_3 and F_4 and it was statistically on par with 75% RD of NPK (F_2) through fertilizers + 25 % RDF through FYM.

Dikshit *et al.* (2001) the effect of integrated use of organic manures and inorganic fertilizers (NPK) were studied on yield and economics of wheat cultivation in Jabalpur, Madhya Pradesh (India). Wheat grain and straw yields increased in all treatments except for 50% NPK + poultry manure (T_{10}). Using 50 or 75% integrated with organic source (compost/farmyard manure), yield level was comparable with full recommended dose of NPK (T_1) and when the application of NPK recommended dose was associated with organic manure, and higher yield levels were obtained. Maximum N uptake (91.10) P_2O_5 (25.83), K_2O (323.0) and S (13.91) kg ha^{-1} occurred in T_2 treatment. The highest grain yield (51.3 q ha^{-1}), straw yield (87.36 q ha^{-1}) were recorded in 100% NPK and compost treatment which accounted for the highest cost of cultivation (Rs 5910 ha^{-1}) but the highest gross returns (Rs 15390 ha^{-1}). Maximum net profit (Rs 9800 ha^{-1}) and cost: benefit ratio (1:1.79) were achieved in NPK+FYM treated plot which indicated that economic yield can be obtained with integrated plant nutrient supply.

Mondol *et al.* (2005) an investigation was undertaken to evaluate the effect of nitrogen and compost alone as well as in combination for wheat productivity. The experiment was designed with 7 treatment combinations with four levels of nitrogen (0, 80, 120 and 160 kg ha^{-1}) and three levels of compost (0, 5 ton and 10 ton ha^{-1}) and laid out in a randomized complete block design with 3 replications. The variety of wheat was Satabdi. The grain yield of wheat was significantly influenced by different treatments over absolute control. The yield was recorded to increase with increasing level of N and compost up to 160 kg ha^{-1} and 10 ton ha^{-1}, respectively. From the response curve the maximum N was found to be 162.2 kg ha^{-1} and economic dose 157.3 kg ha^{-1}.

Gupta *et al.* (2007) observed that net return as well as benefit: cost ratio increased with increase in fertilizer dose and highest returns were observed at 125% of recommended fertilizer dose during first and second year respectively in wheat.

Yadav *et al.* (2009) reported that economics is the ultimate deciding factor to adopt a practice by the farmer. Total cost of cultivation under different treatments varied from 34.25 to 37.55 x 10^3 Rs ha^{-1}. Highest net return of 57.65 x 10^3 Rs per ha^{-1}. Was recorded in the treatment of in situ incorporation WS+GM+EM @ 5 t ha^{-1} + PSM in the crops, rice and wheat.

Zade and Kaleem (2009) reported that the effect of Compost on Economics Slightly higher net return and benefit cost ratio were achieved but actual grain yield, straw yield and test weight which was slightly higher from 100% recommended dose of NPK.

Arvind Kumar *et al.* (2012) The experiment was conducted at the Horticultural Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut (U.P.) during the Year 2009-10 to evaluate the economics, viability and feasibility of NADEP Compost. The economics of NADEP compost was calculated on the basis of cost of production and labors used.

Chaudhary *et al.* (2001) reported that N at 80 kg ha^{-1} + FYM resulted in the highest net return (15275 Rs ha^{-1}). Although N at 40 kg ha^{-1} with no much gave the highest cost benefit ratio (1: 9.37).

Pandey *et al.* (2009) conducted an experiment and found that the highest benefit: cost ratio (1.5 - 1.7) was obtained with l0 t FYM ha^{-1} together with RDF.

Bhoite *et al.* (2006) reported that application of either 50% - 75% N through green manure to rice irrespective of fertilizer applied to both the crops, significantly more net returns and benefit: cost ratio of the system than all other manorial combinations. The next best treatment was 100% NPK to rice and wheat + 50% N through FYM to rice.

Pandey *et al.* (2006) observe that significantly higher net return was observed at 125% of the recommended dose of fertilizer. While the net return per rupees investment increased significantly only upto recommended dose of fertilizer. Ram and Mir (2006) reported that the highest net return were obtain with application of 15 tones FYM+100 kg N ha^{-1}. The maximum net return (Rs 15808) was obtained from 15 t FYM+100 kg N ha^{-1} along with inoculation of Azosprillium+ Azotobactor benefit. Cost ratio was also the highest with the combination (1:1.25).

Vipin Kumar *et al.* (2008) The experiment was conducted at the Horticultural Research Centre of Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut (Uttar Pradesh, India) during 2006-07 to evaluate the economic viability and feasibility of NADEP compost. The experiment consisted of five different treatments viz., T_1 (Normal NADEP), T_2 (Normal NADEP+50 kg Urea), T_3 (Normal NADEP+1 kg *Azotobacter*), T_4 (Normal NADEP+1/2 kg Trichoderma) and T_5 (Normal NADEP+80 kg MOP). The economics of preparing the material (Rs/kg) and the amount of NPK (Rs kg^{-1}) were also determined. The results showed that the treatment (T_1) has the minimum cost of production of NADEP compost i.e., 0.068 Rs kg^{-1}, and the maximum was 0.15 Rs kg^{-1} in treatment (T_5). The minimum cost of production of N (7.77 Rs kg^{-1}), P (5.98 Rs kg^{-1}) and K (7.01 Rs kg^{-1}) were found in treatment T_2, T_4 and T_1 respectively. Whereas the maximum cost of production of N (30.58 Rs kg^{-1}), P (34.75 Rs kg^{-1}) and K (11.58 Rs kg^{-1}) was in treatment T_5.

Reddy *et al.* (2009) A study undertaken on economics of vermicompost production in Coorg district of Karnataka revealed that the production of vermicompost is economically viable as the rate of return per rupee of investment was 1.78 and 1.52 under vat and heap methods of production, respectively. The annual average production costs worked out to Rs. 72680 and Rs. 23262 under vat and heap methods with net incomes of

Rs. 56755.54 and Rs. 12145.80, respectively. As the production of vermicompost is an economically viable and bankable proposition, financial institutions can extend financial assistance to farmers for vermicompost production.

3. MATERIALS AND METHOD

The field experiment entitled "Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P.'' was conducted during *rabi* (winter) seasons of 2011-2012 and 2012-2013. The details of materials used and methodology adopted during the course of investigation are presented below under fallowing heads.

3.1 Experimental site and Location

The field experiment was conducted at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut (Uttar Pradesh) in *rabi* (winter) seasons of 2011-2012 and 2012-2013. Meerut is located on the Delhi-Dehradun highway. The Crop Research Centre is located at 29^0 04' North latitude, 77^0 42' East longitude and at an altitude of 237 meters above the mean sea level. The area lies in the heart of the Western Uttar Pradesh has sub-tropical climate.

3.2 Climate and Weather

The climate of this region is subtropical and semi-arid and climate characterized with very hot and dry summers and extremely cold winters. The mean maximum temperature of this region is about 43^0C to 45^0C is not uncommon during summer while very low temperature (4-10^0C) accompanied by frost may be experienced in December-January. The winters are cool, frost generally occurs towards the end of December and may continue till the end of January. The monsoon generally begins during the third week of June and desists by the end of September. The total precipitation and its distribution in this region various largely, about 80 to 90% of its received during July to September and few showers are also a common feature during the month of December to January and in late spring season.

Mean weekly meteorological data for the season during experimentation period 2011-12 and 2012-13 based on the observations collected at the meteorological observatory of SVPUA&T, Modipuram, Meerut are depicted in Fig.1 (a) and 1(b).

In general, maximum temperature exhibited gradual decline with advancement in crop age up to January and thereafter start to increase up to harvesting of crop. The lowest mean temperature (2.9^{0}C) was recorded in the last week of December during 2011-12. Whereas during 2012-13 the lowest mean temperature (1.2^{0}C) was recorded in first week of January. The maximum temperature (34.14^{0}C) was observed in fourth week of April during 2011-2012 and (35.2^{0}C) in third week of April during 2012-2013.Minimum temperature varying from 2.9^{0}C to 19.71^{0}C during the crop growth period in both years. The mean relative humidity during crop growth period varied from 88.28% to 21.92% during *rabi*, 2011-12 and 96.2% to 29.5% during *rabi,* 2012-13.

While the minimum temperature was 3.88^{0}C in 1st standard week and the Relative Humidity ranged from 80.71 to 96.0% recorded respectively in the morning.

3.3 Soil of the experimental field

The composite soil sample to a depth of 0 – 15 cm was collected from the experiment field prior to sowing of the crop. The sample was analyzed for its Physico-chemical attributes and the values obtained are given in Table 3.1. The mechanical and chemical analysis indicates that the soil of experimental unit was low in organic carbon, and medium in available N, P and K with alkaline in reaction.

Fig. 1(a): Mean weekly Agro-meteorological data during the crop growing season (2011 - 12) of wheat

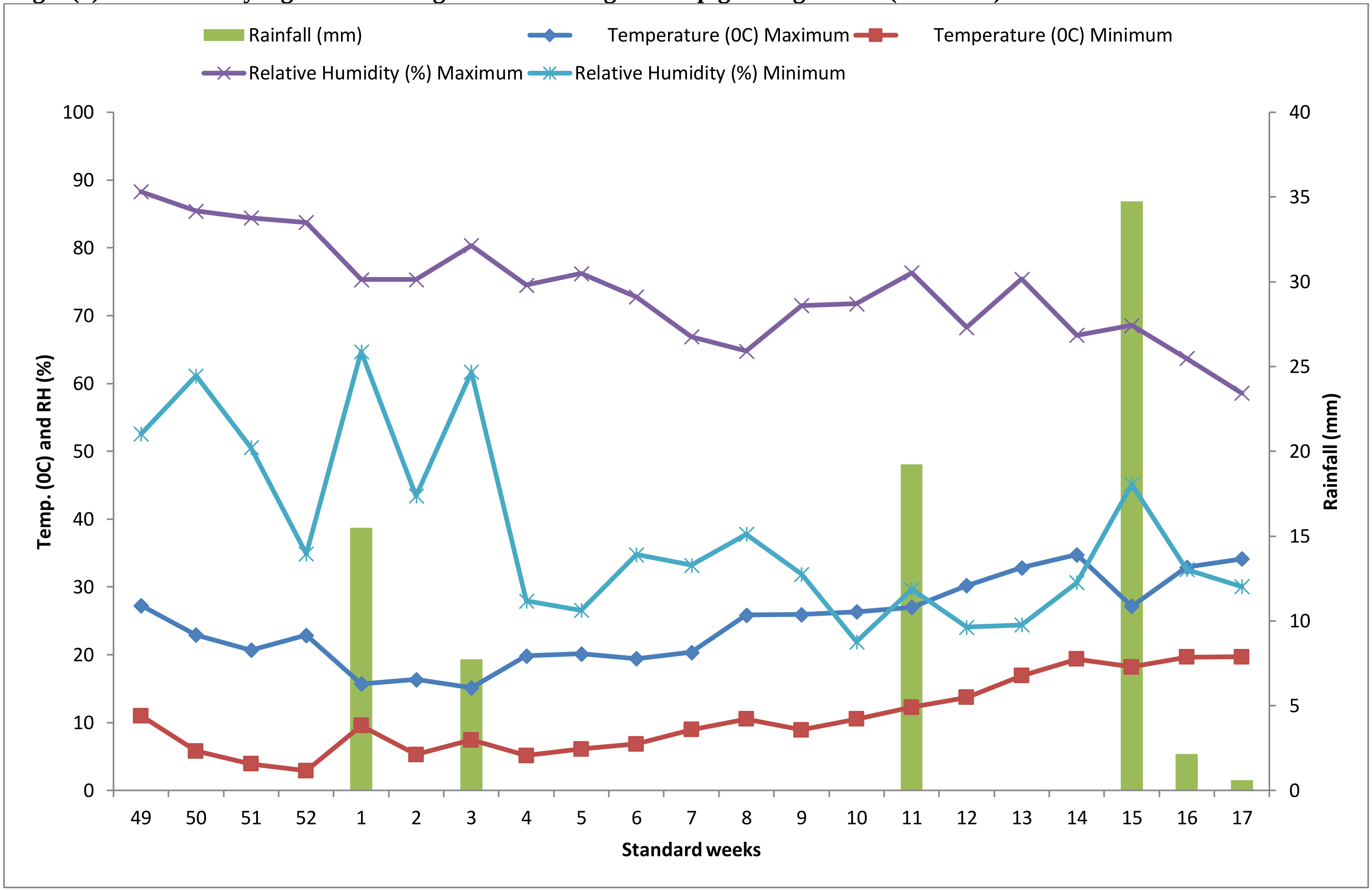


Fig. 2(b): Mean weekly Agro-meteorological data during the crop growing season (2012 - 13) of wheat

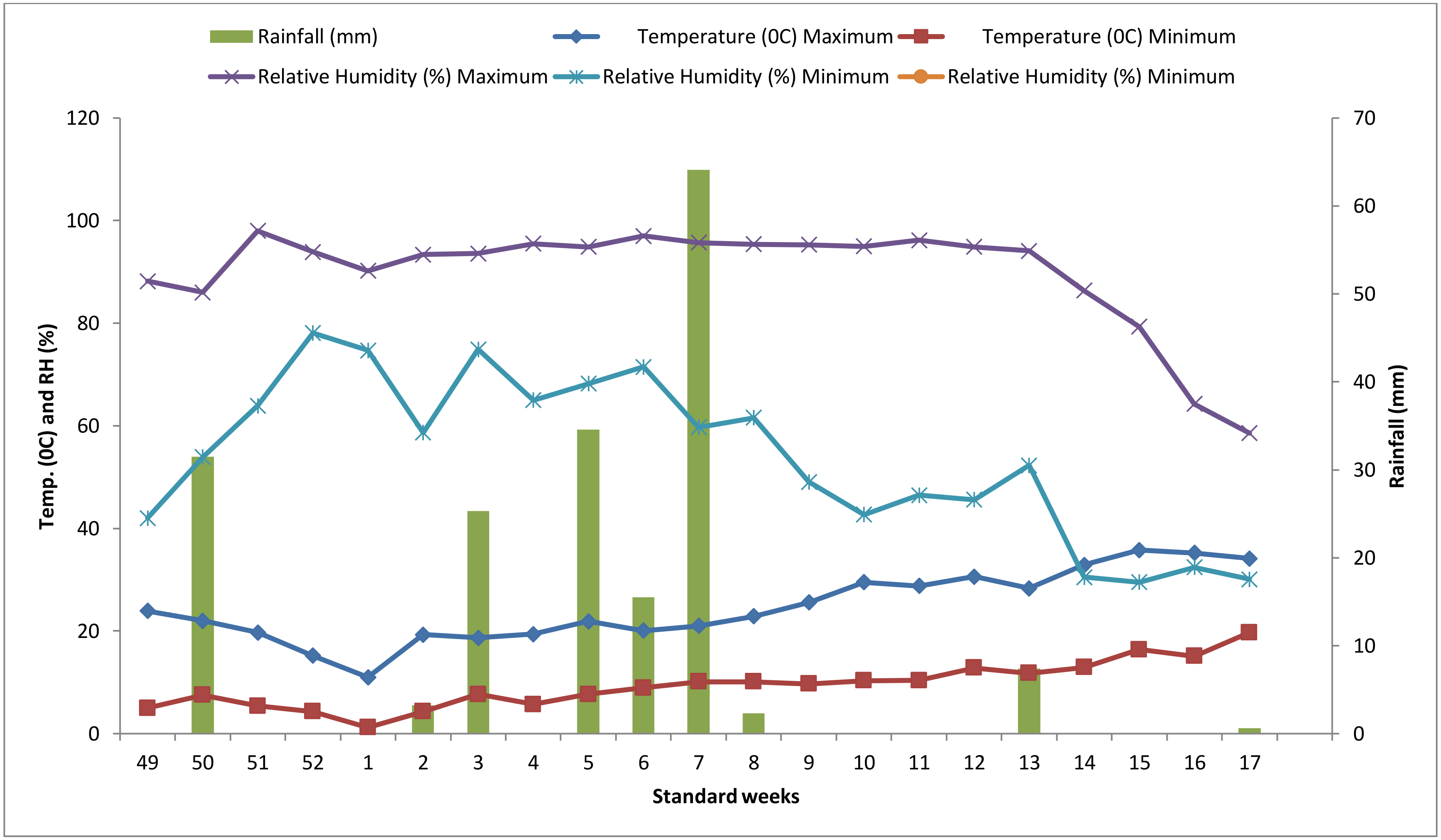


Table.1 Physico-chemical properties of soil of the experimental field.

Soil parameters/characteristic	Values	Methods adopted
A. Mechanical composition		
Clay (%)	20.7	
Sand (%)	61.5	International pipette method (Jackson,1973)
Silt (%)	17.8	
Textural class	Sandy loam	
B. Chemical composition		
Available N (kg ha^{-1})	245.6	Alkaline$KMnO_4$method (Jackson, 1973)
Available P (kg ha^{-1})	13.4	Olsen's method (Olsen *et al.*, 1954)
Available K (kg ha^{-1})	185	Flame photometry (Hanway and Heidel, 1952)
Organic carbon (%)	0.43	Walkley and Black Method (Jackson, 1973)
pH(soil: water, 1:2.5)	7.60	Electrode pH meter Suspension method (Jackson, 1973
Electrical conductivity (dS/m)	0.24	Conductivity meter Suspension method (Jackson, 1973)
C. Physical properties		
Bulk density (Mg/m^3)	1.405	Core sample method (Piper, 1996)
Porosity (%)	45.78	Danielson and Sutheriand (1986)

3.4: Cropping history of the field

The crops grown in the experimental field during previous years have been presented in Table-3.2.

Table.2 Cropping history of the field

S.No.	Year	Crop taken	
		Kharif	Rabi
1.	2008-2009	Rice	Wheat
2.	2009-2010	Rice	Wheat
3.	2010-2011	Rice	Wheat
4.	2011-2012	Rice	Wheat
5.	2012-2013	Rice	Wheat

3.5 Source of fertilizers

Organic Fertilizers - Farmyard manure, Vermicompost, Preesmud.

Inorganic Fertilizers-

Nitrogen source as (Urea 46 %)

Phosphorus sources as (DAP 46 % P_20_5, 18 % N)

Potash sources as (MOP 60 % K_20)

Bio- fertilizer- *Azosprillium*

3.6 Material of Experiment

Wheat variety DBW-16 was used as seed at the rate of 120 kg ha^{-1} and farmyard manure, vermicompost and pressmud as source of organic fertilizers, and Inorganic fertilizers as Urea (46% N), DAP (18% N & 46% P_2O_5) and MOP (60% K_2O) were used as experimental material during the experiment

3.7 Experimental details

The experiment was laid out in randomized block design with different combinations of organic and inorganic fertilizers to supplement RDF. The detail of the treatments description is given in Table-3.3, and layout plan is depicted in Fig.2.

Table.3 Treatment description

Treatments	Treatment combinations
T_1	100% NPK through chemical fertilizer
T_2	75 % NPK + 3 t/ha FYM + Azosprillium
T_3	50 % NPK + 6 t/ha FYM + Azosprillium
T_4	25 % NPK + 9 t/ha FYM + Azosprillium
T_5	75% NPK + 1 t/ha pressmud+ Azosprillium
T_6	50 % NPK + 2 t/ha pressmud+ Azosprillium
T_7	25 % NPK + 3 t/ha pressmud + Azosprillium
T_8	75 % NPK + 1 t/ha vermicompost+ Azosprillium
T_9	50 % NPK + 2 t/ha vermicompost+ Azosprillium
T_{10}	25 % NPK + 3 t/ha vermicompost+ Azosprillium
T_{11}	Control

3.8 Detail of layout

Total cultivated Area	53 m. length and 24 m. Width (1272m^2)
Net cultivated Area	660 m^2
Design	RBD (Randomized Block design)
No. of replications	0 3
Number of Total treatments	11
Total experimental units	33
Crop and Variety	Wheat DBW-16
Main Irrigation channels (1)	1.5 m.
Sub irrigation channel (2)	1.0 m.
Plot border	1.0 m.
Gross plot size	5 × 4 m^2
Net plot size	4.0 x 3.0 m^2
Number of row per plot	11 rows
Space in row to row	20 cm
Direction of row	East to West
Seed (gm / plot)	240 gm
Total used seed	6.500 kg
Seed rate	120 kg/ha

3.9 Cultural operations

The details of cultural operations carried out during pre and post sowing of wheat crop in experimental field are presented in Table 3.4.

3.9.1 Field preparation

Field was ploughed twice with disc harrow during both the cropping seasons and temporary layout was performed to apply organic manure. FYM were applied uniformly as per treatments and incorporated into the soil before the sowing of the crop. To attain good tilth pre-sowing irrigation was applied in the field after making bunds as per treatments. Field was harrowed twice fallowed by cultivator and planking to get well pulverized seed bed.

3.9.2 Fertilizers application

The experimental crop was fertilized uniformly with N, P and K was applied through urea, Di-ammonium phosphate and muriate of potash, respectively. Nitrogen was applied in three splits; 1/2 as basal and the rest was top-dressed in two equal splits at 25 and 60 day after sowing fallowing irrigation.

3.9.3 Seed rate and sowing

Certified seed of wheat DBW-16 were sown at 20 cm rows distance on December 07, 2011 and December 09, 2012 during the first and second growing seasons, respectively. Sowing was done by hand behind the country plough with seed rate of 120 kg ha^{-1}. After sowing, planking was done for proper placing of seed in the furrow.

3.9.4 Herbicide application

Metasulfuran+sulfosulfuran were used as a herbicide and applied uniformly in standing crop to control the weeds.

3.9.5 Water application

Irrigation water applied on critical stages of the crop.

Table.4 Schedule of cultural operations carried out in the experimental field

Particulars of operation	Date of operation		Method used
	2011 - 12	**2012 - 13**	
Pre-sowing irrigation	25-11-2011	27-11-2012	By tube-well
Ploughing	01-12-2011	03-12-2012	Tractor drawn disc plough
Harrowing	03-12-2011	05-12-2012	By Tractor
Levelling	04-12-2011	06-12-2012	Manually
Layout	06-12-2011	08-12-2012	Manually
Sowing	07-12-2011	09-12-2012	Manually
Fertilizers Applications			
(a) Basal Dressing	07-12-2011	09-12-2012	Manually
(b) First top dressing (N)	01-01-2012	03-01-2013	Manually
(c) Second top dressing (N)	27-02-2012	29-02-2013	Manually
Herbicides application	11-01-2012	13-01-2013	Manually (Byknapsack sprayer)
Irrigation			
1st irrigation	28-12-2011	30-12-2013	By tube-well
2nd irrigation	16-01-2012	18-01-2013	By tube-well
3rd irrigation	14-02-2012	16-02-2013	By tube-well
4th irrigation	05-03-2012	08-03-2013	By tube-well
5th irrigation	25-03-2012	28-03-2013	By tube-well
Harvesting	24-04-2012	26-04-2013	Manually by sickle
Threshing	29-04-2012	01-05-2013	Pullman Thresher

3.9.6 Harvesting and threshing

Crop was harvested after the full maturity (complete loss of green colour from the glumes, yellowing of spike lets). The border (2 rows from both sides and 0.5 meter from with sides of plots) were marked and harvested to distinguish the net plot area. The produce of net plot were kept separately and threshed individually with the help of Pullman thresher.

3.10 Treatment evaluation

The following observations were recorded to evaluate treatment effect.

3.10.1 Growth studies

To study the behavior of the developing plant under the influence of different treatments three lines of the one meter row length representing the whole plant in each plot were selected at random and these lines were marked with sticks. From these lines periodical observations were recorded at an interval of 30 days, starting from sowing of wheat. The effect of various treatments on growth in terms of number of plants, tillers, plant height was hooked out for vegetative and reproductive phases of plant.

3.10.2 Plant height

Five plants were tagged randomly from the sampling area for recording height (cm) at 30, 60, 90 DAS and at harvesting. The height was measure from ground surface to the base of fully opened leaf before the ear emergence and up to the base of ear heading.

3.10.3 Number of tillers per meter row length

Total number of tillers per meter row length was recorded from five places (marked with sticks) in each plot 30, 60, 90 DAS and at harvesting.

3.10.4 Dry matter accumulation

Plants were harvested from one meter row length from the one row per plot at 30, 60, 90 DAS and at harvesting. The plants were sun dried separately and then oven dried at 72 ± 0.5^{0}C till the constant weight is obtained. The dry matter accumulation was expressed in gm^{-1} row length.

3.10.5 Leaf area index (LAI)

Leaf area from pre-marked uniform plants from each replication was measured from all the treatments at 30, 60 and 90 DAS. The following formula was used for calculating the leaf area index:

$$LAI = \frac{\text{Leaf area } (cm^2)}{\text{Ground area } (cm^2)}$$

3.10.6 YIELD AND YIELD ATTRIBUTES

The observations on yield and yield attributing characters were taken from three selected rows in each plot at the time of harvest. Following yield attributing characters were recorded.

3.10.7 Spike length (cm)

Ten spikes of wheat were randomly selected at harvest and their length was measured in centimeter from the neck to the tip of the spike and mean length of spike was computed.

3.10.8 Number of spikelets per spike

Spikelets from the ten ear heads were counted and average was computed.

3.10.9 Number of grains spike^{-1}

The number of grains from 5 spikes selected for length of spike as mentioned were above recorded and later an average number of grains spike^{-1} was worked out.

3.10.10 Test weight (1000 grain weight)

After threshing and weighing, a random sample of grains was taken from each plot. From this sample 1000 grains were quanded at random and their weight (g) was taken.

3.10.11 Grain yield (t ha^{-1})

Grains were separated with a plot thresher from biomass obtained from each net plot and converted in t ha^{-1}.

3.10.12 Straw yield (t ha^{-1})

Straw yield net plot area was computed by subtracting the grain yield from biological yield and later converted in to t ha^{-1}.

3.10.13 Biological yield (t ha^{-1})

After harvesting, the wheat crop was sun dried up to five days and then weight of net harvested area of wheat in each plot was recorded and converted in to t ha^{-1}.

3.10.14 Harvest Index

Harvest index was calculated from economic yield (grain) and biological yield (grain + straw) by using the following formula.

$$HI = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.10.15 Protein content

Protein content in grains was calculated by using the formula

Protein content (%) = Nitrogen (%) × 5.73

3.11 Collection of soil samples

From 0-15 cm depth from each plot the soil samples were collected. These samples were processed and analyzed for various physic-chemical properties.

3.11.1 Particle size analysis

The relative proportion of sand, silt and clay in soil sample was determined by using Bouzoukis hydrometer method as describing by **Bouzoukis, (1962)** using hydrogen peroxide (30%) to oxidation of organic matter. This method measures the viscosity of soil suspension at the surface at different time. One hundred gram of processed soil was suspended in distilled water in the presence of 100 ml of 10% sodium hexa Meta phosphate as a dispersing agent and volume was made to one liter. After vigorous agitation, soil suspension was allowed to settle down and hydrometer reading was taken at 40 second and 2 hours interval. Hydrometer reading at 40 second measures the silt and clay content of soil whereas reading at 2 hours measures the clay content. This is accordance with Stake's Law, which states that the resettling of suspended particles is dependent on size of particles, sand being the first to settle, and clay being last. While calculating the temperature correction was also applied to hydrometer reading. Sand, silt and clay content were determined as:

Correction factor (CF) = (Actual room temperature in °F - 68) ×0.2

$$\text{Percent silt + clay} = \frac{(S\text{-}B) + CF}{\text{Weight of sample (g)}} \times 100$$

Where, S & B= sample reading and blank reading respectively take at 40 second

$$\text{Percent clay} = \frac{(S\text{-}B) + CF}{\text{Weight of sample (g)}} \times 100$$

Where, S & B = sample reading and blank reading respectively taken after 2 hours

Percent Silt = Percent silt + clay – Percent clay

Percent sand content can be calculated by difference of

Percent sand = 100- (silt + clay)

3.11.2 Available nitrogen in soil

The available nitrogen was determined by distilling the soil with alkaline potassium permanganate solution 0.32% **(Subbiah and Asija, 1956)** which oxidizes and hydrolyses the organic matter present in the soil. The liberated ammonia was absorbed in the boric acid. Titrate the distillate against 0.02N sulphuric acid taken in burette until pink color start appearing.

3.11.2 Available phosphorus in soil

The available phosphorus content of soil was determined by the method described by **Olsen *et al*. (1954)**. 2.5 gm of dried soil sample containing pinch of Darco G- 60 was extracted with 50 ml of 0.5 M $NaHCO_3$ (pH 8.5) for 30 minutes. Five ml of filtrate was taken in 25 ml volumetric flask; 2-3 drops of p- nitro phenol indicator added resulted yellow Color was developed. After that 5N H_2SO_4 drop by drop were added until yellow color disappear to acidify up to 5 pH. 4 ml of ascorbic acid solution was added to the flask and volume was made. The blue color was obtained; the intensity of blue colour which is proportional to phosphate was read on the spectrophotometer at a wave length of 730 nm by using a red filter. The blank was also prepared by adding the entire chemical except soil. The concentration of available phosphorus in soil was expressed in kg ha^{-1}.

Available phosphorus (kg ha^{-1}) = ppm of P calculated from standard curve × dilution factor × 2.24.

3.11.3 Available potassium in soil

The available potassium content of soil was determined by the method described by **Hanway and Heidel, (1952)** Five gm of processed soil was taken in a 150 ml conical flask and extracted with 25 ml of neutral normal ammonium acetate solution. The filtrate was aspirated in to the atomizer of the calibrated flame photometer and reading was noted. The concentration of available potassium in soil was expressed as kg ha^{-1} and calculated as:

$$\text{Available potassium (kg ha}^{-1}\text{)} = \text{ppm K} \times \text{dilution factor} \times 2.24.$$

3.12 pH Measurement

The pH was determined with the help of glass electrode on a pH meter in (1:2) soil + water suspension (Jackson, 1973).

3.13 Organic carbon

Organic carbon was determined by walkley and Black Method 1934.

3.14 Chemical plant analysis

Analysis of grain and straw samples of wheat crop was carried out for their nitrogen, phosphorus and potassium contents. Sun dried samples were oven-dried at 70 ± 2° C and ground in Wiley Mill. 0.2 And 0.5 g of grain and straw respectively, were digested in di acid mixture of HNO_3 and $HClO_4$ (4:1). After digestion, a known volume was made with distilled water and stored in well washed plastic bottles after filtration through what man filter paper no. 42. All the estimations in the aliquot were made according to the following procedures:

3.15 Total Nitrogen in plant

Nitrogen content in grain, straw of wheat plant was determined by Automatic N analyzes using 0.2 g finally powdered samples.

3.16 Total phosphorus in plant

Phosphorus content in grain, straw of wheat plant in aliquot was determined by vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973)

3.17 Total Potassium in plant

Potassium in grain, straw of wheat plants was determined by flame photometric method (Jackson, 1973).

3.18 ECONOMIC ANALYSIS

3.18.1 Cost of Cultivation (Rs ha^{-1})

Cost of cultivation of wheat crop was worked out including treatment cost on the basis of total market price of different inputs used in cultivation (Appendix XVI).

3.18.2 Gross returns (Rs ha^{-1})

The monetary value of grain and straw yield was computed in rupees using support price of outputs. Gross return was obtained by adding monetary values of grains and straw.

$$\text{Gross Return (Rs ha}^{-1}) = \text{Grain yield (q ha}^{-1}) \times \text{price ((Rs. q}^{-1}) + \text{Straw yield (q ha}^{-1}) \times \text{price ((Rs. q}^{-1})$$

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

Net return for each treatment combination was calculated by deducting the cost of cultivation from the respective grass return.

$$\text{Net Return (Rs. ha}^{-1}) = \text{Gross return} - \text{Cost of cultivation}$$

3.18.4 Net benefit: Cost ratio

The net benefit: cost ratio was computed for the crop as well as for the system by the fallowing formula:

Net benefit: cost ratio $= \dfrac{\text{Net return (Rs./ ha)}}{\text{Cost of cultivation (Rs./ ha)}}$

3.19 Statistical Analysis

The data recorded during the course of investigation were subjected to statistical analysis using analysis of variance technique (ANOVA) for RBD as prescribed by Cochran and Cox (1963). Standard error of Mean in each ease and critical difference only for significant cases were calculated at 5% levels of probability as under.

3.19.1 Standard error of mean

Standard error of mean was calculated as follows:-

Standard Error of mean = $\sqrt{\dfrac{\text{EMSS}}{\text{R}}}$

Where,

SEM $\pm$ = Standard error of mean

EMSS = Error mean sum of square

r = Number of replications on which the observation is based.

3.19.2 Critical Difference

The critical difference at 5% level of significance was estimated to compare treatment means wherever, 'F' test was significant.

C. D. = SEm (±) × √2 × t (at error degree of freedom)

4. EXPERIMENTAL RESULTS

The observation pertaining to crop growth, development, yield and yield attributes and monetary aspects, recorded during the course of investigation entitled "**Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P.**" in crop season of 2011-12 and 2012-13 were subjected to statistical analysis. The effect of nutrient has been systematically tabulated for illustrated graphically for easy comprehension and understanding of pattern, as follows:

4.1 Growth studies

4.1.1 Plant height (cm)

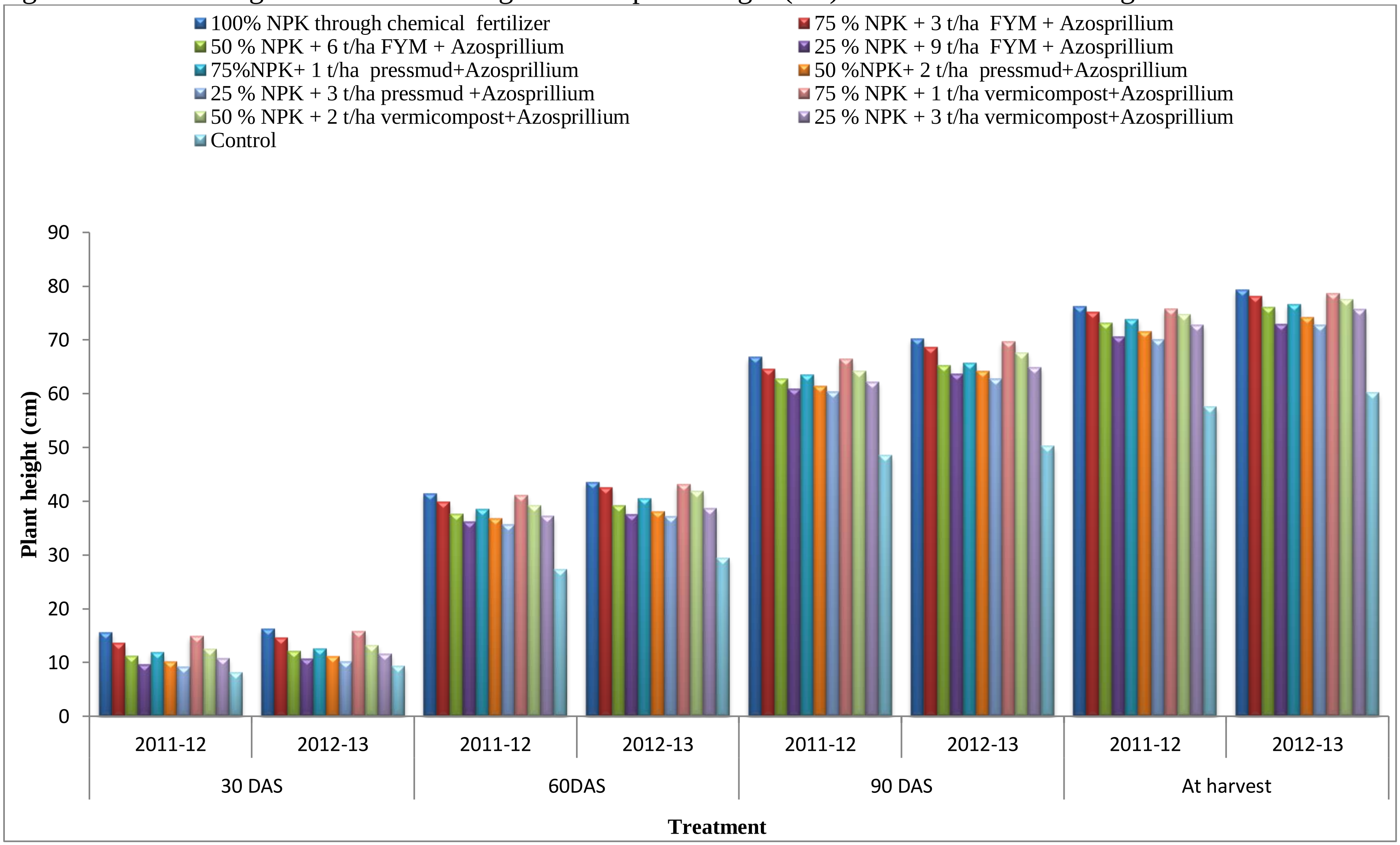
Nutrient had significant effect on plant height at all the growth stages during both the year of investigation. The relevant data present in Table 4.1 and Fig.4.1 and their analysis of variance presented in (Appendix-III).

In general, the crop attained more plant height during 2012-13 than in 2011-12. Further, the plant height picked up with advancement in crop age irrespective of the treatment during both the year investigation. Plant height increased as the crop growth advanced and reached to maximum at maturity. Application of different nutrient management practices influenced the plant height significantly over the control. Each successive nutrient doses from 100% NPK to control plot resulted in significant reduction in plant height at all the growth stages during both the years. The effect of nutrient management on plant height recorded at different stages of crop growth (30, 60, 90 and at harvest) was found significant at both the year. Gain in plant height was much more between 30 to 60 DAS rather than 60 to 90 DAS. The application of 100% NPK produced maximum plant height which was at par with 75% NPK + 1 ton ha^{-1} vermicompost+ *Azosprillium* and it was observed superior over rest of the

Table 4. 1 Effect of integrated nutrient management on plant height (cm) of wheat at various stages.

Treatment	**30 DAS**		**60DAS**		**90 DAS**		**At harvest**	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	15.6	16.2	41.4	43.5	66.8	70.2	76.2	79.3
75 % NPK + 3 t/ha FYM + A*zosprillium*	13.6	14.6	39.8	42.5	64.6	68.6	75.2	78.1
50 % NPK + 6 t/ha FYM + A*zosprillium*	11.2	12.1	37.6	39.2	62.8	65.3	73.2	76.1
25 % NPK + 9 t/ha FYM + *Azosprillium*	9.6	10.7	36.2	37.5	60.8	63.6	70.6	72.9
75%NPK+ 1 t/ha pressmud+*Azosprillium*	11.9	12.6	38.5	40.5	63.5	65.7	73.8	76.6
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	10.2	11.1	36.8	38.1	61.4	64.2	71.5	74.2
25 % NPK + 3 t/ha pressmud +*Azosprillium*	9.2	10.2	35.7	37.1	60.4	62.8	70.1	72.8
75 % NPK + 1 t/ha vermicompost+A*zosprillium*	14.9	15.8	41.1	43.1	66.4	69.7	75.8	78.7
50 % NPK + 2 t/ha vermicompost+A*zosprillium*	12.5	13.2	39.2	41.9	64.2	67.6	74.7	77.5
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	10.8	11.6	37.2	38.7	62.2	64.9	72.8	75.7
Control	8.2	9.3	27.3	29.4	48.5	50.2	57.6	60.2
SEm(±)	0.53	0.49	0.53	0.31	0.41	0.52	0.33	0.26
C.D. (P=0.05)	1.58	1.46	1.58	0.92	1.22	1.54	0.99	0.77

Fig.4.1 Effect of integrated nutrient management on plant height (cm) of wheat at various stages.



treatments at all the stages of plant height during both the year. The control plots resulted significant reduction in plant height compared to other treatments at 30, 60, 90 DAS and at harvest. Control plot produces shorter plant at all the growth stages measured in studies.

4.1.2 Dry matter accumulation (g m^{-1})

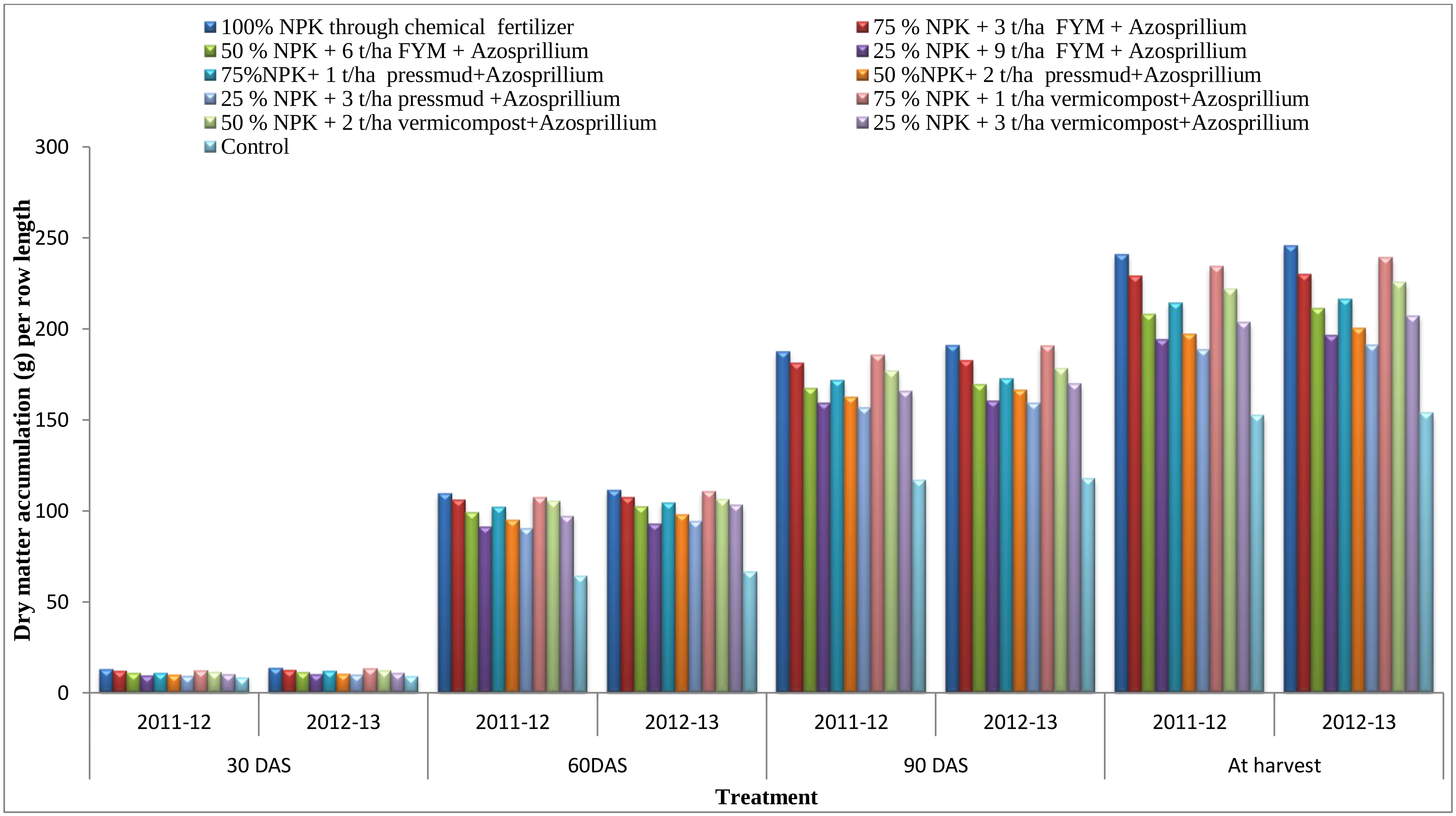
The variations in plants dry matter accumulation (g m^{-1}) under different nutrient management practices were significant at all the stages of crop growth during both the years (Appendix IV).

In general, dry matter accumulation (g m^{-1}) followed an increasing trend with advancement in crop age and reached its peak at maturity (Table 4.2 and Fig 4.2). Nutrient management treatments had significant effect on dry matter accumulation during both years. Further, perusal of the data revealed that dry matter accumulation (g m^{-1}) decreased significantly with nutrient doses from 100% NPK to control irrespective of the crop stages and years. At harvest, 100% NPK crop accumulated more dry matter than other nutrient options during both the years. In general the increase in dry matter accumulation was more up to at harvest stage. Whereas, at 30 DAS the maximum dry matter accumulation per meter row was recorded under 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during both years. The application of 100% NPK had significantly higher dry matter which is at par with 75 % NPK + 1 ton ha^{-1} vermicompost+ Azosprillium while significantly different than control, at 60 DAS during 2011-12 and 2012-13 respectively. Whereas, at 90 DAS and at harvest highest dry matter accumulation was recorded in 100% NPK during both years but which was significantly at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium at harvest during 2011-12, 2012-2013 and it was significantly higher than rest of the treatments during both years. Minimum dry matter

Table 4. 2 Effect of integrated nutrient management on dry matter accumulation (g) m^{-1} row length in wheat at various stages.

Treatment	**30 DAS**		**60DAS**		**90 DAS**		**At harvest**	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	12.6	13.7	109.6	111.3	187.3	190.8	241.0	245.6
75 % NPK + 3 t/ha FYM + *Azosprillium*	11.8	12.3	106.1	107.5	181.2	182.7	229.2	230.0
50 % NPK + 6 t/ha FYM + *Azosprillium*	10.6	11.2	99.3	102.4	167.4	169.3	208.2	211.3
25 % NPK + 9 t/ha FYM + *Azosprillium*	9.5	10.2	91.3	93.1	159.2	160.4	194.3	196.5
75%NPK+ 1 t/ha pressmud+*Azosprillium*	10.8	11.9	102.1	104.6	171.6	172.6	214.3	216.5
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	9.8	10.5	94.9	97.9	162.4	166.5	197.1	200.4
25 % NPK + 3 t/ha pressmud +*Azosprillium*	9.2	9.9	90.4	94.2	156.7	159.2	188.5	191.2
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	12.2	13.3	107.4	110.8	185.5	190.6	234.4	239.3
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	11.2	12.1	105.3	106.2	176.8	178.2	222.1	225.7
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	10.1	10.8	97.2	103.2	165.9	169.8	203.6	207.2
Control	8.2	8.9	64.2	66.7	116.8	117.8	152.6	153.8
SEm(±)	0.23	0.27	0.88	0.75	0.92	1.54	2.41	2.22
C.D. (P=0.05)	0.69	0.79	2.61	3.36	2.74	4.59	7.16	6.60

Fig. 4.2 Effect of integrated nutrient management on dry matter accumulation (g) m^{-1} row length in wheat at various stages.



accumulation was recorded on control plot at 30, at 60, at 90 DAS and at harvest during both years.

4.1.3 Number of effective tillers per meter row length

Number of tillers per meter row length was recorded at different stages of crop growth and data are given in (Table 4.3 and fig 4.3) and their analysis of variance is presented in Appendix V.

The number of tillers increased up to at 90 DAS but maximum tillering was recorded between at 30 and at 60 DAS during both the years. Application of 100% NPK +FYM 10 t ha^{-1} produced highest number of tillers per metre row length (84.8, 71.6 and 68.4 and 92.5, 78.4 and 74.2) which was at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium treated plot at 60, at 90 DAS and at harvest during both years and it was significantly higher than rest of the treatments during both years during both the year 2011-12 and 2012-13, respectively. Lower number of tillers were recorded on control plot at 30, at 60, at 90 DAS and at harvest during both years.

4.1.4 Leaf area index

Nutrient management exhibited significant variation in leaf area index of wheat at all the growth stages during both the years except at 90 DAS during 2011-12 and 2012-2013 and data are given in (Table 4.4 and fig 4.4) their analysis of variance is presented in Appendix VI.

In general, crop had high the LAI during 2012-13 than in 2011-12. Further an increase in LAI was noted with the advancement of crop age up to 60 DAS and a decline thereafter, with treatments and year. The increase was more prominent during 30-60 days period as compared to 60-90 days. Application of 100% NPK had significantly higher LAI than the rest

Table 4.3 Effect of integrated nutrient management on number of effective tillers m^{-1} row length in wheat at various stages.

Treatment	30 DAS		60DAS		90 DAS		At harvest	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	27.8	34.5	84.8	92.5	71.6	78.4	68.4	74.2
75 % NPK + 3 t/ha FYM + *Azosprillium*	26.9	32.7	83.9	90.7	70.8	77.3	67.7	73.1
50 % NPK + 6 t/ha FYM + *Azosprillium*	25.1	30.5	82.1	87.2	69.2	73.1	65.8	69.7
25 % NPK + 9 t/ha FYM + *Azosprillium*	23.5	27.1	80.7	84.4	66.8	70.4	63.5	66.8
75%NPK+ 1 t/ha pressmud+ *Azosprillium*	25.8	31.2	82.7	87.9	69.8	73.9	66.5	70.3
50 %NPK+ 2 t/ha pressmud+ *Azosprillium*	24.2	28.5	81.1	85.5	67.9	71.6	64.4	67.6
25 % NPK + 3 t/ha pressmud + *Azosprillium*	23.2	26.4	80.2	83.7	66.1	69.8	63.1	66.0
75 % NPK + 1 t/ha vermicompost+ *Azosprillium*	27.2	33.6	84.2	91.1	71.3	77.8	68.1	73.8
50 % NPK + 2 t/ha vermicompost+ *Azosprillium*	26.4	32.1	83.3	90.1	70.2	76.7	67.2	72.4
25 % NPK + 3 t/ha vermicompost+ *Azosprillium*	24.8	29.1	81.7	86.4	68.8	72.4	65.1	68.7
Control	15.6	20.9	66.6	71.8	40.2	46.8	38.5	46.3
SEm(±)	2.54	0.02	0.27	0.40	0.27	0.33	0.20	0.37
C.D. (P=0.05)	N.S.	0.07	0.80	1.19	0.79	0.99	0.62	1.09

N.S. non significant

Table 4.4 Effect of integrated nutrient management on Leaf area index in wheat at various stages.

Treatment	30 DAS		60DAS		90 DAS	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	1.38	1.51	3.96	4.39	3.48	3.59
75 % NPK + 3 t/ha FYM + *Azosprillium*	1.36	1.49	3.86	4.3	3.43	3.54
50 % NPK + 6 t/ha FYM + *Azosprillium*	1.31	1.44	3.82	4.24	3.37	3.48
25 % NPK + 9 t/ha FYM + *Azosprillium*	1.25	1.38	3.75	4.14	3.31	3.42
75%NPK+ 1 t/ha pressmud+ *Azosprillium*	1.33	1.46	3.83	4.25	3.39	3.5
50 %NPK+ 2 t/ha pressmud+ *Azosprillium*	1.28	1.41	3.77	4.16	3.33	3.44
25 % NPK + 3 t/ha pressmud + *Azosprillium*	1.22	1.35	3.73	4.12	3.30	3.41
75 % NPK + 1 t/ha vermicompost+ *Azosprillium*	1.37	1.5	3.88	4.32	3.45	3.56
50 % NPK + 2 t/ha vermicompost+ *Azosprillium*	1.35	1.48	3.85	4.29	3.41	3.52
25 % NPK + 3 t/ha vermicompost+ *Azosprillium*	1.29	1.42	3.79	4.21	3.35	3.46
Control	1.18	1.31	3.68	4.02	3.26	3.37
SEm(±)	0.004	0.003	0.027	0.013	0.081	0.083
C.D. (P=0.05)	0.013	0.010	0.079	0.040	N.S.	N.S.

N.S. non significant

Fig. 4.3 Effect of integrated nutrient management on number of effective tillers m^{-1} row length in wheat at various stages.

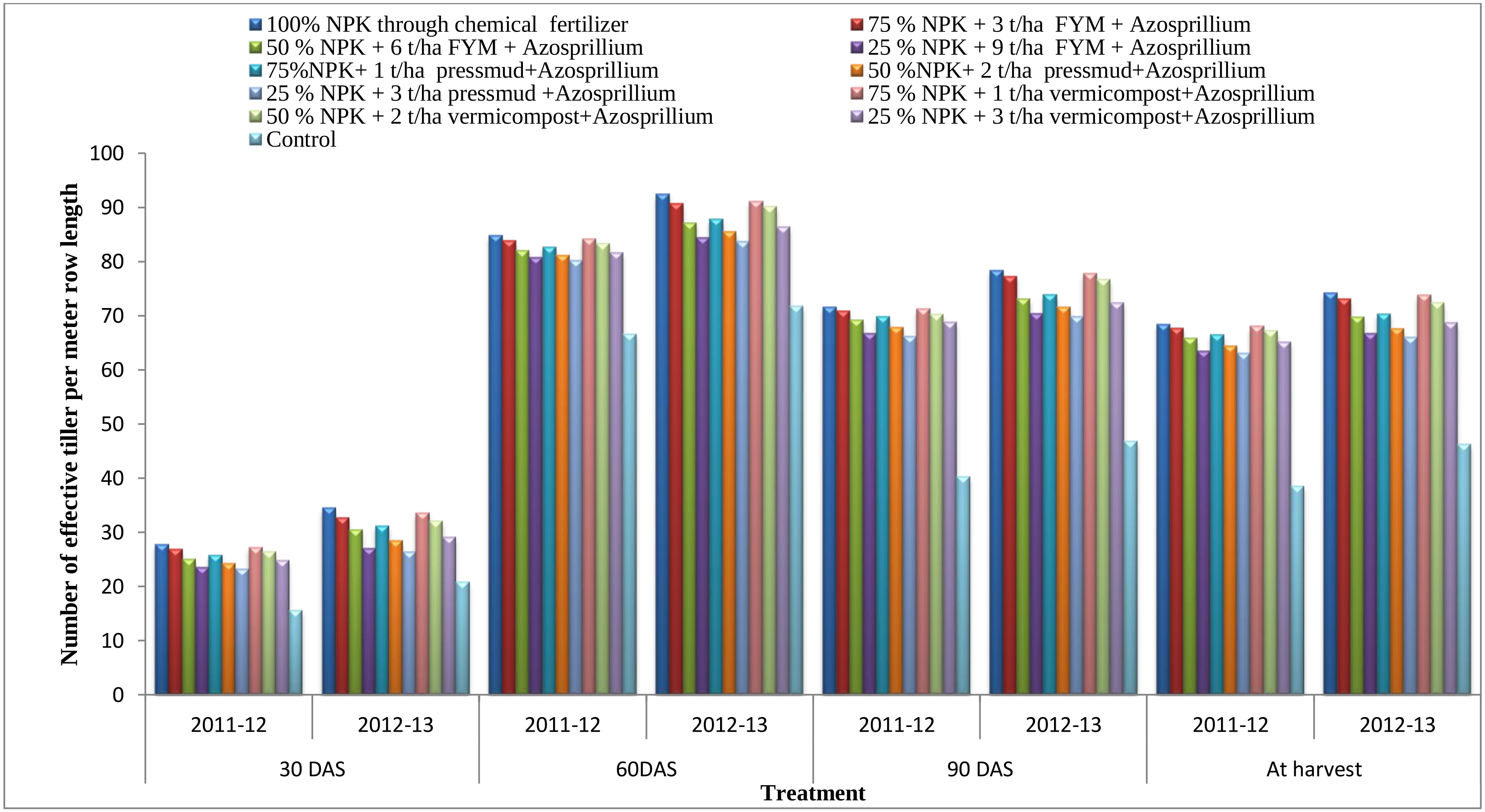
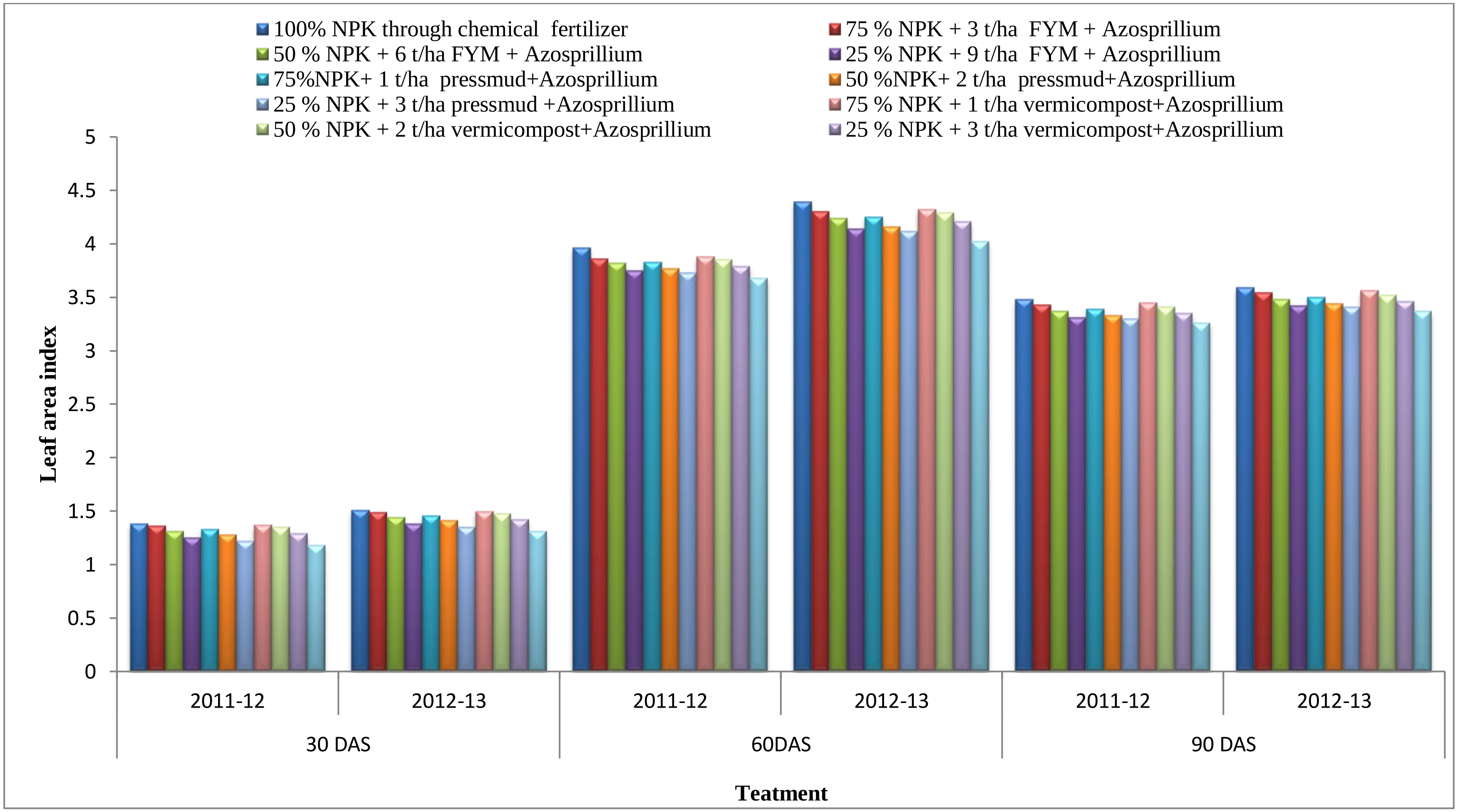


Fig.4.4 Effect of integrated nutrient management on Leaf area index in wheat at various stages.



of the treatment and at 30 and 60 DAS while remain unaffected at 90 DAS during both the year. The Lower LAI was recorded on control plot at 30, at 60, at 90 DAS during both years.

4.2 Yield and Yield attributes

Data on various yield attributing characters viz; spike length, number of spikelets/spike, number of grains/spike and test weight as influenced by different treatments were recorded and presented in (Table 4.5 depicted in (Fig 4.5) and their analysis of variance is presented in Appendix VII.

4.2.1 Spike length (cm)

The crop performed better during 2012-13 than in 2011-12 in respect of spike length. Further the data indicated that spike length differ with the nutrient management option irrespective of years. The spike length measure was significantly affected by nutrient management practices during both the years. Application of 100% NPK resulted in higher spike length (9.6 and 9.9) which was at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium (9.3 and 9.3) and significantly higher than the rest of the treatments during both years. The minimum spike length (5.4 and 5.8) was recorded in control plots.

4.2 .2 Number of spikelets per spike

Nutrient management option significantly influenced the number of spikelet's $spike^{-1}$ during both the years. The data pertaining are presented in (Table 4.5) depicted in (Fig 4.5) and their analysis of variance is presented in Appendix VII.

Number of spikelets per spike were influenced significantly due to nutrient management practices. The highest number of spikelets (14.8 and 15.6) per spike was observed in 100% NPK and these were found statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during 2011-12 and 2012-13 and significantly higher than the remaining treatments. The minimum number of spikelets per spike was recorded in control treatments.

4.2.3 Number of grains per spike

The variations in number of grains spike^{-1} were significant for nutrient management practices during both the years the data was recorded are presented in (Table 4.5) depicted in (Fig 4.5) and their analysis of variance is presented in Appendix VII.

In general, higher number of grains spike^{-1} was noticed in 2012-13 than in 2011-12. Further, perusal of data indicated that number of grains spike^{-1} differ with nutrient management option during both the years. Number of grains per spike were affected significantly by the nutrient management practices. Among nutrient management practices significantly higher number of grains (35.5 and 36.7) per spike was observed under 100% NPK over the treatments being at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium in respect to grains per spike during both the year 2011-12 and 2012-13. The minimum number of grains per spike was recorded in control treatments during both years.

4.2.4 1000-grain weight (g)

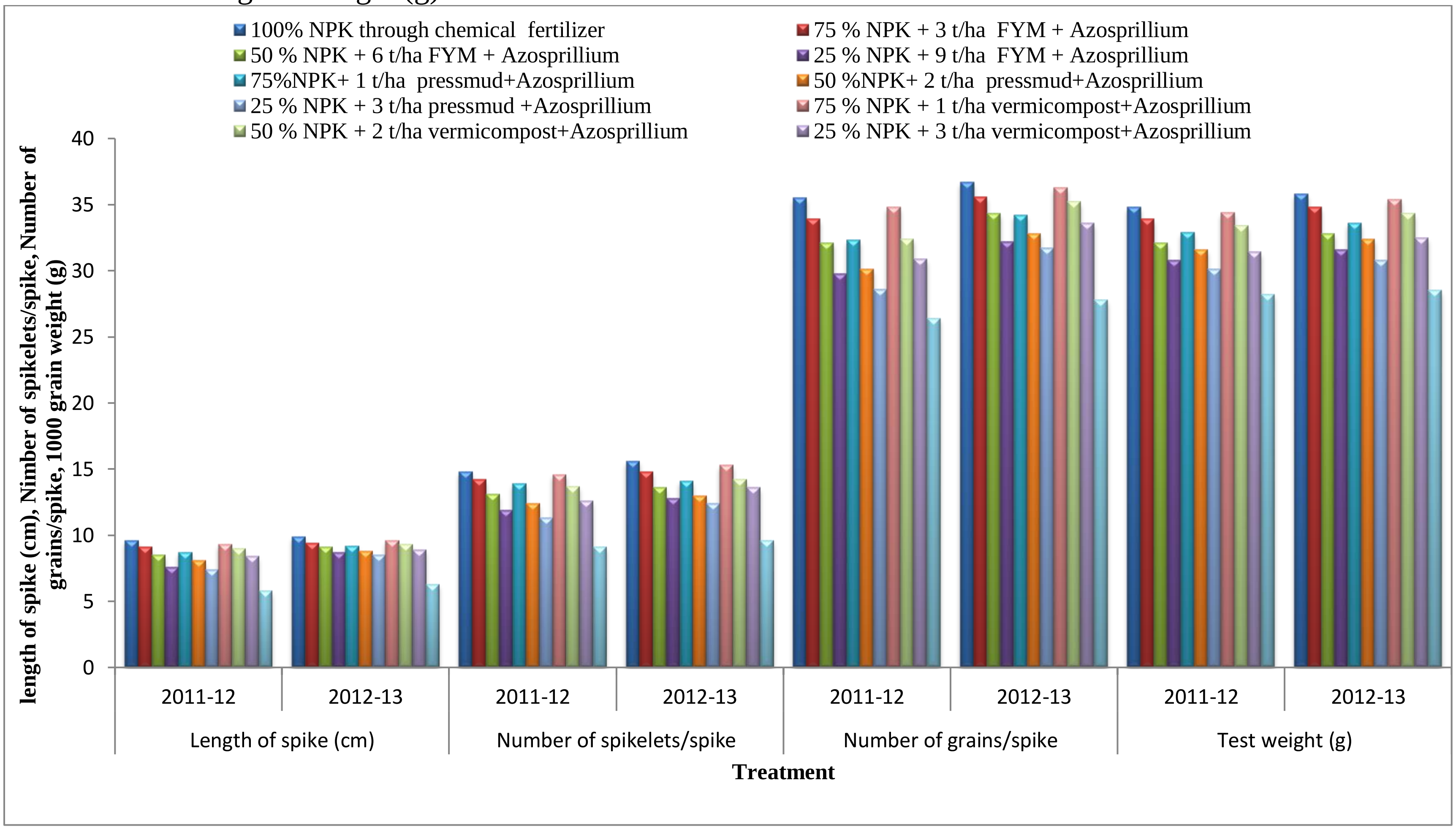
Significant variation in 1000-grain weight was recorded under nutrient management option during both the years. The data pertaining to test weight i.e 1000 grain weight of wheat recorded are presented in (Table 4.5) depicted in (Fig 4.5) and their analysis of variance is presented in Appendix VII.

The nutrient management practices had significantly affected on the 1000-grains weight of wheat during both years. The higher test weight (34.8 and 35.8) observed in the treatment 100% NPK statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during 2011-12 and 2012-13, were significantly superior over rest of the treatments. Lowest test weight (28.2 and 28.5) was recorded in control treatment.

Table 4. 5 Effect of integrated nutrient management on length of spike (cm), spikelet's spike^{-1}, number of grain spike^{-1} and 1000-grain weight (g).

Treatment	**Length of spike (cm)**		**Number of spikelets/spike**		**Number of grains/spike**		**1000 -grain weight (g)**	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	9.6	9.9	14.8	15.6	35.5	36.7	34.8	35.8
75 % NPK + 3 t/ha FYM + *Azosprillium*	9.1	9.4	14.2	14.8	33.9	35.6	33.9	34.8
50 % NPK + 6 t/ha FYM + *Azosprillium*	8.5	9.1	13.1	13.6	32.1	34.3	32.1	32.8
25 % NPK + 9 t/ha FYM + *Azosprillium*	7.6	8.7	11.9	12.8	29.8	32.2	30.8	31.6
75%NPK+ 1 t/ha pressmud+*Azosprillium*	8.7	9.2	13.9	14.1	32.3	34.2	32.9	33.6
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	8.1	8.8	12.4	13.0	30.1	32.8	31.6	32.4
25 % NPK + 3 t/ha pressmud +*Azosprillium*	7.4	8.5	11.3	12.4	28.6	31.7	30.1	30.8
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	9.3	9.6	14.6	15.3	34.8	36.1	34.4	35.4
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	9.0	9.3	13.7	14.2	32.4	35.2	33.4	34.3
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	8.4	8.9	12.6	13.6	30.9	33.6	31.4	32.5
Control	5.8	6.3	9.1	9.6	26.4	27.8	28.2	28.5
SEm(±)	0.15	0.13	0.14	0.23	0.39	0.34	0.29	0.29
C.D. (P=0.05)	0.44	0.39	0.43	0.68	1.17	1.01	0.86	0.85

Fig. 4.5 Effect of integrated nutrient management on length of spike (cm), spikelet's spike^{-1}, number of grain spike^{-1} and 1000-grain weight (g).



4.3 Grain yield (q ha^{-1})

Significant variation was noted in wheat grain yield under different nutrient management option during both the years (Table 4.6), depicted in (Fig 4.6) and their analysis of variance in Appendix VIII. A close perusal of the data shows that yield was more during second year than first year of experimentation.

The yield is the final assessment of treatment in any agronomic investigation. Grain yield was significantly influenced by nutrient management practices. Adoption of nutrient management practices increased the grain yield significantly over control treatment during both years. The maximum grain yield (41.50 and 43.78 q ha^{-1}) observed with the application of 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the remaining treatments during both the year. Lowest grain yield (24.10 and 25.23) was recorded in control. Grain yield increased by 41.92 and 41.33 percent due to application 100% NPK and 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium over control during 2011-2012. While such increase was 42.37 and 40.43 percent during 2012-2013. Inoculation effect of Azosprillium along with FYM and V.C on grain yield of wheat was more or less similar during both the year while pressnud was found significantly inferior to vermicompost.

4.3.1 Straw yield q ha^{-1}

Difference in straw yield per hectare due to nutrient management practices was significant during both the years. Data pertaining to the straw yield as influenced by nutrient management option are presented in (Table 4.6), depicted in (Fig 4.6) and their analysis of variance is presented in Appendix VIII.

The data indicate that straw yield varied significantly due to nutrient management treatments during both the years. The highest straw yield (60.90 and 62.26) recorded with the application of 100% NPK was found statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the remaining treatments during both the years. Straw yield increased by 35.20 and 34.75 percent due to application 100% NPK and 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium over control during 2011-2012. While such increase was 34.13 and 62.67 percent during 2012-2013. Lowest straw yield (43.43 and 41.23) was recorded in control treatment.

4.3.2 Biological yield q ha^{-1}

Various nutrient management practices brought significant differences in biological yield of wheat during both the years. A close perusal of the data presented in (Table 4.6), depicted in (Fig 4.6) and their analysis of variance is presented in Appendix VIII. Reveal that adoption of nutrient management practices increased the biological yield significantly over control during both years. Biological yield decreased significantly with nutrient management, 100% NPK produced higher biological yield as compared to other nutrient management options during both the year. The maximum biological yield (102.40 and 106.04) observed in the treatment 100% NPK was statistically at par with the 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly superior over rest of the treatments during both years. Lowest biological yield (63.56 and 66.23) was recorded in control treatment.

4.3.3 Harvest Index

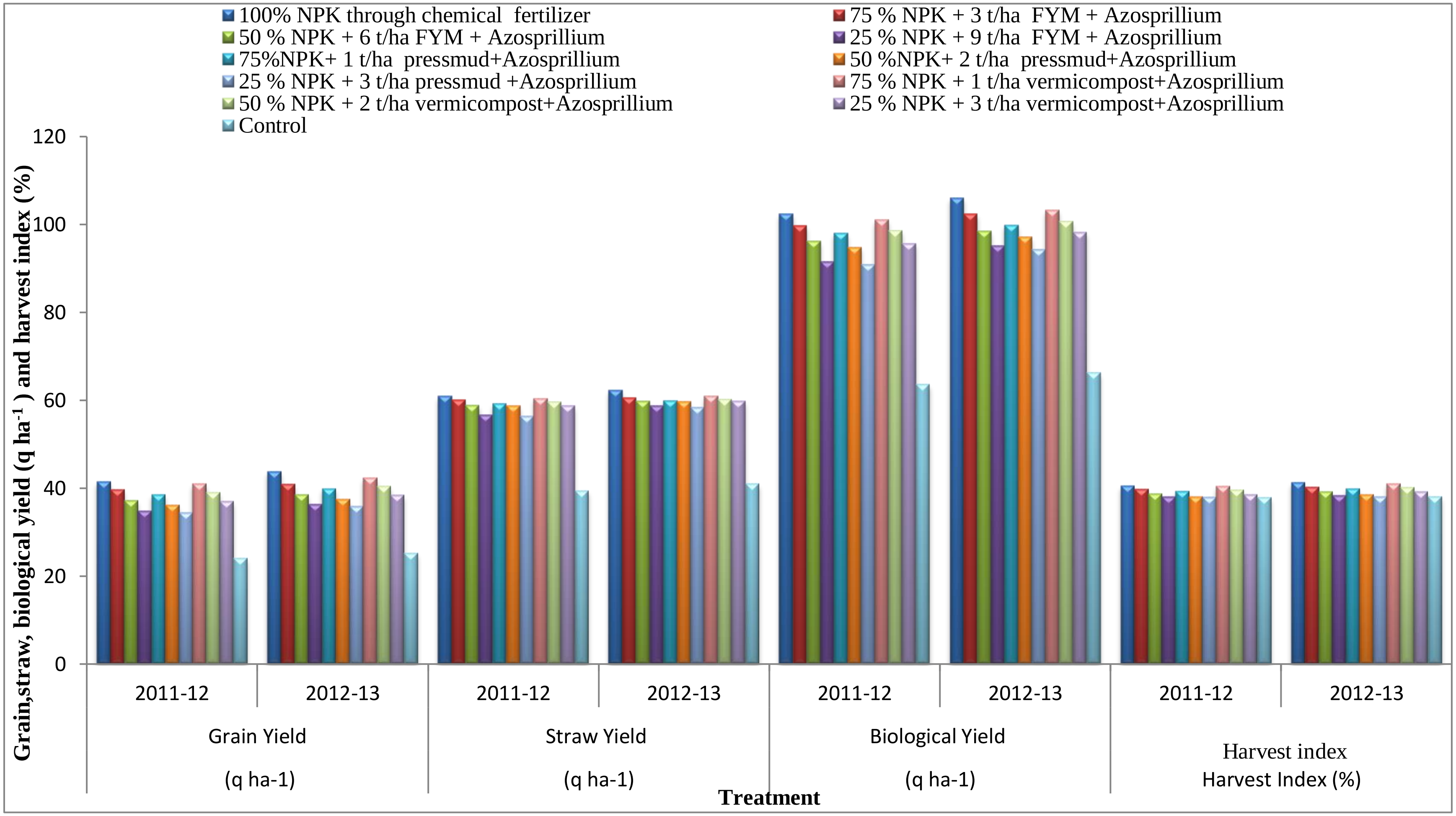
Harvest index, a measure of source-sink relationship, differed non significantly under nutrient management practices. The data pertaining harvest index to wheat recorded is presented in (Table 4.6) and (Fig 4.6) and their analysis of variation are presented in Appendix VIII.

Table 4.6 Effect of integrated nutrient management on Grain, straw, biological yield (q ha^{-1}) and harvest index (%) of wheat.

Treatment	**Grain Yield (q ha^{-1})**		**Straw Yield (q ha^{-1})**		**Biological Yield (q ha^{-1})**		**Harvest Index (%)**	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	41.50	43.78	60.90	62.26	102.40	106.04	40.52	41.28
75 % NPK + 3 t/ha FYM + *Azosprillium*	39.70	40.86	60.05	60.54	99.75	102.40	39.79	40.25
50 % NPK + 6 t/ha FYM + *Azosprillium*	37.26	38.63	58.86	59.82	96.12	98.45	38.76	39.23
25 % NPK + 9 t/ha FYM + *Azosprillium*	34.85	36.45	56.63	58.69	91.48	95.14	38.09	38.31
75%NPK+ 1 t/ha pressmud+A*zosprillium*	38.59	39.94	59.26	59.94	98.01	99.88	39.37	39.98
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	36.14	37.48	58.66	59.71	94.80	97.19	38.12	38.56
25 % NPK + 3 t/ha pressmud +*Azosprillium*	34.50	35.94	56.38	58.36	90.94	94.30	37.93	38.11
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	41.08	42.36	60.42	60.90	101.05	103.26	40.47	41.02
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	39.08	40.45	59.58	60.15	98.66	100.70	39.61	40.16
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	37.00	38.45	58.72	59.78	95.72	98.23	38.65	39.14
Control	24.10	25.23	39.46	41.00	63.56	66.23	37.91	38.09
SEm(±)	0.55	0.66	0.17	0.40	0.87	1.12	2.84	2.86
C.D. (P=0.05)	1.63	1.97	0.50	1.19	2.58	3.32	N.S.	N.S.

N.S. non significant

Fig. 4.6 Effect of integrated nutrient management on Grain, straw, biological yield (q ha^{-1}) and harvest index (%) of wheat.



Harvest index which express proportion of economic yield in total biological yield did not influenced significantly by the nutrient management practices during both years. Numerically maximum harvest index value (40.52 and 41.28) was observed in the treatment 100% NPK than rest of the treatments during both years. Lowest harvest index (37.91 and 38.09) was recorded in control treatment.

4.4 Nutrient content (%) and uptake (kg ha^{-1}) by crop

4.4.1 Nitrogen content

Data pertaining to the nitrogen content in wheat grain and straw are presented in (Table 4.7), depicted in (Fig 4.7a) and their analysis of variation are presented in Appendix IX.

Application of nutrient management treatments significantly affected the nitrogen content in grain as well as straw during both years of study. The maximum nitrogen content (1.71 and 1.93) in grain recorded with the treatment 100% NPK was at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the remaining treatments during both years. Highest nitrogen content (0.41 and 0.46) in straw was recorded in treatment 100% NPK which were at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the remaining treatments during 2011-12 and 2012-13. Lowest nitrogen content in grain (1.23 and 1.26) was recorded in control plots. Similarly lowest nitrogen content was found in control plot straw during both the years.

4.4.2: Nitrogen Uptake

The data pertaining nitrogen uptake by grain and straw of wheat are presented in (Table 4.7), depicted in (Fig 4.7b) and their analysis of variation are presented in Appendix IX.

Nitrogen uptake was more during 2012-13 in both grain as well as in straw. The uptake of nitrogen in grain and straw differ significantly with the application of nutrient management treatments during both years. Maximum nitrogen uptake (70.96 and 84.70) in grain recorded with the application of 100 % NPK was statistically similar to T_8 and significantly higher than rest of the treatments during both years. Highest nitrogen uptake (24.97 and 28.63) in straw recorded in treatment 100% NPK was statistically at par with T_8 and significantly higher than rest of the treatments during both years. Lowest nitrogen uptake by grain (29.64 and 31.92) and straw (6.70 and 7.38) was recorded in control plots.

4.4.3: Total Nitrogen Uptake

The data pertaining total nitrogen uptake by wheat are presented in (Table 4.7), depicted in (Fig 4.7b) and their analysis of variation are presented in Appendix IX.

Total uptake of nitrogen differ significantly with the application of nutrient management practices during both years. The highest total uptake of nitrogen (95.93 and 113.12) by wheat recorded with the treatment 100% NPK was statistically at par with T_8 and significantly higher than rest of the treatments during both years. Lowest total nitrogen uptake (36.34 and 39.16) was recorded in control plots during 2011-12 and 2012-13 respectively.

4.4.4: Phosphorus content

The data pertaining to phosphorus content of wheat grain and straw given in (Table 4.8), depicted in (Fig 4.8a) and their analysis of variation are presented in Appendix X.

Phosphorus content was more in grain as compared to straw during both years. The maximum phosphorus content (0.36 and 0.37) in grain recorded with the treatment 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the rest of the treatment during both the year 2011-12 and 2012-

Table 4.7 Effect of integrated nutrient management on N content, N uptake and total uptake of nitrogen by Grain and Straw of wheat.

Treatment	**N content (%)**				**N uptake (kg ha^{-1})**				**Total uptake (kg ha^{-1})**	
	Grain		Straw		Grain		Straw			
	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13
100% NPK through chemical fertilizer	1.71	1.93	0.41	0.46	70.96	84.7	24.97	28.63	95.93	113.12
75 % NPK + 3 t/ha FYM + *Azosprillium*	1.62	1.80	0.36	0.40	64.31	74.7	21.61	24.21	85.92	97.75
50 % NPK + 6 t/ha FYM + *Azosprillium*	1.52	1.68	0.31	0.34	56.63	65.45	18.24	20.33	74.87	85.22
25 % NPK + 9 t/ha FYM + *Azosprillium*	1.41	1.57	0.24	0.28	49.14	57.36	13.59	16.43	62.73	73.65
75%NPK+ 1 t/ha pressmud+*Azosprillium*	1.55	1.72	0.34	0.38	59.81	68.69	20.14	22.77	79.95	91.46
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	1.45	1.61	0.26	0.29	52.40	60.34	15.25	17.31	67.65	77.65
25 % NPK + 3 t/ha pressmud +*Azosprillium*	1.37	1.55	0.20	0.23	47.26	56.57	11.27	13.42	58.53	69.12
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	1.68	1.88	0.38	0.42	69.01	80.01	22.96	25.57	91.97	105.20
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	1.60	1.76	0.35	0.37	62.53	72.58	20.85	22.25	83.38	93.44
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	1.47	1.62	0.29	0.33	54.39	62.4	17.02	19.72	71.41	82.00
Control	1.23	1.26	0.17	0.18	29.64	31.92	6.70	7.38	36.34	39.16
SEm(±)	0.011	0.030	0.01	0.02	1.79	3.12	0.93	1.01	3.04	4.08
C.D. (P=0.05)	0.033	0.088	0.04	0.05	5.32	9.21	2.77	2.99	9.05	12.12

Fig.4.7(a) Effect of integrated nutrient management on N content by Grain and Straw of wheat.

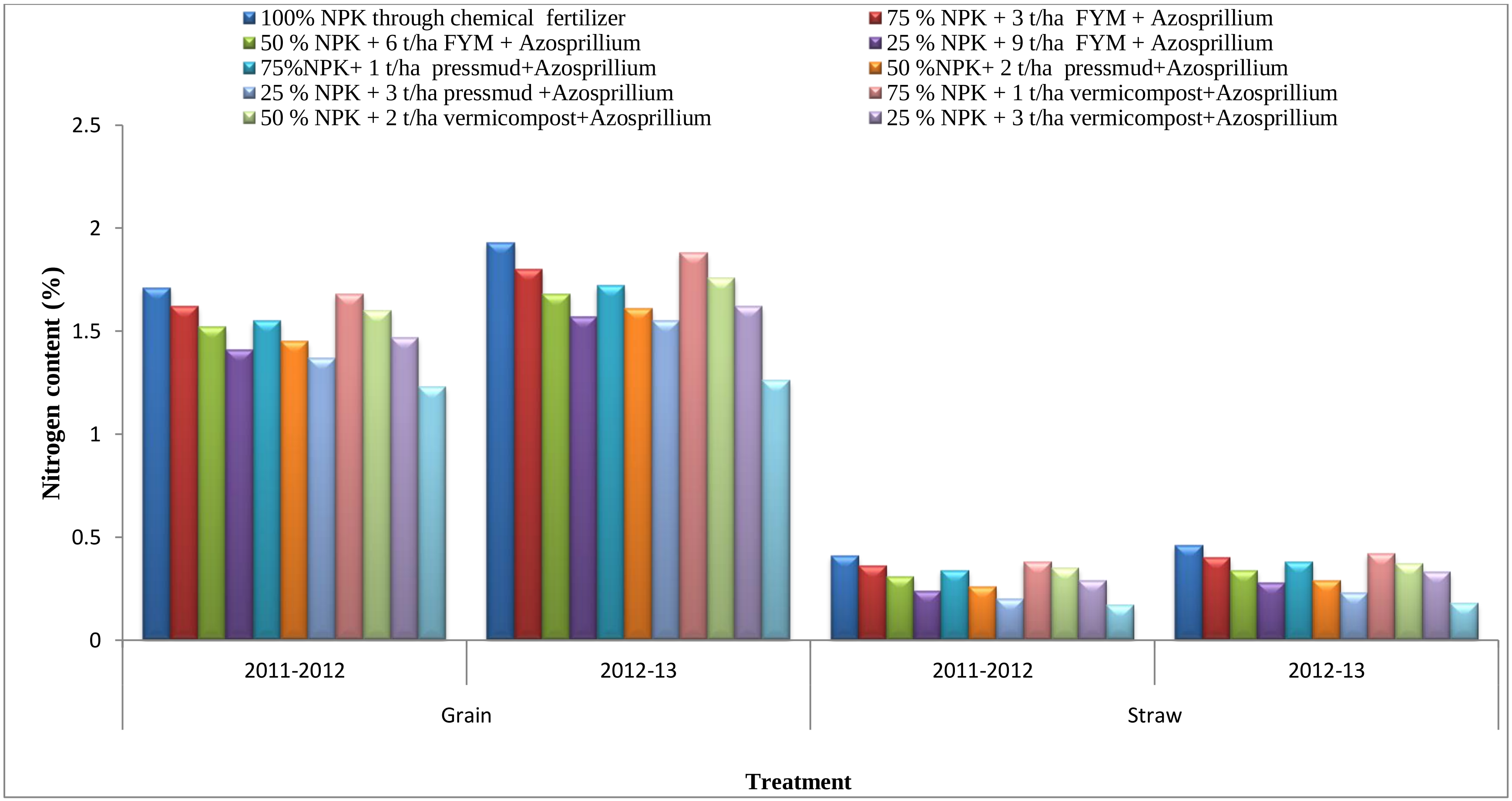
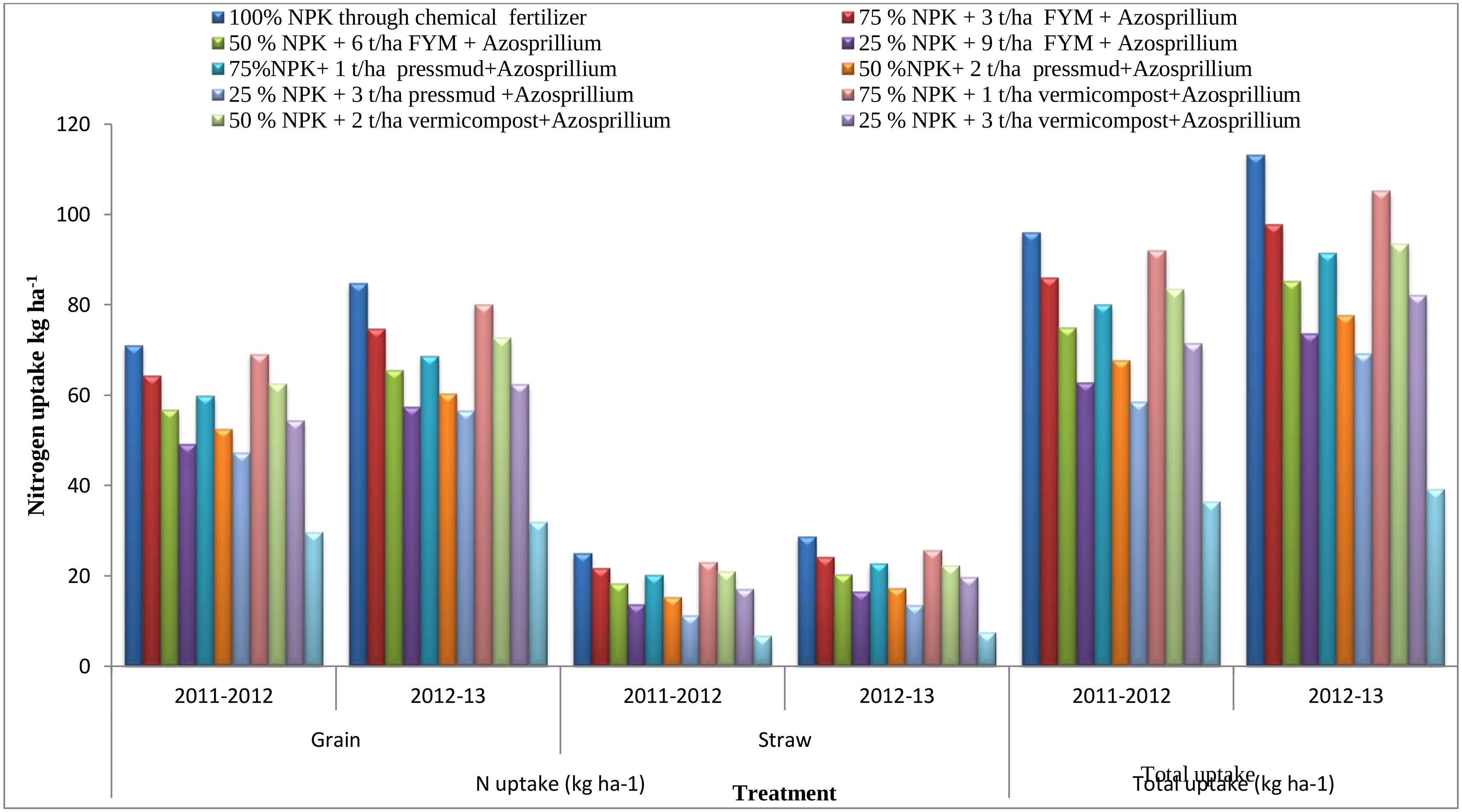


Fig.4.7(b) Effect of integrated nutrient management on N uptake, total uptake of nitrogen by Grain and Straw of wheat.



2013. Highest phosphorus content (0.17 and 0.19) in straw was recorded in treatment 100% NPK being statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than rest of the treatments during both years. Lowest phosphorus content in grain (0.25 and 0.27) and (0.10 and 0.11) in straw was recorded in control plots.

4.4.5: Phosphorus uptake

The data pertaining phosphorus uptake by wheat grain and straw are presented in (Table 4.8), depicted in (Fig 4.8b) and their analysis of variation are presented in Appendix X.

Application of nutrient management treatments resulted in a significant variation in phosphorus uptake by wheat grain as well as in straw. The maximum phosphorus uptake (14.52 and 15.76) in grain recorded with the treatment 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the rest of the treatment during both the year 2011-12 and 2012-2013. Highest phosphorus uptake (9.74 and 11.20) by straw also recorded in treatment 100% was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during both the year. Lowest phosphorus uptake by grain (6.02 and 6.81) and (3.94 and 4.51) by straw was recorded in control plots.

4.4.6: Total phosphorus uptake

The data pertaining total phosphorus uptake by wheat are presented in (Table 4.8), depicted in (Fig 4.8b) and their analysis of variation are presented in Appendix X.

Total uptake of phosphorus in wheat was significantly affected by different nutrient management treatments over the control during both years. The maximum total phosphorus uptake (24.26 and 26.96) in wheat recorded with the treatment 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during both the year. Lowest

Table 4.8 Effect of integrated nutrient management on P content, P uptake and total uptake of Phosphorus by Grain and Straw of wheat.

Treatment	P content (%)				P uptake (kg ha^{-1})				Total uptake (kg ha^{-1})	
	Grain		Straw		Grain		Straw			
	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13
100% NPK through chemical fertilizer	0.36	0.37	0.17	0.19	14.52	15.76	9.74	11.20	24.26	26.96
75 % NPK + 3 t/ha FYM + *Azosprillium*	0.33	0.34	0.15	0.17	13.10	13.89	9.00	10.29	22.10	24.18
50 % NPK + 6 t/ha FYM + *Azosprillium*	0.31	0.32	0.12	0.13	11.55	12.36	7.06	7.77	18.61	20.13
25 % NPK + 9 t/ha FYM + *Azosprillium*	0.30	0.31	0.11	0.11	10.45	11.30	6.22	6.45	16.67	17.75
75%NPK+ 1 t/ha pressmud+A*zosprillium*	0.32	0.33	0.13	0.12	12.34	13.18	7.70	7.19	20.04	20.37
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	0.30	0.31	0.11	0.12	10.84	11.61	6.45	7.16	17.29	18.77
25 % NPK + 3 t/ha pressmud +*Azosprillium*	0.29	0.30	0.11	0.11	10.00	10.78	6.20	6.41	16.20	17.19
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	0.34	0.35	0.16	0.17	13.96	14.82	9.66	10.35	23.62	25.17
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	0.32	0.33	0.15	0.16	12.50	13.34	8.93	9.62	21.43	22.96
25 % NPK + 3 t/ha vermicompost+Azosprillium	0.31	0.32	0.12	0.13	11.47	12.30	7.04	7.77	18.51	20.07
Control	0.25	0.27	0.10	0.11	6.02	6.81	3.94	4.51	9.96	11.32
SEm(±)	0.006	0.006	0.004	0.006	0.464	0.475	0.223	0.261	0.744	0.852
C.D. (P=0.05)	0.018	0.017	0.012	0.017	1.378	1.410	0.664	0.774	2.211	2.533

Fig.4.8(a) Effect of integrated nutrient management on P content by Grain and Straw of wheat.

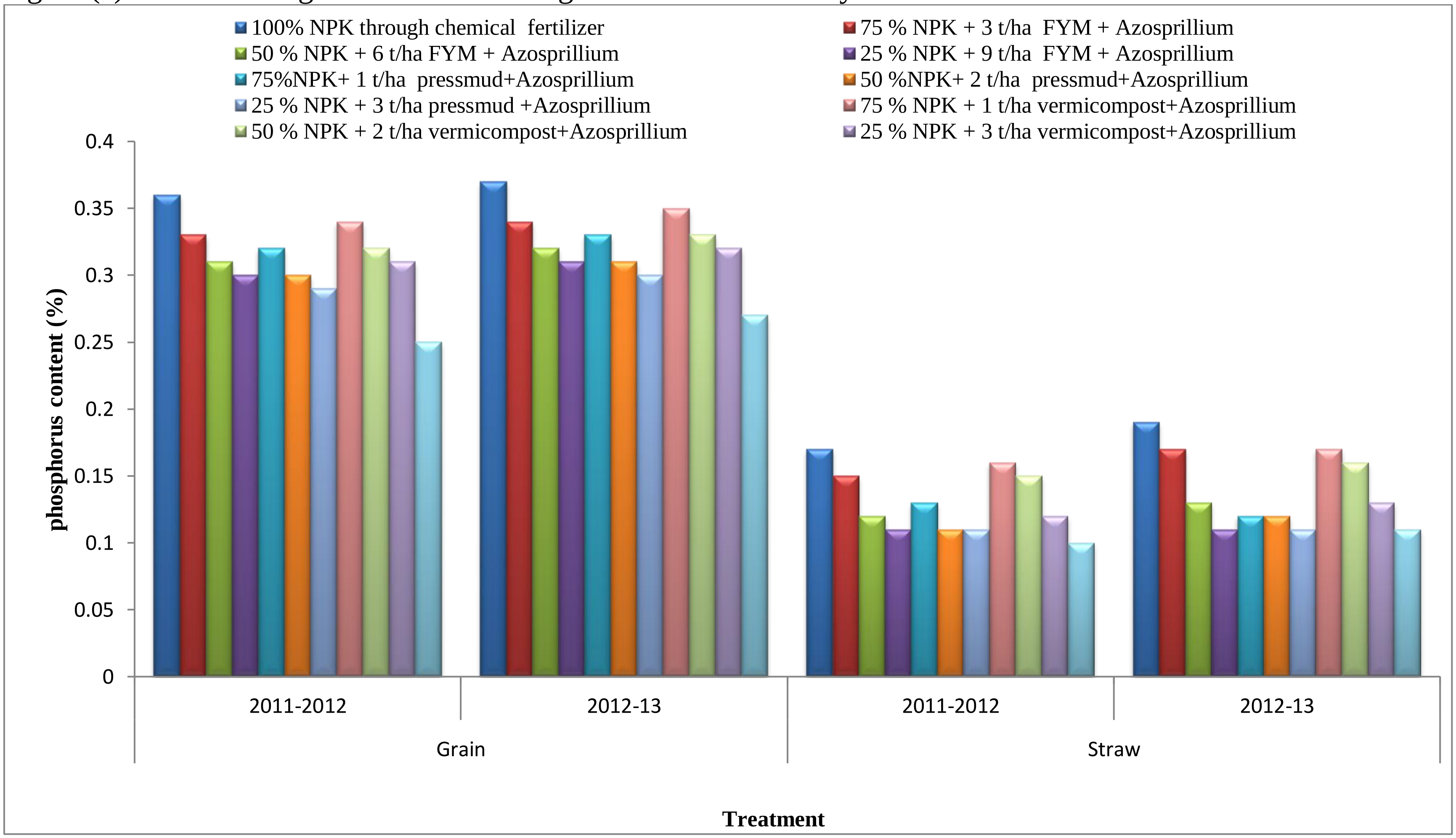
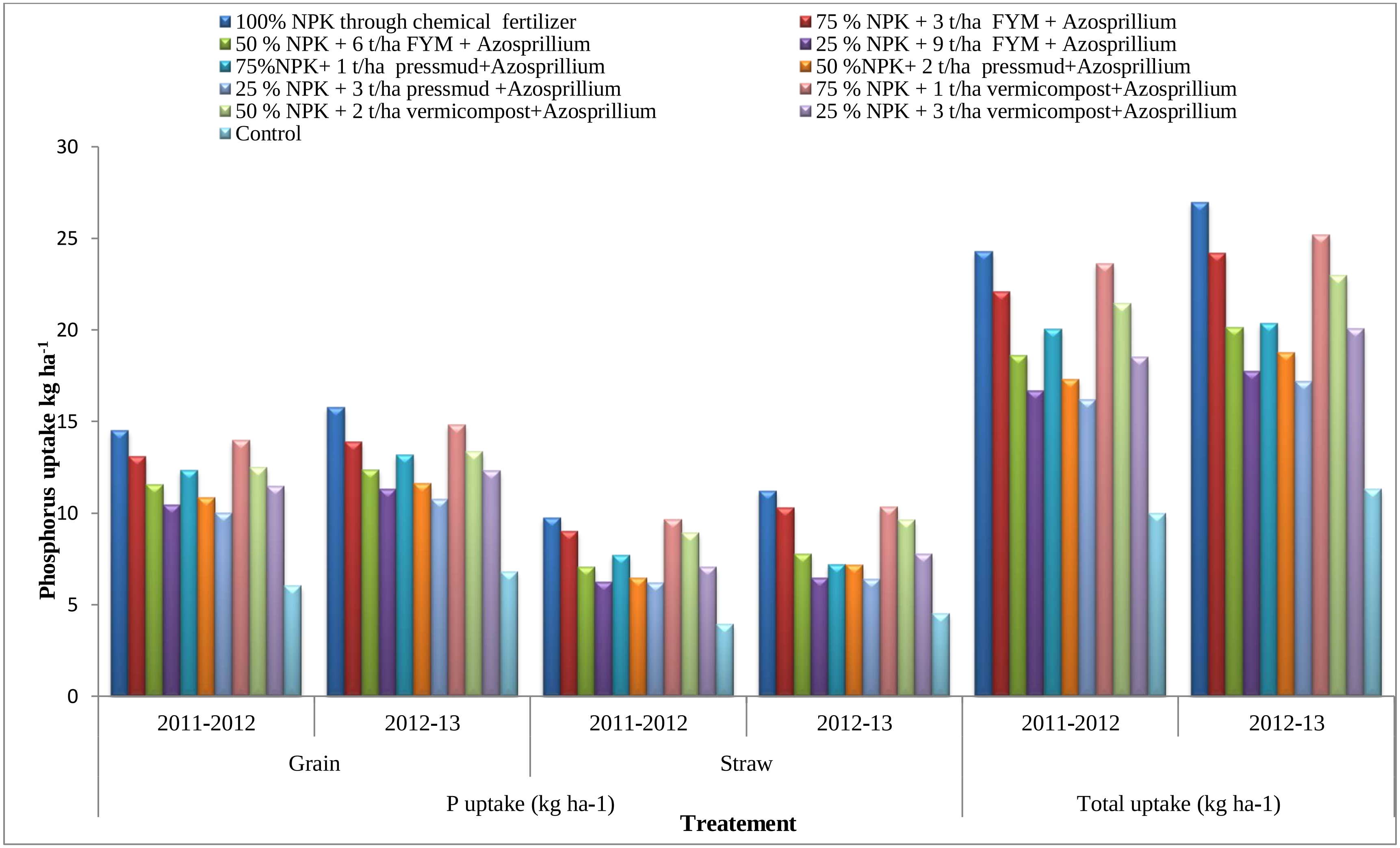


Fig.4.8 (b) Effect of integrated nutrient management on P uptake, total uptake of Phosphorus by Grain and Straw of wheat.



total phosphorus uptake (9.96 and 11.32) was recorded in control plots during 2011-12 and 2012-13 respectively.

4.4.7: Potassium content

The data pertaining to potassium content of wheat grain and straw are presented in (Table 4.9), depicted in (Fig 4.9a) and their analysis of variation are presented in Appendix XI.

Potassium content in grain and straw was significantly affected by different nutrient treatments during both years. The maximum potassium content (0.42 and 0.44) in grain recorded with the treatment 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the rest of the treatments during both years. Highest potassium content (1.66 and 1.68) by straw was recorded with the treatment 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the rest of the treatment during both years. Lowest potassium content in grain (0.25 and 0.27) and (1.21 and 1.22) straw was recorded in control plots.

4.4.8: Potassium uptake

The data pertaining to potassium uptake by wheat grain and straw are presented in (Table 4.9), depicted in (Fig 4.9b) and their analysis of variation is presented in Appendix XI.

Application of nutrient management treatments gave significantly higher uptake of potassium in grain as well as in straw over control. The maximum potassium uptake (17.01and 18.82) by grain recorded with the treatment 100% NPK was statistically at par with 75 % NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and significantly higher than the rest of the treatment during both years. Highest potassium uptake (101.09 and 104.60) by straw recorded with the treatment 100% NPK was statistically at par with 75% NPK + 1 ton ha^{-1}

Table 4.9 Effect of integrated nutrient management on K content, K uptake, total uptake of Potassium by Grain and Straw of wheat.

Treatment	K content (%)				K uptake (kg ha^{-1})				Total uptake (kg ha^{-1})	
	Grain		Straw		Grain		Straw			
	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13	2011-2012	2012-13
100% NPK through chemical fertilizer	0.42	0.44	1.66	1.68	17.01	18.82	101.09	104.60	118.10	123.42
75 % NPK+3 t/ha FYM +*Azosprillium*	0.38	0.38	1.59	1.61	15.08	15.52	95.48	97.47	110.56	112.99
50 % NPK+6 t/ha FYM +*Azosprillium*	0.33	0.35	1.48	1.50	12.29	13.52	87.11	89.73	99.40	103.25
25 % NPK+9 t/ha FYM +*Azosprillium*	0.27	0.29	1.31	1.32	9.40	10.57	74.18	77.47	83.58	88.04
75%NPK+1 t/ha pressmud+*Azosprillium*	0.34	0.35	1.51	1.53	13.12	13.97	89.48	91.71	102.60	105.68
50 %NPK+2 t/ha pressmud+*Azosprillium*	0.29	0.31	1.34	1.36	10.48	11.61	78.60	81.21	89.08	92.81
25 % NPK+3 t/ha pressmud +*Azosprillium*	0.26	0.28	1.29	1.31	8.97	10.06	72.73	76.45	81.70	86.51
75 % NPK+1 t/ha vermicompost+*Azosprillium*	0.40	0.41	1.62	1.64	16.43	17.36	97.88	99.88	114.31	117.24
50 % NPK+2 t/ha vermicompost+*Azosprillium*	0.36	0.37	1.57	1.59	14.06	14.96	93.54	95.64	107.60	110.60
25 % NPK+3 t/ha vermicompost+*Azosprillium*	0.32	0.33	1.37	1.39	11.84	12.68	80.45	83.09	92.29	95.77
Control	0.25	0.27	1.21	1.22	6.02	6.81	47.75	50.02	53.77	56.83
SEm(±)	0.009	0.008	0.016	0.018	0.597	0.701	2.129	2.127	1.589	1.621
C.D. (P=0.05)	0.026	0.023	0.049	0.055	1.772	2.082	6.324	6.319	4.721	4.816

Fig.4.9(a) Effect of integrated nutrient management on K content by Grain and Straw of wheat.

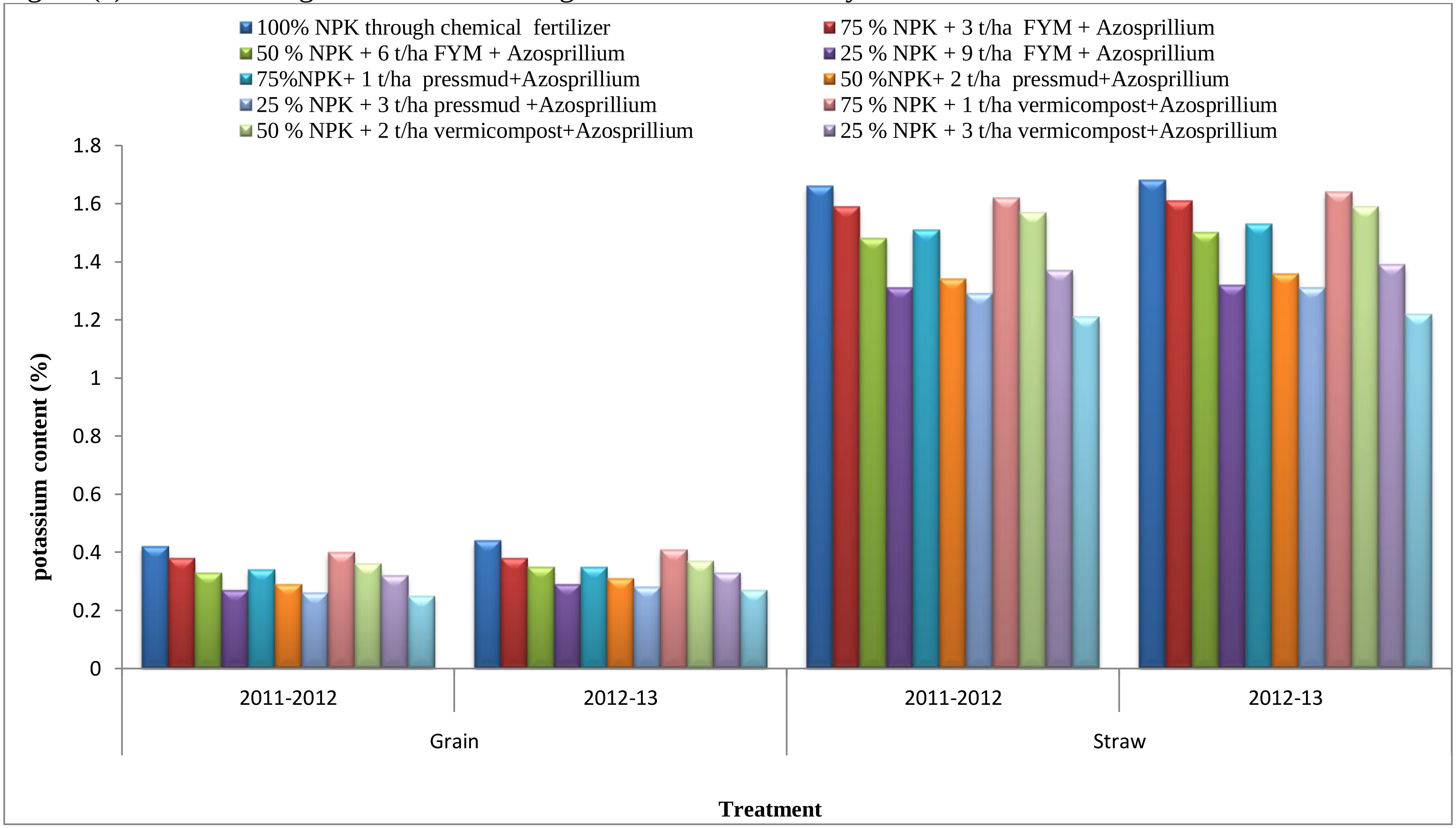
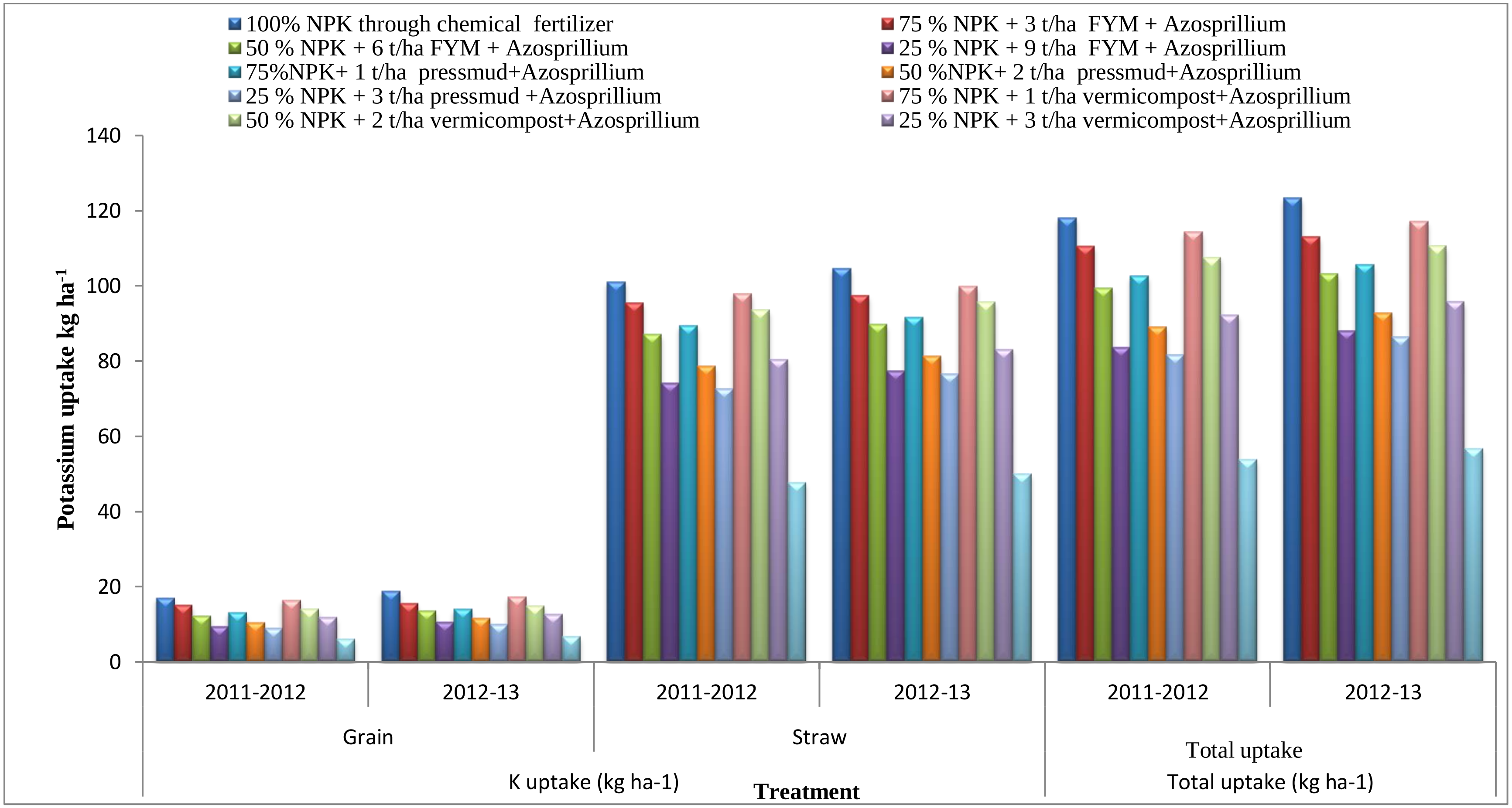


Fig.4.9(b) Effect of integrated nutrient management on K uptake, total uptake of Potassium by Grain and Straw of wheat.



vermicompost+ Azosprillium and significantly higher than the rest during both the year 2011-12 and 2012-2013. Lowest potassium content in grain (60.02 and 6.81) and (47.75 and 50.02) straw was recorded in control plots.

4.4.9: Total potassium uptake

The data pertaining total potassium uptake by wheat are presented in (Table 4.9), depicted in (Fig 4.9) and their analysis of variation are presented in Appendix XI.

Total potassium uptake by wheat was significantly affected by different nutrient management treatment over control during both years. The highest total potassium uptake (118.10 and 123.42) by wheat recorded with the treatment 100% NPK which was at par with the 75 % NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during both years. Lowest total potassium uptake (53.77 and 56.83) was recorded in control plots during 2011-12 and 2012-13 respectively.

4.5 Combined NPK uptake (Kg ha^{-1})

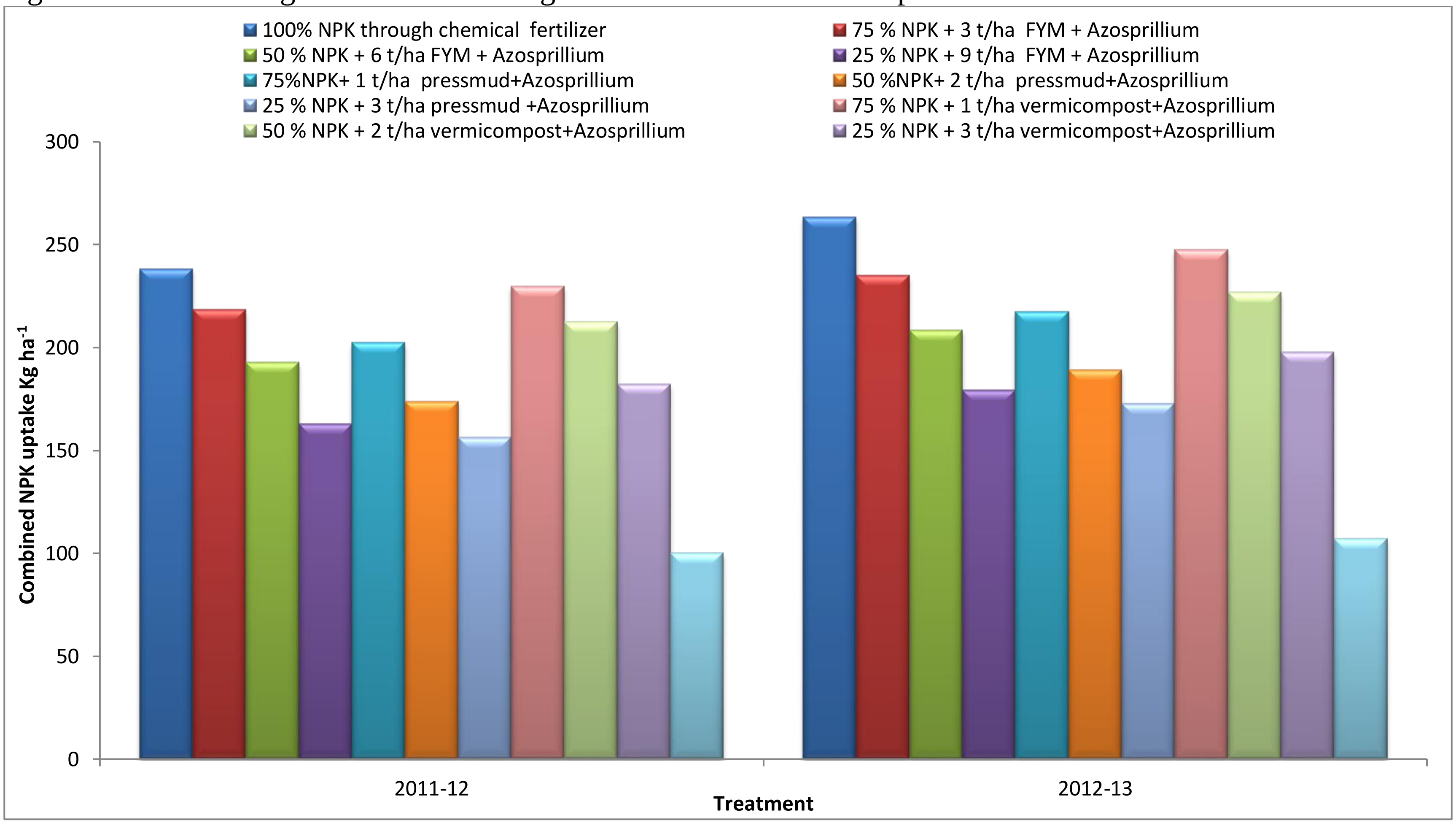
The data pertaining combined NPK uptake by wheat are presented in (Table 4.10), depicted in (Fig 4.10) and their analysis of variation are presented in Appendix XII.

Combined NPK uptake by wheat was significantly affected by different nutrient management treatment over control during both years. The maximum NPK uptake by wheat recorded with the treatment 100% NPK was at par with the 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during both years. Lowest NPK uptake was recorded in control plots during 2011-12 and 2012-13

Table 4.10 Effect of integrated nutrient management on combined NPK uptake of wheat.

Treatment	**Combined NPK uptake (Kg ha^{-1})**	
	2011-12	**2012-13**
100% NPK through chemical fertilizer	238.29	263.50
75 % NPK + 3 t/ha FYM + *Azosprillium*	218.58	234.92
50 % NPK + 6 t/ha FYM + *Azosprillium*	192.88	208.60
25 % NPK + 9 t/ha FYM + *Azosprillium*	162.98	179.44
75%NPK+ 1 t/ha pressmud+*Azosprillium*	202.59	217.51
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	174.02	189.24
25 % NPK + 3 t/ha pressmud +*Azosprillium*	156.43	172.82
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	229.90	247.61
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	212.41	227.0
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	182.21	197.84
Control	100.07	107.31
SEm(±)	3.316	5.028
C.D. (P=0.05)	9.851	14.938

Fig.4.10 Effect of integrated nutrient management on combined NPK uptake of wheat.



4.6 Protein content

Protein content in wheat grain is influenced significantly by the integrated nutrient management and Azosprillium application. The data related to protein content are presented in Table 4.11; Fig 4.11 and the analysis of variance are shown in Appendix XIII.

Application of 100% NPK has proven the best with (10.69 % and 12.06 %) protein content in grain at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium with (10.50% and 11.00 %) and significantly higher than the rest of the treatments during both the year . However, lowest protein content was recorded (7.69 % and 7.88 %) under treatment control plot during 2011- 2012 and 2012-2013.

4.7 Nutrient availability in soil

Soil samples were taken from plough layer of soil (15 cm depth) and were analysed for available N.P.K, organic carbon and soil pH after harvest of the wheat crop.

4.7.1 Available nitrogen in soil (kg ha^{-1})

The data pertaining to available nitrogen in soil are presented in (Table 4.12), depicted in (Fig 4.12) and their analysis of variation are presented in Appendix XIV.

Application of nutrient management treatment significantly improved the available nitrogen in soil over control during both years. It indicated that highest available nitrogen (235.60 and 236.71) in soil recorded with the treatment application 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium was at par with 100% NPK and significantly higher than the rest of the treatment during both years. Lowest available nitrogen (200.01 and 200.73) was recorded in control plots during 2011-12 and 2012-13 respectively.

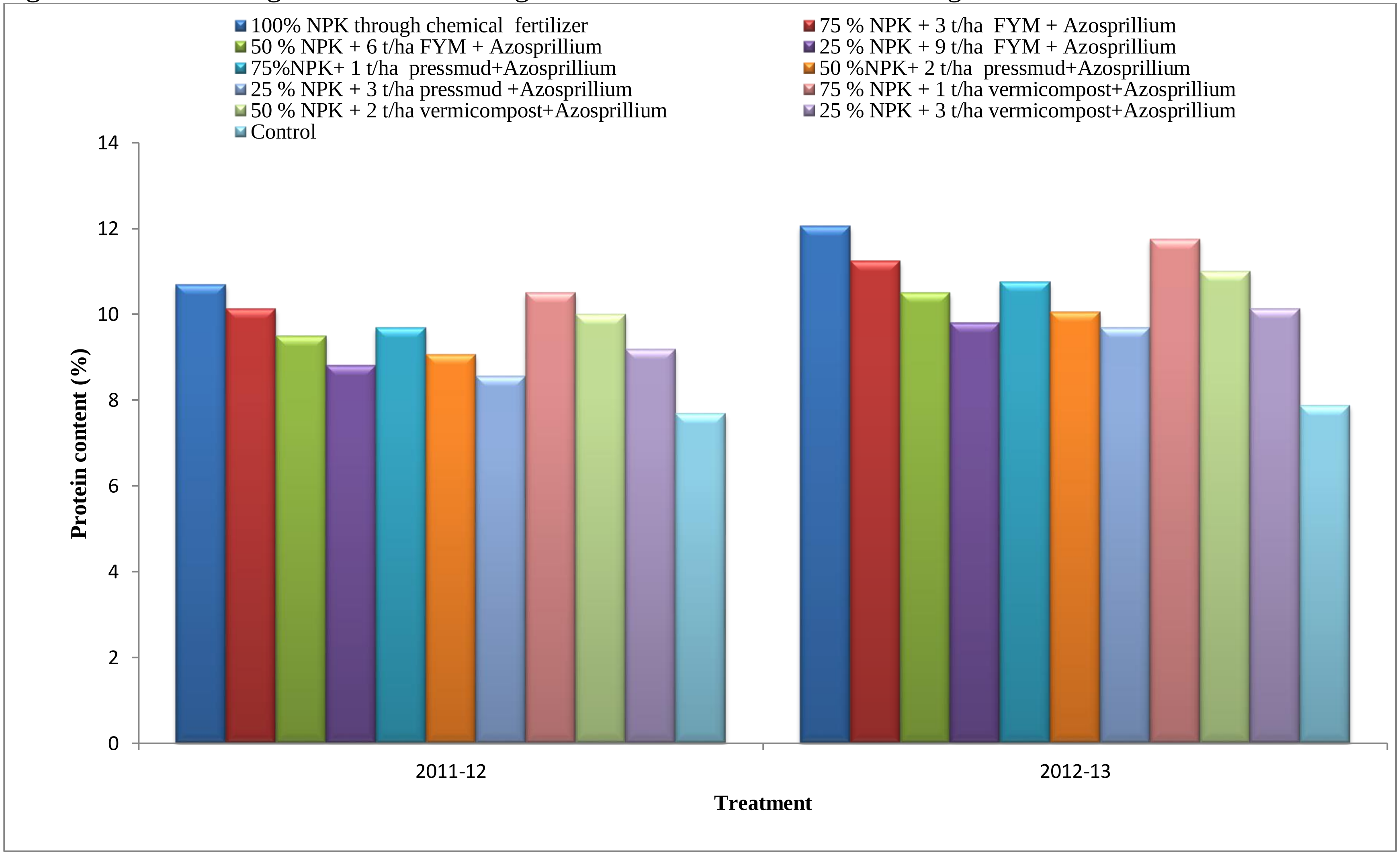
4.7.2 Available Phosphorus in soil (kg ha^{-1})

The data pertaining to available phosphorus in soil are presented in (Table 4.12), depicted in (Fig 4.12) and their analysis of variation are presented in Appendix XIV.

Table 4.11 Effect of integrated nutrient management on Protein content in wheat grain.

Treatment	Protein content (%)	
	2011-12	**2012-13**
100% NPK through chemical fertilizer	10.69	12.06
75 % NPK + 3 t/ha FYM + *Azosprillium*	10.13	11.25
50 % NPK + 6 t/ha FYM + *Azosprillium*	9.50	10.50
25 % NPK + 9 t/ha FYM + *Azosprillium*	8.81	9.81
75%NPK+ 1 t/ha pressmud+*Azosprillium*	9.69	10.75
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	9.06	10.06
25 % NPK + 3 t/ha pressmud +*Azosprillium*	8.56	9.69
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	10.50	11.75
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	10.00	11.00
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	9.19	10.13
Control	7.69	7.88
SEm(±)	0.31	0.44
C.D. (P=0.05)	0.91	1.30

Fig.4.11 Effect of integrated nutrient management on Protein content in wheat grain.



Application of nutrient management treatment and significantly increased the available phosphorus in soil over control during both years. The highest available phosphorus (14.64 and 15.14) in soil recorded with the treatment application 75 % NPK + 1 t ha^{-1} vermicompost+ Azosprillium was statistically at par with 100% NPK and significantly higher than the rest of the treatments during both years. Lowest available phosphorus (10.54 and 10.68) was recorded in control plots during 2011-12 and 2012-13 respectively.

4.7.3 Available Potassium in soil (kg ha^{-1})

The data pertaining to available potassium in soil are presented in (Table 4.12), depicted in (Fig 4.12) and their analysis of variation are presented in Appendix XIV.

Nutrient management treatments significantly increased the available potassium in soil over control during both years. The highest available potassium (180.56 and 180.56 and 181.06) in soil recorded with the treatment application 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium was statically at par to 100% NPK and significantly higher than the rest of the treatment during both years. Lowest available potassium (166.75 and 166.95) was recorded in control plots during 2011-12 and 2012-13 respectively.

4.7.4 Organic carbon in soil

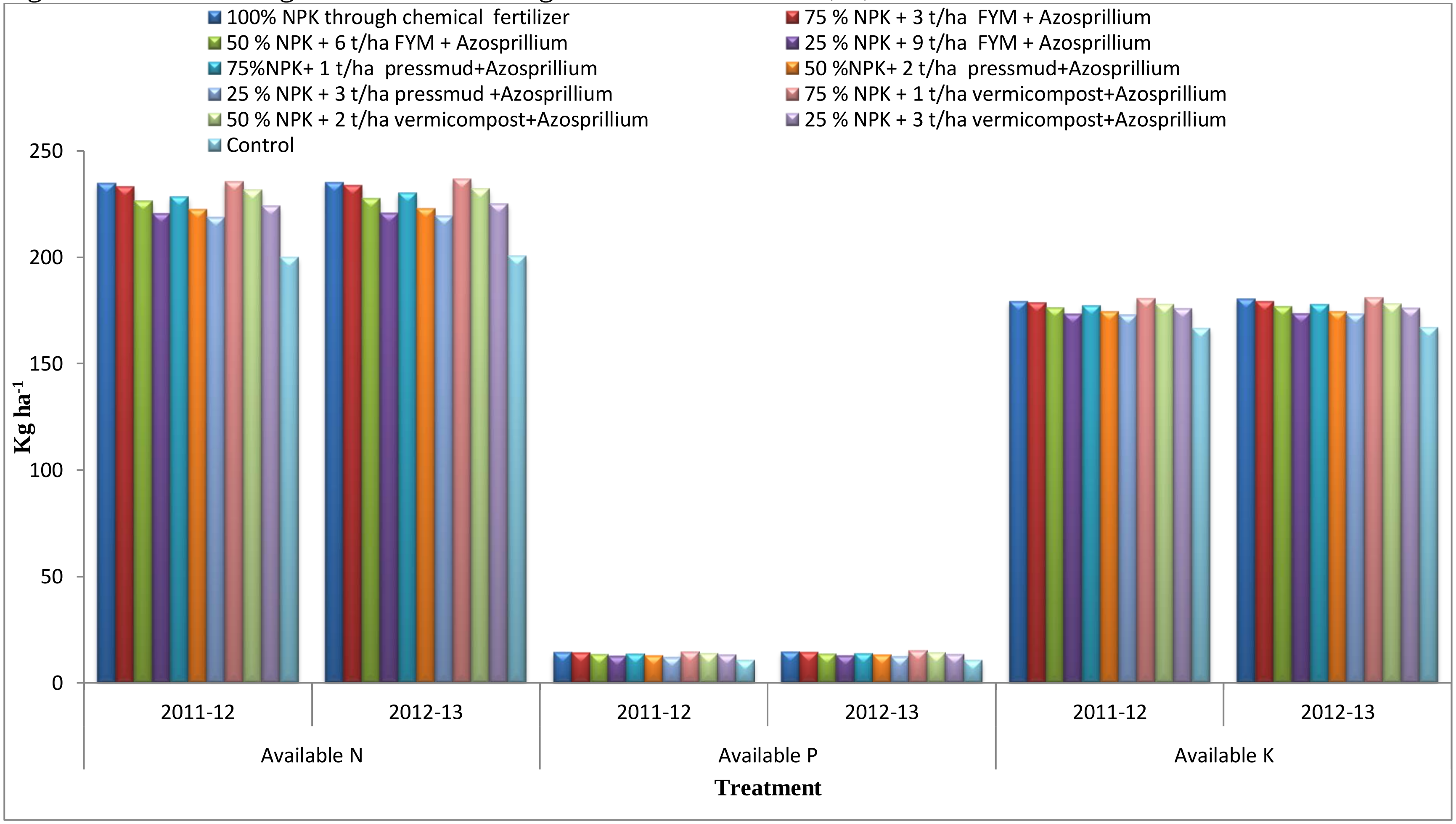
The data pertaining to organic carbon in soil are presented in (Table 4.13), depicted in (Fig 4.13) and their analysis of variation are presented in Appendix XIV.

Organic carbon content in soil was influenced significantly by nutrient management. The highest organic carbon content (0.51 and 0.52) in soil recorded with the application 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium was statistically at par with 100% NPK and 75% NPK + 3 t/ha FYM + Azosprillium during both years. Lowest organic carbon (0.40 and 0.42) was recorded in control plots during 2011-12 and 2012-13 respectively.

Table 4.12 Effect of integrated nutrient management on Available N, P, K of the soil after harvest in wheat.

Treatment	Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	234.78	235.38	14.24	14.64	179.45	180.35
75 % NPK + 3 t/ha FYM + *Azosprillium*	233.23	233.75	14.02	14.38	178.65	179.25
50 % NPK + 6 t/ha FYM + *Azosprillium*	226.54	227.68	13.45	13.65	176.40	176.70
25 % NPK + 9 t/ha FYM + *Azosprillium*	220.65	220.84	12.56	12.85	173.25	173.43
75%NPK+ 1 t/ha pressmud+*Azosprillium*	228.45	230.26	13.60	13.80	177.38	177.76
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	222.54	222.86	12.89	13.19	174.46	174.66
25 % NPK + 3 t/ha pressmud +*Azosprillium*	218.89	219.45	12.14	12.42	173.10	173.28
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	235.60	236.71	14.64	15.14	180.56	181.06
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	231.72	232.14	13.79	14.13	177.89	178.19
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	224.05	225.25	13.14	13.32	175.80	176.05
Control	200.01	200.73	10.54	10.68	166.75	166.95
SEm(±)	0.66	0.80	0.19	0.22	0.54	0.58
C.D. (P=0.05)	1.95	2.37	0.58	0.65	1.62	1.73

Fig.4.12 Effect of integrated nutrient management on Available N, P, K of the soil after harvest in wheat.



4.7.5 Soil pH

The data pertaining harvest index to wheat recorded is presented in (Table 4.13), (Fig 4.13) and their analysis of variation are presented in Appendix XV.

Soil pH did not differ significantly by the nutrient management practices during both years. Numerically the maximum soil pH value (8.20 and 8.22) was observed in the treatment control plot during both years. Lowest soil pH (7.44 and 7.45) was recorded in 25% NPK + 3 ton ha^{-1} pressmud + Azosprillium treatment.

4.8 ECONOMICS

4.8.1 Cost of cultivation (Rs ha^{-1})

The data pertaining to cost of cultivation are presented in (Table 4.14), (Fig 4.14). The data indicates the highest cost of cultivation (28,532and 31,254) was observed in the treatment 25 % NPK + 3 t/ha vermicompost+Azosprillium due to high amount of costly vermicompost which was applied in the treatment followed by 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The lowest cost of cultivation (19,740and 21,530) observed in control plots.

4.8.2 Gross return (Rs ha^{-1})

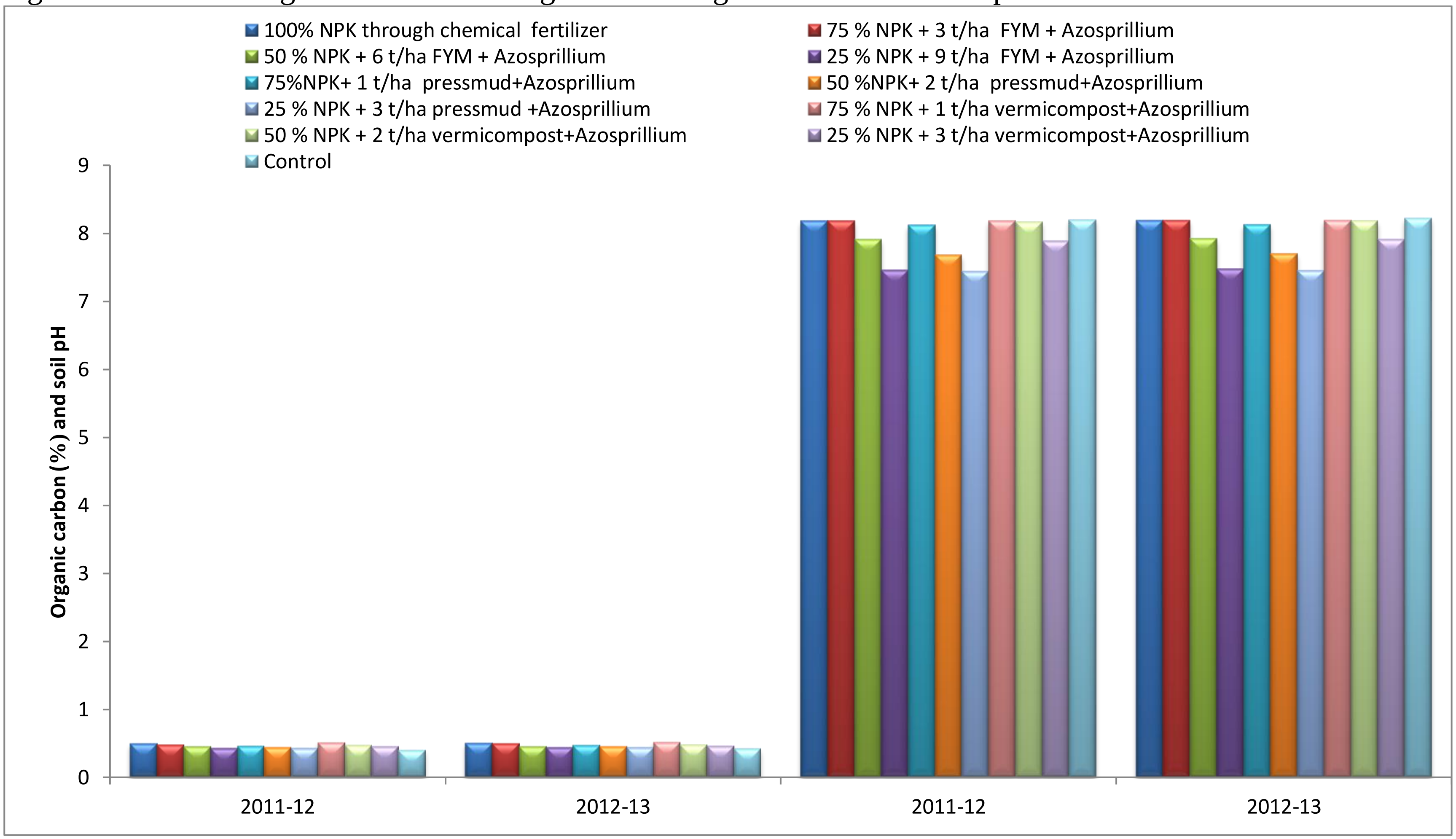
The data pertaining to gross return is presented in (Table 4.14) and (Fig 4.14). The data indicates the highest gross return (69,175and 77,781) was observed in the treatment 100% NPK which was applied in the treatment followed by 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The lowest gross return (41,195and 46,361) observed in control plots during both years.

Table 4.13 Effect of integrated nutrient management on Organic carbon and Soil pH of the soil in wheat.

Treatment	**Organic carbon(%)**		**Soil pH**	
	2011-12	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	0.49	0.50	8.18	8.19
75 % NPK + 3 t/ha FYM + *Azosprillium*	0.48	0.49	8.18	8.19
50 % NPK + 6 t/ha FYM + *Azosprillium*	0.45	0.45	7.91	7.92
25 % NPK + 9 t/ha FYM + *Azosprillium*	0.43	0.44	7.46	7.48
75%NPK+ 1 t/ha pressmud+*Azosprillium*	0.46	0.47	8.12	8.13
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	0.44	0.45	7.68	7.70
25 % NPK + 3 t/ha pressmud +*Azosprillium*	0.43	0.44	7.44	7.45
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	0.51	0.52	8.18	8.19
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	0.47	0.48	8.17	8.18
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	0.45	0.46	7.89	7.91
Control	0.40	0.42	8.20	8.22
SEm(±)	0.01	0.01	0.59	0.20
C.D. (P=0.05)	0.03	0.03	N.S.	N.S.

N.S. non significant

Fig.4.13 Effect of integrated nutrient management on Organic carbon and Soil pH of the soil in wheat.



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

The data pertaining to net return is presented in (Table 4.14) and (Fig 4.14). The data indicates the highest net return (44,904and 51,518) was observed in the treatment 100% NPK which was applied in the treatment followed by 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The lowest net return (21,455and 24,831) observed in control plots during both years.

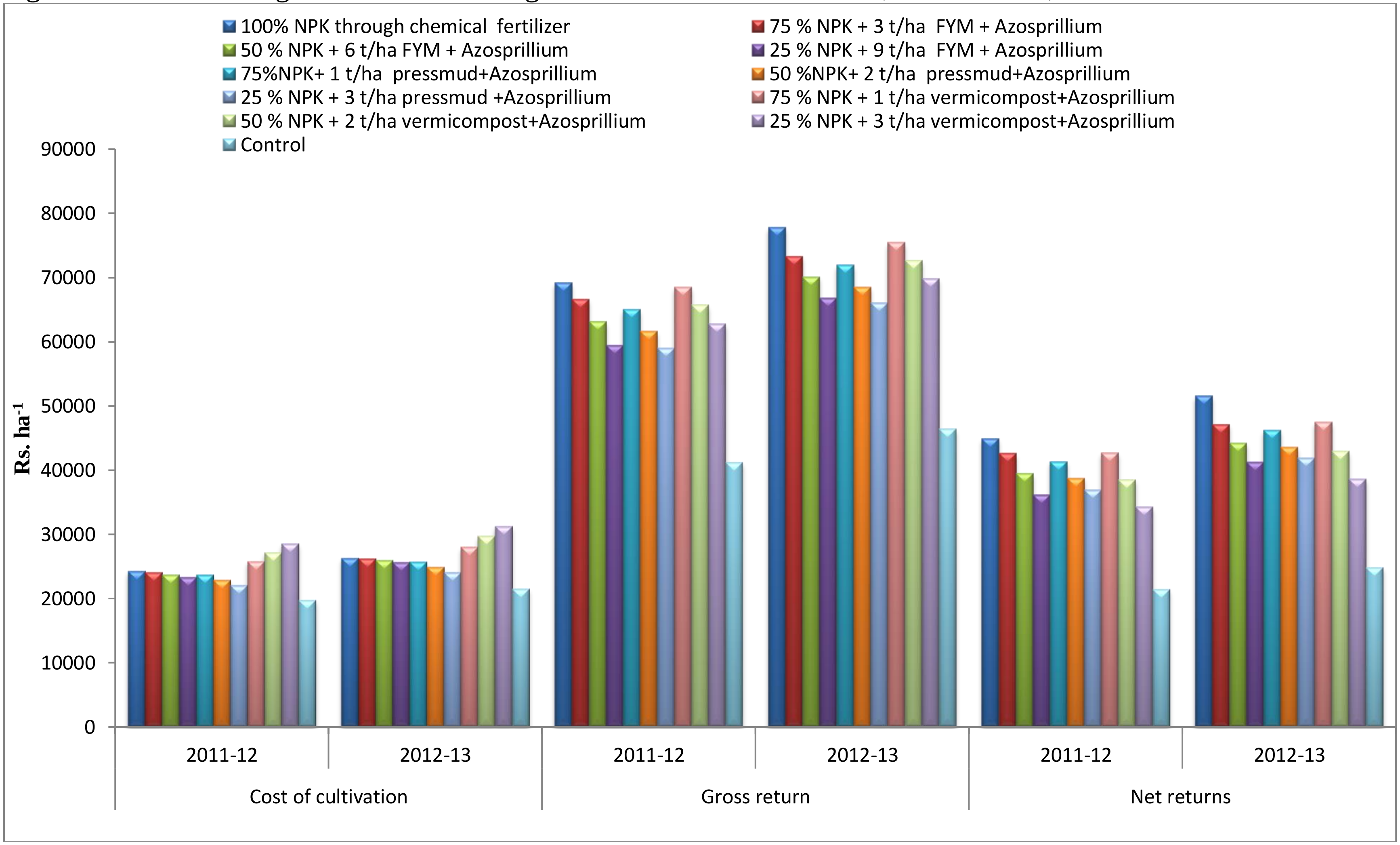
4.8.4 B: C ratio

The data pertaining to B: C ratio is presented in (Table 4.14) and (Fig 4.15). The data indicates the highest B: C ratio (1.85 and 1.96) was observed in the treatment 100% NPK closely followed by 75 % NPK + 3 t/ha FYM + Azosprillium. The lowest B: C ratio (1.09 and 1.15) observed in control plots during both years.

Table 4.14 Effect of integrated nutrient management on Cost of cultivation, Gross return, Net returns and B: C ratio of wheat.

Treatment	**Cost of cultivation (Rs ha^{-1})**		**Gross return (Rs ha^{-1})**		**Net returns (Rs ha^{-1})**		**B: C ratio**	
	2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
100% NPK through chemical fertilizer	24271	26263	69175	77781	44904	51518	1.85	1.96
75 % NPK + 3 t/ha FYM + *Azosprillium*	24048	26179	66623	73323	42575	47144	1.77	1.80
50 % NPK + 6 t/ha FYM + *Azosprillium*	23664	25896	63153	70097	39489	44201	1.67	1.71
25 % NPK + 9 t/ha FYM + *Azosprillium*	23282	25613	59463	66815	36181	41202	1.55	1.61
75%NPK+ 1 t/ha pressmud+*Azosprillium*	23648	25679	64982	71901	41334	46222	1.75	1.80
50 %NPK+ 2 t/ha pressmud+*Azosprillium*	22864	24896	61647	68511	38783	43615	1.70	1.75
25 % NPK + 3 t/ha pressmud +*Azosprillium*	22082	24113	58945	66027	36863	41914	1.67	1.74
75 % NPK + 1 t/ha vermicompost+*Azosprillium*	25798	28012	68509	75456	42711	47444	1.66	1.69
50 % NPK + 2 t/ha vermicompost+*Azosprillium*	27164	29745	65699	72653	38535	42908	1.42	1.44
25 % NPK + 3 t/ha vermicompost+*Azosprillium*	28532	31254	62780	69842	34248	38588	1.20	1.23
Control	19740	21530	41195	46361	21455	24831	1.09	1.15
SEm(±)	819.00	906.97	719.09	1016.67	738.98	1471.57	0.06	0.11
C.D. (P=0.05)	2433.08	2694.41	2136.24	3020.28	2195.30	4371.69	0.17	0.32

Fig. 4.14 Effect of integrated nutrient management on Cost of cultivation, Gross return, Net returns of wheat.



The experimental evidences presented in preceding chapter, in order to quantify the relative contribution of nutrient management, provide a detailed account of wheat performance in terms of growth, development, yield, yield attributes and monetary aspects. An attempt has been made here to examine and evaluate the important observations recorded during the course of investigation in terms of 'causes' and relationship as for as possible.

Plant nutrition which is the most important factor affecting growth and development of a crop is not a simple problem. Its solution depends upon much more than the liberal use of commercial fertilizers, organic manures or other materials. Under these situations integration of chemical fertilizers with organic manures has been found quite promising not only in maintaining higher productivity but also in providing greater stability in crop production as evident from the long term fertilizer experiments (Nambiar and Abrol, 1992). Farmyard manure (FYM) is being used as a major source of organic manure in field crops since ancient times. Limited availability of this manure is, however, an important constraint in its use as a source of nutrients. Wheat crop responds positively to applied fertilizers with FYM (Gill *et al.,* 1994). Application of organic along with inorganic sources not only improve soil health but with also improve the produce quality and fertilizer use efficiency and there by reducing the cost of cultivation. Organic manures, particularly FYM, not only supply macronutrients, but also meet the requirement of micronutrients, besides improving soil health Tripathi, (2010).

The capacity of a crop to produce economic yield is the function of its nutrient and environment that largely govern growth and development right form germination to maturity.

Crop performance at maturity is the resultant of success or failure of various plant processes occurs through vegetative and reproductive phases.

The three most vital nutrients that a plant can receive are nitrogen (N), phosphorous (P) and potassium (K). Nitrogen aids in the plant's growth above ground. Phosphorous enhances plant cell division. It also helps in flower and seed production and in the development of a strong root system. Potassium improves the plant's ability to fight off disease. It also gives it strong stems. Plant nutrition is the most important factor affecting grain yield, nutrient uptake and quality of a crop. This factor becomes still more important when an exhaustive crop like wheat is grown in an intensive crop rotation consisting of cereal crops. Hence, integrated nutrient management consisting of use of organic manures and chemical fertilizers are gaining importance for maintaining soil productivity. Its effect on wheat was studied in the present investigation and compared with different nutrient sources. The results of investigation are described and the explained in the light of work done by various workers. The effects of various treatments were observed on various growth, yield and nutrient uptake parameters and can be grouped under following head:

Weather conditions

Nutrient and environment interaction studies made on various crop in India and abroad categorically advocates significant and large variations in expression of nutrient with environment. Weather variations i.e. temperature, relative humidity and rainfall etc. are of great significance that change invariably with i.e. latitude, longitude and geological location, attitude, season etc. Comparison of weather attributes of the study years revealed variation in temperature, relative humidity and rainfall encompassing the critical stages of crop growth and development. This led to yield variation between the study seasons i.e. *rabi* 2011-12 and 2012-13. Wheat crop, irrespective of the treatments, performed better during 2011-12 than during 2012-13. Critical perusal of growth and yield attributes vindicated better crop establishment, growth and yield formation during 2012-13 in comparison to 2011-12. Dry matter accumulation, an overall growth index was also higher during 2012-13, irrespective of the growth stages and this provided the base for better formation and synthesis of reproductive organs i.e. number of spikes, spikelet's spike^{-1} etc. exclusively the yield determiners. Cumulative effect of better formation of the yield determiners was possibly behind the yield superiority during 2012-13. The weather attributes are suggestive of more congenial environment for growth and yield formation as crop received 80 mm rains during 2011-12 as against 184.5 mm during 2012-13, better distribution of rainfall would have favored the crop growth and development. Maximum temperature ranged from 15.14-34.78 ^{0}C and minimum from 2.9-19.71 ^{0}C during 2011-12 as against respective maximum and minimum temperature of 11.0-34.14 ^{0}C and 1.2-19.71 ^{0}C during 2012-13.

Effect on plant Growth and growth parameters

Vegetative and reproductive growth of a plant is affected by physiological and metabolic processes which are modified by environmental conditions and varying cultural practices. Although, it is not possible to modify entirely the plant environment under field conditions to suit the seeds of a particular plant type, however, it can be manipulated to a great extent by judicious organization of controllable factors like selection of variety, seed rate, sowing time, nutrient supply, irrigation and plant protection.

In the present studies application of nutrient management treatments affected the overall growth of wheat plants measured in terms of plant height, number of tillers and dry matter accumulation, during both years.

Plant height (Table 4.1) increased at a faster rate during at 60 at 90 DAS was significantly affected by different nutrients treatments. The plant height was significantly affected at 30, at 60, at 90 DAS and at harvest in different treatments. The maximum plant height were recorded with the application of 100% NPK which is at par with the 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium during both years. The control plots resulted significant reduction in plant height than rest of the treatments at all the growth stages. Such a higher plant height in 100% NPK can be associated with sufficient nutrient supply at the active growth stage. Similar results of increased plant height were also reported by Kumar and Ahlawat (2004), Tulsa Ram and Mir (2006), Singh *et al.* (2007) ,Singh *et al.* (2008), Thakral *et al.* (2003) and Singh *et al*. (2006), Patra *el al.* (1998).

Dry matter production in crop is a function of current photosynthesis. Balanced nutrition helps in achieving higher dry matter accumulation through enhanced canopy cover which ultimately increased higher amount of assimilated through higher rate of current photosynthesis. Dry matter accumulation (Table 4.2) is a function of total plant stand, plant height, number of tillers per meter row length hence all these characters will ultimately affect dry matter accumulation by crop. Maximum dry matter accumulation was observed in 100% NPK being at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium at 30, 60, 90 DAS and at harvest during 2011-12 and 2012-2013, respectively. Minimum dry matter accumulation was recorded in control plots at 30, at 60, at 90 DAS and at harvest. The beneficial impact of organic manures on physical, biological and chemical properties of soils is widely known but the full appreciation for the some remains largely ignored in commercial chemical agriculture. Organic manures also increase the nutrient holding capacity of soil and minimize the effect of toxicants. Organic manures make the soil biologically active as these are good source of food and energy for soil micro-organisms and increase the activity of microbes which bring non-available plant nutrients into available from (Yawalkar *et al.* 1992) thus improving the growth character. The contributions of organic and inorganic sources of nutrients also produced better growth parameters viz., plant height, number of effective tillers and finally dry matter. Similar results were also reported by Jakhar *et al.* (2006), Sepat *et al.* (2010).

The number of tillers per meters row length (Table 4.3) increased up to at 60 DAS and started declining their after at 90 DAS and at harvest. The highest number of tillers per meter row was recorded in 100% NPK which were at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. Lowest number of tillers was recorded in control plots at 30, at 60, at 90 DAS and harvest. Such a higher number of tillers in these treatments can be linked with optimum supply of essential nutrients at active tillering stage. Similar results were also reported by Singh and Agarwal (2001) and Jat *et al.* (2013).

The maximum leaf area index (table 4.4) were recorded with 100% NKP which was statistically at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium and found significantly superior over control plot during all the stages. Minimum number of leaf area index was observed in control plot at all stages. A similar result has been reported by Rehman *et al.* (2010). It may be due to mineralization of organic manure and increased activity of bio fertilizers under soil environment. The enhancement in growth with increased in fertility was owing to rapid conversion of synthesized photosynthates in to protein to from more protoplasm, thus increasing the number and size of cell which might have increased the leaf area.

Yield attributes and yield

The yield of a crop depends upon the source sink relationship and is the cumulative function of various growth parameters and yield attributing components viz; spike length, spikelets per spike, number of grains per spike and test weight (1000 grain weight). Any factors affecting these parameter ultimately affects the biological and economical yields of crop. Applications of vermicompost with inorganic sources of fertilizer at any level were found to improve the yield attributing character (Table 4.5) grain, straw and biological yield (Table 4.6) in comparison to control. An increase of 65.51 and 57.14, 62.63 and 62.50, 34.46 and 32.01 and 23.40 and 25.61 per cent of length of spike, spikelets per spike, number of grains per spike and 1000 grain weight was observed during 2011-12 and 2012-13 respectively, with 100% NPK over control. The effect of 100% NPK being statistically at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium and were superior to control during both years in respect of yield attributing characters. More yield attributes were found in the treatment where organic and inorganic sources of plant nutrients were applied over control. This may be due to effect of organic and inorganic sources on the adequate nutrient supply for longer period, which will affect crop growth and photosynthetic activity. Similar results were reported by Muhammad *et al*. (2008), Patil and Blihore (2001). Stimulated vegetative growth of wheat on account of adequate and prolonged supply of essential nutrients in treatment receiving vermicompost and biofertilizer in addition to 75% NPK manifested itself in increase number of effective tillers, grain/spike and test weight similar beneficial effect of INM on yield attributes of wheat has been reported by Sharma *et al.* (2009). Such improved yield attributes can be linked with balanced nutrition particularly nitrogen with play a vital role in cell division and cell elongation as well as increase in sink size which provide a feedback to sources for production of higher amount of photo-synthate. Higher level of nutrients improved the fertility level of soil and creates congenial condition for better growth and development thus improved the yield attributes. These results are in conformity with those reported by Sen *et al.* (2003), Singh and Yadav (2006), Singh *et al.* (2007) and Ashutosh Barthwal *et al*. (2013), Singh and Singh 2005 and Ranwa (1999).

Application of nutrient management treatments significantly increased the grain, straw and biological yield of wheat during the years of experimentation. The grain, straw and biological yields were recorded significantly higher in the treatments 100% NPK which were 41.50 and 43.78; 60.90 and 62.26 and 102.40 and 106.04 q ha^{-1} which was at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium during both years. Overall the grain yield increased was 72.19 and 73.52, 35.20 and 51.85 and 61.13 and 60.11 per cent over control by the application of 100% NPK, 75 % NPK + 1 t ha^{-1} vermicompost+ Azosprillium 2011-12 and 2012-13 respectively. The harvest index was not influenced significantly by the application of nutrient management treatments during both years of study. Highest number of harvest index was found in 100% NPK and lowest in control plot.

The beneficial effect of organic manures on grain, straw, biological yields and yield attributing characters might be assigned to the fact that after proper decomposition and mineralization, these manures supplied available plant nutrients directly to the plants and also had solublising effect on fixed forms of nutrients in soil. Similar findings were also reported by Mubarak and Singh, (2011). The combination use of organic manures and chemical fertilizers enhanced the inherent capacity of soil as reported by Pandey *et al.* (2009), Verma and Mathur, (2009), Verma, *et al.* (2010) and Meena *et al.* (2012), Singh and Singh (2005). The organic manures also increase the adsorptive power of soil for cations and anion particularly phosphates and nitrates and these adsorbed ions are released slowly for the benefit of crop during entire crop growth period leading to higher yields reported by Dhaliwal and Walia, (2008).

Nitrogen, phosphorus and potassium contents and uptake by crop

Application different nutrient management treatments increased nitrogen, phosphorus and potassium content and their uptake and total uptake by wheat grain and straw significantly over control during both years (Table 4.7, 4.8, 4.9) with few exceptions. Among different nutrient management treatments, highest value for NPK content and uptake was recorded with 100% NPK. An increment of 39.02 and 53.17, 44.00 and 37.04 and 68.00 and 62.96 per cent in N, P and K content in grain and 141.17 and 155.55, 70.00 and 72.72 and 37.19 and 37.70 per cent in straw was recorded with 100% NPK+FYM over control during 2011-12 and 2012-13 respectively (Table..) Similarly higher nitrogen content in the treatment where INM was followed may be more translocation of photosynthesis to gain. Similar results are in confirmation with the finding of Jadhav *et al.* (1997) and Srivastava *et al.* (2008). NPK contents increase might be due to the solubilisation effect of organic manures on native nutrients solubilisation and releasing of nutrients for a longer duration might be the reason for greater availability. Kathurai *et al.* (2004) reported that organic sources had a longer and greater efficiency as compared to inorganic source that might be responsible for higher uptake by building material.

Application different nutrient management treatments increased significantly the uptake of NPK in grain and straw over control (Table 4.7, 4.8, 4.9). The uptake of these nutrients was more in 2012-13 as compared to 2011-12 because the yield was more during the Second year of experiment. Among nutrient management treatments 100% NPK and 25% NPK + 3 t ha^{-1} pressmud + Azosprillium recorded maximum and minimum NPK uptake, respectively.

Total uptake by crop was significantly affected in grain and straw. Total N, P and K uptake was observed highest in grain and straw under the treatment 100% NPK followed by 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium over control during 2011-12 and 2012-13 respectively. More uptake of nitrogen in the treatment where fertilizer was applied alone and with combination over control may be due to better availability of nutrient to plant owing to improved physical condition of soil. Similarly higher nitrogen content in the treatment where INM was followed may be more translocation of photosynthesis to gain. Phosphorus better vegetative growth and the phosphorus were finally translocated to the grain from straw making total phosphorus significant due to different treatments. Removal of potassium is very high by cereal crops. Unfortunately, application of K did not receive due attention for most of Indian soil which were considered adequate in native K supply. But intensive agriculture led to occurrence of K deficiency in soil and thereby low uptake of K by the crop. Applications of organic manures are also found to increase the exchangeable K status of the soil. Higher N, P and K contents and their uptake by wheat have also been reported by Gupta and Sharma (2006), Sharma *et al*. (2007), Singh *et al.* (2008), Pandey *et al.* (2009), Sepat *et al.* (2010), Mubarak and Singh (2011) and Meena *et al.* (2012). Jadhav *et al.* (1997) and Srivastava *et al.* (2008), Kathuria *et al.* (2004)

Combined NPK uptake was increased significantly by the combine application of 100% NPK resulted into highest uptake of NPK in the soil, it was significantly at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The decomposition of FYM and Vermicompost resulted in the formation of CO2 which plays important role in the solubilization of P and K resulting into formation of phosphohumic complex, which are more easily extracted by plants. Farm yard manure is better for building of nutrient in soil due to its higher quality applied to the soil compared to Vermicompost. The application of organic manures have been reported not only to improve the nutrient content in the soil but help in bringing native nutrient content to uptake form in the soil due to priming effect. Similar results were reported by Singh *et al.* (1999).

Protein content

Application of 100% NPK has proven the best with 10.69 and 12.06% Protein it was statistically at par with 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The result in table indicate that integrated nutrient application through chemical fertilizer, vermicompost ad bio- fertilizer improve the protein content in grain over control. Similar results have been reported by Hasan and Kamal (1998). Nitrogen is most important factor which determines protein constituent of grain. It is essential for vegetative and reproductive stages. Nitrogen not only affects wheat productivity but also has a synergistic effect on quality of grain. Nitrogen is important constituent of protein, enzyme and chlorophyll and is involved in all processes associated with protoplasm, enzymatic reaction and photosynthesis (Tisdale *et al.*, 1995).

Effect on available NPK and organic carbon in soil

Incorporation of organic manures and chemical fertilizers generally affects physical, chemical and biological properties of soil. During this study available N, P and K organic carbon were measuring during 2011-12 and 2012-13 after harvest of crop from various treatments during both years. Available N, P and K increased in soil with the application of different nutrient management treatments during both years. The application of organic manures have been reported not only to improve the nutrient content in the soil but also helps in bringing native nutrients into the available from thus increasing the available nutrient contents in the soil. Moreover, organic manures crates better environment for biological activity in the soil which results into more fixation of N and more solubilising effect on other fixed form of nutrients. The available nitrogen was significantly higher in the treatment 75%

NPK + 1 t ha^{-1} vermicompost+Azosprillium followed by 100% NPK during both the year. The highest available phosphorous content was observed with the treatment 75% NPK + 1 t ha^{-1} vermicompost+Azosprillium which was at par with 100% NPK during both the year. The highest available potassium content was observed with the treatment 75% NPK + 1 t ha^{-1} vermicompost+Azosprillium which was at par with 100% NPK during both the year. Lowest available nitrogen, phosphorous and potassium was recorded in control plot during 2011-12 and 2012-13. Increase in nutrients in soil by the application of organic manures was also reported by Sharma *et al.* (2007), Dhaliwal and Walia (2008) and Prasad *et al.* (2010).

Organic carbon in soil varied significantly among different nutrient treatment. Maximum carbon content was recorded in 75 % NPK + 1 t/ha vermicompost+Azosprillium (0.51 and 0.52) was statistically at par with 100% NPK (0.49 and 0.50) during both the years which was significantly higher to control. In soil pH was non significantly different among different nutrient treatments during both the year. Studies conducted by various workers have established the fact of maintenance of soil fertility in terms of improved organic content and available nutrients in soil by application of organic manures in combination with chemical fertilizers in different ratio as Singh *et al.* (2008), Verma and Mathur (2009) and Verma *et al.* (2009).

Above result on effect of different nutrient option on available N, P, K indicates that were also reported by Robinson *et al.* (1992). Application of FYM, vermicompost with fertilizer significantly improves the soil health along with enhanced organic carbon in soil that the application of fertilizer alone. Similar result was also reported by Pandey *et al.* (2009). Inclusion of FYM in the different treatment schedule improved the organic carbon status and available N, P and K in soil. Similar result were also reported by Singh *et al.* (2006) and Hakeem *et al.* (2010).

Economics

Cost of cultivation (Rs ha^{-1}), Net return, B: C ratio

Based on two years studies it can be conducted that maximum highest cost of cultivation was observed in the treatment 25% NPK + 3 t/ha vermicompost+Azosprillium which was applied in the treatment followed by 50% NPK + 2 t/ha vermicompost+Azosprillium and rest of the treatments. The lowest cost of cultivation observed in control plots both the year. Gross return was observed highest in treatment 100% NPK closely followed by 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The lowest gross return observed in control plots in 2011-12 and 2012-13. Similar result was also reported by Pandey *et al.* (2006). Net return was observed highest in treatment 100% NPK closely followed by 75% NPK + 1 t ha^{-1} vermicompost+ Azosprillium. The lowest net return observed in control plots in both the year. B: C ratio was observed to be highest in treatment 100% NPK closely followed by 75 % NPK + 3 t ha^{-1} FYM + Azosprillium. The lowest B: C ratio observed in control in 2011-12 and 2012-13. Similar result was also reported by Ram and Mir, (2006). The result on current studies showed that cost of cultivation was marginally higher when the nutrients were applied in combination. Due to higher grain and straw yields, the gross return and net income was also higher with use of organic and inorganic fertilizers. Similar result was also reported by Singh *et al.* (2006) and Bhaduri and Gautam (2012), Zabe and Kaleem (2009) and Lone *et al.* (2011).

6. SUMMARY AND CONCLUSION

The investigation entitled, "**Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P.**" was conducted during winter season 2011-12 and 2012-13 at Crop Research Centre of Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut with the objective to study the effect of different level of organic manures (Vermicompost, FYM and Pressmud), fertilizers and bio-fertilizer on growth yield attributing, yield and economic of wheat and work out optimum combination of organic and inorganic sources of nutrients. Experiment was laid out in a randomized block design with three replications. Studies were conducted with eleven treatments viz., 100% NPK, 75% NPK+ 3 ton ha^{-1} FYM+ Azosprillium, 50% NPK+ 6 ton ha^{-1} FYM+ Azosprillium, 25% NPK+ 9 ton ha^{-1} FYM+ Azosprillium, 75% NPK+ 1 ton ha^{-1} pressmud+ Azosprillium, 50% NPK+ 2 ton ha^{-1} pressmud+ Azosprillium, 25% NPK+ 3 ton ha^{-1} pressmud+ Azosprillium, 75% NPK+ 1 ton ha^{-1} vermicompost+ Azosprillium, 50% NPK+ 2 ton ha^{-1} vermicompost+ Azosprillium, 25 % NPK+ 3 ton ha^{-1} vermicompost+ Azosprillium, Control.

The findings of the present investigation are summarized below:

- Among the different nutrient management practices the application of 100% NPK recorded maximum plant height which was at par with 75% NPK + 1 ton ha^{-1} vermicompost + Azosprillium and was significantly superior over rest of treatments at 30, 60, 90 and harvest.

- The maximum dry matter accumulation was recorded with the treatment 100% NPK which was statistically at par with 75% NPK+ 1 ton ha^{-1} vermicompost+ Azosprillium and significantly superior over rest of the treatments. At maturity dry matter accumulation (g m^{-1}) was 241.0 and 245.6 in 100% NPK during 2011-12 and 2012-13.

Minimum dry matter accumulation was weighted with the control plot. Reduction in dry matter accumulation was 36.69 % and 37.38 % was observed during 2011-12 and 2012-13 over control.

- At all stages maximum number of tillers per meter row length was found in 100% NPK treated plot. Which was statistically at par with 75% NPK+ 1 ton ha^{-1} vermicompost + Azosprillium at all the growth stages during both the year. The only exception was number of tillers per meter row length in 30 DAS which remained unaffected by nutrient management treatment during 2011-12 minimum number of tillers per meter row length were obtained in control plot at all the stages in comparison to rest of the treatments.
- Leaf area index (LAI) differed significantly at 30, 60, and 90 days stages during both the years under different nutrient management practices. LAI declined at 30 and 60 days stages with each nutrient management from 100% NPK to control. The maximum Leaf area index (LAI) was recorded with the treatment 100% NPK which was statistically at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium. Minimum dry matter accumulation was weighted with the control plot.
- Yield attributing characters like length of spike, number of spikelet $spike^{-1}$, number of grains $spike^{-1}$, 1000-grain weight exhibited variations due to different nutrient management practices. A declining trend was noticed with nutrient doses in respect of all parameters. With the application of 100% NPK highest mean spike length (9.7 cm), mean number of spikelet's per spike (15.2 cm) mean number of grains per spike (36.1) and mean 1000-grain weight (35.3 g) followed by rest of the treatment. Number of grains per spike declined significantly from 25.63 to 24.25 % when doses of nutrient were declined from 100% NPK to control.

- Significant variations were noted in wheat grain yield under different nutrient management during both the years. Mean, over the years, yield reduction was 17.97 q ha^{-1} or 42.14 % with 100% NPK to control. Almost similar trend was noticed in respect of straw and biological yield being highest in 100% NPK followed by 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium and lowest in control during 2011-12 and 2012-13
- Harvest index did not influenced significantly by the application of nutrient management treatments during both years. It was observed maximum in 100% NPK followed by 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium lowest harvest index was recorded in control plots.
- Nitrogen, phosphorus and potassium content and their uptake by wheat grain and straw and total NPK uptake increased significantly under the influence of nutrient management treatments in comparison to control treatments during both years of experimentation. Among nutrient management treatments maximum and minimum N, P and K content and their uptake were recorded with 100% NPK and control, respectively.
- Significantly higher protein content was found with the application of 100% NPK proven the best with (10.69 % and 12.06 %) protein content in grain which was at par with 75% + 1 t ha^{-1} vermicompost+ Azosprillium (10.50 % and 11.75 %).
- Available N, P and K in soil were observed highest in treatment 75% + 1 t ha^{-1} vermicompost+ Azosprillium followed by 100% NPK during the both years. Available N, P and K observed highest in 75% + 1 t ha^{-1} vermicompost+ Azosprillium than other treatments. Lowest available N, P and K were recorded in control plot.

- Organic carbon in soil varied significantly among different nutrient treatments. Highest organic carbon in soil was recorded with the application of 75% + 1 t ha^{-1} vermicompost+ Azosprillium. Lowest organic carbon was recorded in control plots.
- Soil pH differs non-significantly among different management during both the year. Highest soil pH in control plot and lowest in 100% NPK.
- The data indicates the highest cost of cultivation (28,532 and 21,254) was observed in the treatment 100% NPK which was applied in the treatment followed by 25% NPK + 3 ton ha^{-1} vermicompost+ Azosprillium. The lowest cost of cultivation (19,740 and 21,530) observed in control plots.
- Gross return, net return and B: C ratio differed significantly under different nutrient management practices. Application of 100% NPK fetched highest gross return of Rs 73478 ha^{-1}, net return of Rs 4821 ha^{-1} with B: C ratio of 1.90 while the lowest returns were obtained with control, gross return being Rs 43778 ha^{-1}, net return-Rs 23143 ha^{-1} and B: C ratio of 1.12. Significantly higher gross return & Net return was found with the application of 100% NPK which was found at par with 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium.

CONCLUSION

On the basis of two years study on "Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P." the highest growth characters were recorded with 100% RDF through inorganic source of nutrient which were statistically similar to the treatment of 75% NPK + 1 ton ha^{-1} vermicompost + Azosprillium and significantly higher than the rest of the treatments and control. Among the different combination of organic manures with inorganic source of nutrients, 75% NPK + 1 ton ha^{-1} vermicompost + Azosprillium recorded significantly higher yield attributes and yield along with higher gross return and net return and Soil organic carbon (%). Although application of 100% NPK yielded more among all the nutrient management options but it was found at par with 75% NPK + 1 ton ha^{-1} vermicompost + Azosprillium in grain yield, gross return and net return. In view the buildup of Soil organic carbon and improvement in nutrient availability, application of 75% NPK + 1 ton ha^{-1} vermicompost+ Azosprillium was found best among all nutrient management options. Keeping in view the sustainability of soil health 75% NPK + 1 ton ha^{-1} vermicompost + Azosprillium proved better. Thus 75% NPK + 1 ton ha^{-1} vermicompost + Azosprillium may be suggested for good performance of wheat crop and sustainability of soil health and crop yields in future.

Agamy, R.A., Mohamed, G.F. and Raddy, M.M. 2012. Influence of the application of fertilizer type on growth, yield, anatomical structure and some chemical components of wheat (*Triticum aestivum* L.) grown in newly reclaimed soil. *Australian Journal of Basic and Applied Sciences,* **6**(3): 561-570.

Agarwal, S.B., Singh, A. and Dwivedi, G. 2003. Effect of vermicompost, farmyard manure and chemical fertilizers on growth and yield of wheat (*Triticum aestivum* L. var. HP 2643*). Plant Achieves,* **3**(1): 9-14.

Ahmed, M., Afzal, M., Ahmad, A., Ahmad, A.U.H. and Azeem, M.I. 2013. Role of Organic and inorganic nutrient sources in improving wheat crop production. *Cercetari Agronomic in Moldova,* **46**(1): 21-24.

Akhtar, Muhammad, Naeem, Asif, Akhtar, Javed, Bokhari, S.A. and Ishaque, wajid 2011. Improvement in nutrient uptake and yield of wheat by combined use of urea and compost. *Soil and Environment,* **30**(1): 45-49.

Alam, I. and Sinha, K.K. 2008. Response of wheat (*Triticum aestivum*) genotypes to levels of nitrogen under irrigated condition. *Environment and Ecology*, **26**(4 A): 1925-1926

Alvrez, M.I., Sueldo, R.J. and Barassi, C.A. 1996. Effect of *Azospirillum* on coleoptile grown in seedling under water stress. *Cereal Research Communication,* **24**(1): 101-107.

AmoAghaic, R., Mostageran, A. and Emtiaji, G. 2002. Effect of *Azospirillum* inoculation on some growth parameter and yield of three wheat cultivars *Journal of Science and technology Agriculture and Natural Resource*, **7**(2): 127-139.

Anon. 2009. Resource saving equipment for agriculture leading to higher.

Ardakani, M.R., Mazaheri, D. and Nour Mohammadi, G. 2001. Effect of Azospirillum mycarrhiza and streptomyces with manure utilization on yield and yield components of wheat. *Journal of Agriculture Science Islamic Azad University*, **7**(1): 15.

Azad, B.S. and Singh, H. (1997). Effect of weed control measures and nitrogen on productivity of wheat (*Triticum aestivum*). *Indian J. Agron*, **42**(1): 91-103.

Bajpai, R.K., Chilate, S., Upadhyay, S.K. and Urkurkar, J.S. 2006. Long- term studies on soil physico-chemical properties and productivity of rice-wheat system as influence by integrated nutrient management in inceptisol of Chhattisgarh. *Journal of the Indian Society of soil Science*, **54:** 24-29

Banga, R.S., Singh, T. and Yadav, S.K. 1996. Effect of irrigation and fertility level on nitrogen and phosphorus uptake in winter wheat under shallow water table condition. *Haryana J Agron*, **12**(1): 38- 42.

Banwasi, Rakesh and Bajpai, R.K. 2001. Effect of integrated nutrient management on root growth of wheat in a rice wheat cropping system. *Agricultural- Science- Diges*, **21**(1): 1-4.

Barthwal, Ashutosh, Bhardwaj, A.K., Chaturvedi, S. and Pandiaraj, T. 2013. Site specific NPK recommendation in wheat (*Triticum aestivum*) for sustained crop and soil productivity in mollisols of Tarai region**.** *Indian Journal of Agronomy*, **58**(2): 208-214.

Behara, U.K., Sharma, A.R. and Pandey, H.N. 2007. Sustaining productivity of wheat-soyabean cropping system through integrated nutrient management practices on the vertisols of central India. *Plant and Soil*, **297**(1/2): 185-199.

Bhaduri, D. and Gautam, P. 2012. Balanced use of fertilizers and FYM to enhance nutrient recovery and productivity of wheat (*Tritiucm aestivum* cv UP-2382) in a mollisol of Uttrakhand. *Intl. Journal of Agric. Biotech*, **5**(4): 435-439.

Bhagat, R.K. 2001. Integrated nutrient management in groundnut-wheat cropping system. *Journal of Research, Birsa Agriculture University*, **13**(2): 137- 139.

Bhardwaj, B., Khandal, D.K. Nagendra, B., Bhardwaj, N. 2000. Effect of vermicompost of Echhomia on two cultivar of wheat. *J. of Eco- Phisiology*, **5**(3-4):143-148.

Billore, S.D., Joshi, O.P., Ramesh, A. and Vyas, A.K. 2009. Enhancing wheat production through tillage and integrated nutrient management. *Indian Journal of Fertilizers*, **5**(11): 25-27.

Bindia, B.D. and Mankotia, B.S. 2005. Effect of integrated nutrient management on growth and productivity of wheat crop. *Agricultural Science Digest*, **25**(4): 235-239.

Brar, B.S., Benipal, D.S. and Singh, J. 2009. Response of wheat to different level of phosphorus and sulphur in alluvial soils of Punjab. *Indian Journal of Ecology*, **36**(1): 18-21

Brar, B.S., Dhillon, N.S and Chinna, H.S. 2001. Integrated use of farmyard manure and inorganic fertilizers in maize (*Zea mays*). *Indian Journal of Agriculture Science*, **71**(9): 605-607.

Chaplot, P.C. and Sumeriya, H.K. 2013. Effect of balanced Fertilization, organic manures and bio regulator on growth, chlorophyll content and dry matter accumulation of late sowed wheat (*Triticum aestivum* L.) *Environment and Ecology*, **31**(2C): 1057-1060.

Chaturvedi, Indira. 2006. Effect of phosphorus levels alone or in combination with phosphate- solubilizing bacteria and farmyard manure on growth yield and nutrient uptake of wheat (*Tritium aestivum*). *Journal of Agriculture and Social Sciences*, **2**: 96-100.

Chaudhary, J.B., Thakur, R.C., Bhargava, M., Sood, R.D. 2001. Effect of level of nitrogen with FYM mulching on the yield of late sown wheat *(Triticum aestivum* L.*)* under rainfed condition. *Himanchal Journal of Agriculture Research*, **27**(8): 19-24, 7 refs.

Chudhary, V.S., Singh, Vikrant, Gola, R.P., Kumar, Satish 2007. Influence of integrated nutrient management on the physical growth of wheat. Department of Agronomy, C.C.S.S. D.S. (P.G.) collage Iglas, Aligarh (U.P.), *Indian Research on crops*, **8**(1): 62-64.

Creus, C.M. Sueldo, R.J. and Barossi, C.A. 2004. Water relation and *yield* in Azospirillum wheat exposed to drought in the field. *Conadian Journal of of Botany*, **82**(2): 273-289.

Dahiya, D.S., Dahiya, S.S., Lathwal, O.P., Sharma, R. and Sheoran, R.S. 2008. Integrated nutrient management in wheat under rice-wheat cropping systems. *Haryana Agriculture University Journal of Research,* **24**(1/2): 51-54.

Davari, M.R., Sharma, S.N. and Mirzakhani, M. 2012. The effect of combinations of organic materials and bio fertilizers on productivity, grain quality, nutrient uptake and economics in organic farming of wheat. *Journal of organic systems*, **7**(2): 26-35.

Deshmukh, P.H., Andhale, R.P., Sinare, BT. and Shinde, S.H. 2007. Effect of nitrogen levels and seed rates on growth and yield of wheat under furrow irrigated reduced till bed planting system. *Annals of Plant Physiology*, **21**(1): 67-70.

Dhaliwal, S.S. and Walia, S.S. 2008. Integrated nutrient management for sustaining maximum productivity of rice-wheat system under Punjab conditions. *J. Res. Punjab Agriculture University*, **45**(1 &2): 12-16.

Dikshit, P. R., Patel, K. S., Nayak, G. S. and Khatik, S.K. 2001. Integrated plant nutrient supply for obtaining economical yield of wheat grown in haplustert clay of Jabalpur. *Journal of Soils and Crops*, **11**(1): 7-12.

Duhan, B.S., Kataria, D., Singh, J.P., Dahiya, S.S. and Yadav, H.D. 2006. Effect of nitrogen, FYM and metribuzin on yield and nitrogen content of wheat *(Triticum aestivum* L.). *Haryana Agriculture University Journal of Research*, **36**(1): 35-39.

Dwivedi, D.K. and Thakur, S.S. 2000. Production potential of wheat (*Triticum aestivum*) crop as influenced by residue organics direct and residual fertility levels under rice-wheat cropping system. *Indian Journal of Agronomy*, **45**(4): 641-647.

Eid, R.A., Sedera, A. and Attia, M. 2006. Influence of nitrogen fixing bacteria incorporation with organic and inorganic fertilizers on growth, flower yield and chemical composition of *Celosisa argentia.* World *Journal of Agriculture Science*, **2**(4): 450-458.

FAO, 2013. Food and Agriculture organization of the united nation, (http://www.fao.org/statistic/en/).

FAOSTAT, 2014. Food and Agriculture Organization of the United Nations, FAOSTAT database. *Available at http://faostat.fao.org*.

Fecondo, G., Bucciarelli, S., Civitella, D., Ventura, F. 2012.The effects of compost on wheat and tomato. *Informatore Agrario*, **68**(43): 52-55.

Gill, M. S., Singh Tarlok and Rana, D. S. 1994. Integrated nutrient management in rice - wheat cropping system in semi-arid tropics. *Indian J. Agron*, **39**(4): 606-608.

Gopinath, K.A., Saha, Supradip, Mina, B.L., Pande, Harit., Kundu, S. and Gupta, H.S. 2008. Influence of organic amendments on growth, yield and quality of wheat and on soil properties during transition to organic production. *Nutrient cycling in Agro Ecosystems*, **82**(1):51-60.

Gowda Channabasana, Patil N.K.B, Patil, N.B., Awakha-Var-J.S., Ningahur-B.T., Hunje Ravi 2008. Effect of organic manures on growth, seed yield and quality of wheat. Department of seed Science and Technology, University of Agricultural Sciences, Dharwad-580005, India, Karnataka, *Joumal of Agricultural Sciences*, **21**(3): 366-368.

Gupta, A., Gupta, M. and Bali, A.S. 2009. Effect of different nitrogen doses on durum wheat *(Triticum durum*) cultivars under the subtropical condition of Jammu. *Advances on Plant Sciences*, **22**(2): 469- 470.

Gupta, M., Bali, A.S., Sharma, B.C., Kachroo, D. and Bharat, A. 2007. Productivity, nutrient uptake and economics of wheat (*Triticum aestivum*) under various tillage and fertilizer management practices. *Indian Journal of Agronomy*, **52**(2): 127-130.

Gupta, R.K., Paradkar, V.K., Raghuvanshi, R.K.S. and Rande, D.H. 1990. Effect of depth and frequency of irrigation on performance of wheat growth on a sodic tyipik chromustert. *Indian Journal of Soil Science*, **34**: 1-4.

Gupta, V. Sharma, R.S. and Vishwakarma, S.H. 2006. Long term effect of integrated nutrient management on sustainability and soil fertility of rice (*oryza sativa*) wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy*, **51**(3): 160-164.

Gupta, Vikas and Sharma 2007. Effect of integrated nutrient management on productivity and balance of rice- wheat cropping system. *Ann. PI soil Res*, **8**(2): 148-151.

Gwal, H. B., Tiwari, R. J., Jain, R. C. and Prajapati, P. S. 1999. Effect of different levels of fertilizer on growth, yield and quality of late-sown wheat. *Rachis*, 1999. **18**(1): 42-43.

Hakeem, Shabnum, Hakeem, S.A., Chandra, R. and Wani, Shagufta 2010. Effect of different inorganic and organic sources of N on growth and yield of wheat (*Triticum aestivum*) CV PRW-33 and nutrient status of soil. *Environment and Ecology*, **28**(1A):436-438.

Hanway, J.J., and H. Heidel, 1952. Soil analysis methods as used in Iowa State College, Soil Testing Leboratory. *Iowa Agriculture, 27:1-13.*

Hasan, M. A. and Kamal, A. M. 1998. Effect of fertilizer on grain yield and *m* grain protein content of wheat. *J. Nat. Sci. council of Sri Lanka*, **26**(1): 1-8.

Hati, K.M., Mandal, K.G., Mishra, A.K. and Acharya, C.L. 2000. Effect of irrigation regime and nutrient management on soil water dynamics, evapo transpiration and yield of wheat in vertisols. *Indian J. Agric. Sci.*, **71**(9): 581-586.

Hesse, P.R. 1984. Potential of organic materials for soil improvement In-organic matter and rice, IRRI, pp 35-43.

Hussain, M. I., Shah, S. H., Hussain, Sajjad and Khalid Iqbal 2002. Growth, yield and quality response of three wheat (*Triticum aestivum* L.) varieties to different levels of N, P and K. *International Journal of Agriculture and Biology*, **4**(3): 362-364.

Hussain, M.F., Kabir, M.A.M., Majunder, U.K., Sikandar, M.S. and Chaudhary, M.M.A.A. 2005. Influence of irrigation and nitrogen level on yield of wheat. *Pakistan Journal Biological Science*, **8**(1): 152-155.

Ibrahim, M.S. 2008. Effect of irrigation regime, organic and inorganic N fertilizers on wheat yield and its component and residual soil nitrate. *Journal of Applied Science Research*, (August): 1008-1016.

Ibrahim, Muhammad, Hassan, Anwar, Muhammad Iqbal, Valeem, E.E. 2008. Response of wheat growth and yield to various levels of compost and organic manure. *Pakistan Journal of Botany*, **40**(5): 2135-2141.

Jackson, M.L. 1973. Soil chemical analysis. *Prentice Hall of India Pvt.Ltd.* New Delhi.

Jadhao, S.L., Giri, D.E., Kharat, B.S., Deshmuk, J.P. and Kubde, K.J. 2001. Effect of integrated nutrient management on productivity of sorghum-wheat cropping system. *Annals of Plant Physiology,* **13**(2): 128-132.

Jadhav, A.D., Talashilkar, S.C. and Powar, A.G. 1997. Influence of conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice. *J. Maharastra Agric. Uni.***,** (Pub. 1998) 22: 249-250.

Jakhar, Parveen, Singh, Jagdev and Nanwal, R.K. 2006. Growth analysis of wheat (*Triticum aestivum* L.) as influenced by planting methods, bio-fertilizers and nitrogen levels. *Haryana Journal of Agronomy,* **22**(1):77-78.

Jan, M.T., Ahmad, Nazir and Khan, N.A. 2003. Effect of organic and inorganic nitrogen source on some growth parameters of wheat. *Sarhad Journal of Agriculture*, **19**(1): 21-30.

Jat, G., Majumdar, S.P., Jat, N.K. and Majundar, S.P. 2013. Potassium and zinc fertilization of wheat (*Triticum aestvum*) in Western arid zone of India. *Indian Journal of Agronomy*, **58**(1) 67-71.

Jat, M.L., Gupta, R.K., Erinstein, O. and Ortiz, R. 2006. Diversifying the intensive cereal cropping systems of Indo-Ganges through horticulture. *Chronica Horticulture*, **46**(3): 16-20.

Kachroo, D. and Razdan, R. 2006. Growth nutrient uptake yield of wheat *(Trticum aestivum)* as influenced by biofertilizer and nitrogen. *Indian Journal of Agronomy,* **15**(1): 37-39.

Kajla, Mamta, Thakral, S.K., Pahuja, S.S. and Mehta, A.K. 2008. Yield and nutrient content of wheat as affected by organic and inorganic fertilizers. *Environment and Ecology,* **26**(1A):470-471.

Kamla, Kanwar, Paliyal, S.S., Bedi, M.K. 2006. Integrated management of green manure, compost and nitrogen fertilizer in a rice-wheat cropping sequence. *Crop Research (Hisar)* **31**(3): 334-338.

Kataria, N. and Bassi, K. 1997. Effect of organic mulch and nitrogen on early sown wheat (*Triticum aestivum*) under rainfed condition. *Indian J. Agron*., **42**(1): 94-97.

Katharia, M.K., Singh, Harbir, Singh, K.P. and Kanadian, U.S. 2005. Effect of Integrated nutrient management on wheat grain production and some physio-chemical properties of soil under Cereal Fodder - Wheat cropping System. *Crop Research Hisar*, **30**(1): 10-14.

Kathuria, M.K., Singh, H., Singh, K.P. and Kadian, V.S. 2004. Effect of INM on N and P content and uptake by wheat under cereal fodder wheat cropping system. *Research on crops*, **5**(1):31-35.

Kaur, S., Kler, D.S., Singh, S., Kaur, G. and Singh, S. 2001. Effect of planting techniques at higher nitrogen on tillers count, PAR interception, soil temperature, grain yield and yield attributing characters of wheat *(Trticum aestivum* L.). *Journal of Environmental and Ecology,* **19**(2): 313-319.

Kazemeini, S.A., Ghadiri, H., Karimian, N. Nagighi, A.A.K. and Kheradnam, M. 2008. Interaction effect on growth and yield of dryland wheat *(Trticum aestivum). Journal of Science and Technology of Agriculture and Natural Resource,* **12**{45 (B)}: 461-473.

Khalil, A. A., Nasef, M.A., Ghazal, F.M., and El-Emam, M. A. 2004. Effect of integrated organic manuring and bio fertilizer on growth and nutrient uptake of wheat

(*Triticum aestivum*) plants grown in diverse textured soil. *Egyptian Journal of Agricultural Research*, **82**(2): 221-234.

Khan, N.H., Ali, M.R.A. and Sayeed, M.A.N.A.S. 2011. Physio-chemical traits, productivity and net return of wheat as attached by phosphorus and zinc requirements under arid climates. *Pakistan Journal of Botany*, **43**(2): 991-1002. 48 ref.

Kulkarni, R.V., Marathe, A.B. and Patil, A.P. 2005. Response of application of potassium fertilizers on yield and uptake of potassium by wheat on K deficient soils. *Journal on Soil and Crops*, **15**(1): 57-59.

Kumar, A. and Yadav, D.S. 1995. Use of organic manure and fertilizer in riec-wheat cropping system sustainability**.** *Indian j. Agric. Sci.*, **65**(10): 703- 707**.**

Kumar, S. and Tripathi, C.M. 1999. Nitrogen and cutting management and NPK on fertility status of soil yield and nutrient uptake in maize. *Madras Agric. J.*, **83**(3): 181-184.

Kumar, S., Badiyala, D. and Singh, C.M. 1999. Nitrogen and cutting management in winter wheat under dry temperate high hills. *Indian J. Agron.*, **45**(2)**:**36-39.

Kumar, V. and Ahlawat, I.P.S. 2004. Carry over effect of bioferilizers and nitrogen applied to wheat *(Triticum aestivum*) and direct applied N in maze *(Zea mays)* in wheat maize cropping systems. *Indian journal of Agronomy*, **49**(4): 233-236.

Kumar, Alok, Yadav, D.S. and Kumar, A. 2003. Long term nutrient management for sustainability in rice- wheat cropping system. *Ferti-News*, **48** (8), 27-28.

Kumar, S. B. and Arora, R.P. 2003. Variation in normalized difference vegetation index of wheat under different doses of NPK. *Annals of Agricultural Research*, **24**(3): 615-619.

Kumar, S., Singh, K. and Jatav, A.L. 2007. Effect of nitrogen levels on growth and yield of recently released variety Malviya- 468 under late sown condition. *Progressive Agriculture,* **7**(1/2): 25-27.

Kumar, Alok, Tripathi, H.P. and Yadav, D.S. 2007. Correcting nutrient for sustainable crop production. *Indian Journal of fertilizer*, **2**(11): 37-44.

Kumar, Vipin, Kumar, Arvind, Kumar, Ashok, Kumar, Mukesh, Sharma, Amit and Singh, I.B. 2008. A study on economic viability and feasibility of different value added NADEP. *Progressive Agriculture*, **8**(2): 150-153.

Kumar, Ghanshyam and Jat, R.K. 2010. Productivity and soil fertility as affected by organic manures and inorganic fertilizers in green gram (*Vigna radiate*) wheat (*Triticum aestivum* L.) system. *Indian Journal of Agronomy*, **55(**1**)**: 16-21.

Kumar, Arvind, Kumar, Ashok, Singh, V.K., Chauhan, B.P., Tripathi, S.K. 2012. Study of different sources for enrichment of compost through NADEP. *Progressive Agriculture*, **12**(2): 365-369.

Kumar, Parvinder and Pannu, R.K. 2012. Effect of different sources of nutrition and irrigation levels on yield, nutrient uptake and nutrient use efficiency of wheat. *International Journal of Life Sciences Biotechnology and Pharma Research*, **1**(4):187-192.

Laghari, G.M., Oad, F.C., Tunio, S.D., Gandahi, A.W., Siddiqui, M.H., Jagirani, A.W. and Oad, S.M. 2010. Growth yield and nutrient uptake of various wheat cultivars under different fertilizer regimes. *Sarhad J. Agric.*, **26**(4): 489-497.

Lakhdar, A., Achiba, W.B., Montemurro, F., Jedidi, N., Abdelly, C. 2009. Effect of municipal solid waste compost and farmyard manure application on heavy-metal uptake in wheat. *Communications in Soil Science and Plant Analysis*, **40**(21/22): 3524-3538.

Laximinarayan, K. and Patiram 2006. Effect of integrated use of inorganic, biological and organic manures on rice productivity and soil fertility in ultisols of Mizoram. *Journal of Indian Soc. Soil Science*, **54**(2): 213-220.

Lone, A. A., Mahdi, S. S., Bhat, M. I., Bhat, R. A., Faisul-ur-Rasool and Singh, O.P. 2011. Productivity and phosphorus use efficiency of wheat (*Triticum aestivum* L.) as influenced phosphorus under subtropical conditions of U.P. *Environment and Ecology*, **29**(3A): 1321-1325.

Maitra, D.N., Sarkar, S.K., Saha, S., Tripathi, M.K., Majumdar, B. and Saha, A.R. 2008. Effect of phosphorus and farmyard manure applied to sun hemp on yield and nutrient uptake of sunhemp- wheat (*Triticum aestivum* L.) cropping system and fertility status in a typic Ustocrept of Uttar Pradesh. *Indian Journal of Agricultural Sciences*, **78**(1): 70-74.

Mandal, A., Patra, A. K., Singh, D., Swarup, A., Purakayastha, T.J. and Masto, R.E. 2009. Effects of long- term organic and chemical fertilization on N and P in wheat plant and in soil during crop growth. *Agro chemical*, **53**(2): 79-91.

Maqsood, M., Akbar, M., Yousaf, Nadeem, Mehmood, Tahir and Ahmad, S. 1999. Effect of different rate of N, P and K combinations on yield and components of yield of wheat. *International Journal of Agriculture and Biology*, **1**(4): 359-361.

Maqsood, M. and Ali, A. 2002. Effect of irrigation and nitrogen levels on grain yield and quality of wheat. *International Journal of Agric. and Bio.*, **4**(1) : 164- 165**.**

Meena, B.L., Phogat, B.S., Jat, S.L., Singh, A.K. and Sharma, H.B. 2012. Effects of planting and integrated nutrient management systems on root phenology and grain yield of wheat. Etennded Summaries: 3rd International Agronomy Congress, Nov., 26-30, New Delhi, India.

Meena, M.C., Dwivedi, B.S., Singh, Dhyan, Singh, Sharma, B.M., Kumar, Krishan, Singh, R.V., Kumar, Pradeep and Rana, D.S. 2012. Effect of integrated nutrient management on productivity and soil health in pigeonpea (*Cajanus cajan*)-wheat (*Triticum aestvum*) cropping system. *Indian Journal of Agronomy*, **57**(4): 333-337.

Mondol, A.T.M.A.I., Solaiman, A.R.M., Islam, M.S., Karim, A.J.M.S. Rahman, M. J. 2005. Effect of nitrogen and compost on wheat productivity in the grey terrace soils. *International Journal of Sustainable Agricultural Technology*, **1**(4): 40-45.

Mubarak, T. and Singh, K.N. 2011. Nutrient management and productivity of wheat (*Triticum aestivum*) based cropping system in temperate zone. *Indian Journal of Agronomy*, **56**(3): 176-181.

Mukherjee, Dhiman 2008. Effect of different bio fertilizers and organic sources of nutrient along with chemical fertilizer on wheat (*Triticum aestivum)* under mid-hill situation. *Indian Agriculturist*, **52**(1/2): 49-52.

Nayak, A.K. and Gupta, M.L. 1995. Phosphorus, zinc and organic matter interaction in relation to uptake, tissue concentration and absorption rate of phosphorus in wheat. *Indian Journal of Soil Science*, **43**(4): 633-636.

Nehra, A.S. and Hooda, I.S. 2000. Effects of integrated use of organic manures with fertilizers on wheat. (*Triticum aestivum*) growth and yield. IFOAM 2000: the world grows organic. *Proceedings 13th International Ifoam Scientific Conference, Basel, Switzerland*, 28 to 31 Augist 2000.

Nehra, A.S., Hooda, I.S. and Singh, K.P. 2001. Effect of integrated nutrient management on growth and yield of wheat (*Triticum aestivum*). *Indian J. Agron*., **46**(1): 112-117.

Punia, Nitika and Khetarpaul, N. 2008. Physic-chemical characteristics, nutrient composition and consumer acceptability of wheat varieties grown under organic and inorganic farming conditions. *International Journal of Food Science and Nutrition*, **59**(3): 224-245.

Olsen, S.R., Cale, C.W., Wantanable, F.S. and Dean, L.A. 1954. Estimation of available phosphorous in soil by extraction with sodium bicarbonate. *Circular United status Department of Agriculture (Washington):* 19.

Pal, S.K., Kapur, J., Thakur, R., Verma, U.N. and Singh, M.K. 1996. Effect of variety, seeding date and fertilizers on growth and yield of wheat (*Triticum aestivum).* *Indian. J. Agron*., **41**(3): 386-389.

Panchal, A.R., Tank, D.A. and Vaishnav, P.R. 2008. Response of irrigated durum wheat (*Trticum durum* Desf. J variety GW- 1139) on yield and quality to nitrogen levels and its time of application**.** *Research on Crops*, **3**(2): 497-499.

Pandey, A.K., Singh, S.K. and Prasad, Rajeshwar 2009. Long term influence of organic and inorganic fertilizers on nutrient uptake by rice and wheat in calcareous soil. *Environment and Ecology*, **27**(4B):1903-1906.

Pandey, I.B., Bharti, V, Bharti, R.C. and Mishra, S.S. 2004. Effect of fertilizer level and seed rates on growth and yield of surface seeded wheat *(Triticum aestivum)* under low land rice ecosystem of North Bihar. *Indian of Agronomy*, **49**(1): 43-45.

Pandey, I.B., Diwedi, D.K. and Pandey, R.K. 2009. Integrated nutrient management for sustaining wheat *(Triticum aestivum)* production under late sown condition. *Indian Journal of Agronomy*, **54**(3): 306-309.

Pandey, I.B., Dwivedi, D.k. and Prakash, S.C. 2006. Impact of method and level of fertilizer application and weed management on nutrient economy and yield of wheat (*Triticum aestivum*). *Indian Journal of Agronomy*, **51**(3): 193-198.

Pandey, I.B., Singh, H. and Tiwari, S. 2003. Response of timely sown wheat in levels and time of nitrogen application. *Journal of research, BAU*, **15**(1): 35-38.

Pandey, S.B., Pandey, I.P. and Singh, R.S. 2004. Effect of potassium and magnesium on growth, yield and uptake of nutrients in wheat. Annals of Plant Soil Research, **3**(1): 74-78.

Pandey, S.N. and Sinha, B.N. 2009. Function of mineral nutrition in plant. *Plant physiology* Edn., 4th pp 120-139.

Pang, X.P. and Letay, J. 2000. Organic farming challenge of timing nitrogen availability to crop nitrogen requirements. *Soil Sci Soc. Amer. J.*, **64**(1): 32-35.

Pareta, D.K., Ojha, R.K. and David, A.A. 2009. Response of N and Zn on physico-chemical properties of soil and yield of wheat under alluvial soil condition. Environment and Ecology, **27**(4 B): 1895-1898.

Parihar, N.S., Saini, R.S., Pathan, A.R.K. 2005. Effect of sulphur, zinc and organic manures on yield and nutrient uptake of wheat in typic ustipsamment soil. *Annals of Agricultural Research*, **26**(1):64-68.

Parihar, S.S. 2004. Effect of integrated sources of nutrient, paddling and irrigation schedule on productivity of rice (*Oryza-sativa*) – wheat (*Triticum aestivum*) cropping system. *Indian J. Agronomy*, **49**(2): 74-79.

Patidar, M. and Mali, A.L. 2001. Integrated nutrient management in sorghum (sorghum Bicolor) and its residual effect on wheat (*Triticum aestivum*). *Indian Journal of Agricultural Sciences*, **71**(9): 587-591.

Patil, V.S. and Bhilare, R.I. 2001. Effect of vermicompost prepared from different organic sources on growth and yield of wheat. *J. Maharashtra Agric Univ*., **25**(3): 305-306.

Patra, A.P., Panda, D., Patra, B.C. and Karmakar, A.J. 1998. Effect of FYM, Zinc and NPK fertilizer on yield components and yield of wheat after winter rice in West *Bangal. J. Intracademicia*, **2**(1/2): 1-6.

Polara, K.B., Sardhara, R.V., Parmar, K.B., Babariya, N.B. and Patel, K.E. 2009. Effect of potassium on inflow rate of N, P, K, Ca, S, Fe, Zn and Mn at various growth stages of wheat. *Asian Journal of Soil Science*, **4**(2): 228-235.

Prasad, B. and Prasad, J. 1998. Effective efficient use of fertilizer for wheat growth in alfisol using targeted yield concept fertilizer news, **43**(8): 37-40.

Prasad, B., Sinha, K. and Sinha N.P. 1982. Effect of continuous application of manure and fertilizer on available soil potassium and its uptake by potato. *Journal of the Indian Society of Soil Science*, **30**: 235-236.

Rahim, A., Rahamtullah, A.M. and Waraich, E.A. 2010. Effect of phosphorus use efficiency. *Soil and Environment*, **29**(1): 15-22.

Rajhans Verma, W.P., Maurya, B.R., Bikrmaditya, P., Deewan, P. 2011. Comparative study of physio-chemical properties and quality of wheat straw compost by different methods. *Progressive Agriculture*, **11**(2): 311-316.

Rajput, A.L. 1997. Effect of nitrogen and zinc split application on wheat and their residual effect on rice (*Oriza sativa*). *Indian. J. Agron*., **42**(1): 22-25.

Ram, T., Yadav, S.K. and Sheoran, R.S. 2005. Growth analysis of wheat (*Triticum aestivum*) under varying fertility levels and Azotobactor strains. *Indian Journals of Agricultural Research*, **39**(4): 225-298.

Randhe, Minakshi, Jadhao, S.D. and Mane, S.S. 2010. N, P and K content and uptake of wheat crops as affected by organic and inorganic fertilization. *Green Farming*, **1**(3): 253-256.

Ranwa, R.S., Singh, K.P. and Dahia, S.S. 2001. Growth analysis of wheat as influenced by integrated levels of vermicompost with chemical fertilizers. *Haryana J. Agron*., **17**(1&2): 9-13.

Ranwa. R.S. 1999. Studies on integrated nutrient management wih vermicompost in wheat. Ph.D Thesis, CCS Haryana Agriculture university, Hissar.

Rao, A.S., Reddy, D.D., Reddy, K.S. and Takkar, P.N, 1998. Crop Yield and phosphorus recovery in soybean-wheat cropping system. *J. Indian Soc. Soil Sci.*, **46**(2): 249-257.

Rathor, S.A. and Sharma, N.L. 2010. Effect of integrated nutrient management on productivity and nutrient uptake in wheat and soil fertility. *Asian Journal of Soil Science*, **4**(2): 208-210. 6 ref.

Reddy, B.R., Govardhan, S and Abraham, T. 2006. Performance of wheat under integrated nutrient management. *National symposium on conservation agriculture and Environment*, Oct.2628, Varanasi, U.P., India.

Reddy, B.V.C., Honnaiah Reddy, P.N.S., Kale, R.D., Balakrishna, A.N. 2009. Economics of vermicompost production and marketing in Southern Karnataka. *Mysore Journal of Agricultural Sciences*, **43**(1): 125-131.

Rehman, S., Shad, K.K., Muhammad, F., Rehman, A., Khan, A.Z., Amanullah, Rehman, A., Saljoki, Muhammad, Z. and Khalil, I.H. 2010. Phenology, leaf area index and grain yield of rain fed wheat influenced by organic and Inorganic fertilizer. *Pak. J. Bot.*, **42**(5): 3671-3685.

Rovinson, C.H., Ineson, P., Piearse, T.G. and Rowland, A.P. 1992. Nitrogen metabolization by earth worm in lined peat soil under piceasitshensis. *J. Apl. Scol.*, **29**: 226-237.

Sen, A., Pandey, M.D., Sharma, S.N., Singh, R.K., Kumar, A., Shukla, P. and Srivastava, V.K. 2003. Surface seeding of wheat as affected by seed rate and nitrogen level. *Indian Journal of Agriculture Science*, **73**(9): 509-511.

Sen, A., Pandey, M.D., Sharma, S.N., Singh, R.K., Kumar, A., Shukla, P. and Srivastava, V.K. 2003. Surface seeding of wheat as affected by seed rate and nitrogen level. *Indian Journal of Agriculture Science*, **73**(9): 509-511.

Sepat, R.N., Rai, R.K. and Dhar, S. 2010. Planting systems and integrated nutrient management for enhanced wheat (*Triticum aestivum*) productivity. *Indian Journal of Agronomy*, **55**(2): 114-118.

Shah, Z and Ahamad, M.I 2006. Effect of integrated use of farmyard manure and urea on yield and nitrogen uptake of wheat. *Journal of Agricultural and Biological Science*, **1**(1): 1-6.

Sharma, A., Singh H. and Nanwal, R.K. 2007. Effect of integrated nutrient management on productivity of wheat (*Triticum aestivum*) under limited and adequate irrigation supplies. *Indian Journal of Agronomy*, **52**(2): 120-123.

Sharma, P.K. and Manohar, S.S. 2002. Response wheat *(Triticum aestivum* L.) to nitrogen and sulphur and their residual effect on succeeding Pearl millet *(Penisetum glaucum). Indian Journal of Agronomy*, **47**(4): 473-476.

Sharma, R., Dahiya, S., Rathee, A., Singh, D., Nandal, J.K. and Malik, R.K. 2009. Effect of INM on growth, yield, economicsand soil fertility in rice-wheat cropping system. *Indian Journal of Fertilizers*, **5**(3): 31–34.

Sharma, S.C. and Vyas, A.K. 2001. Residual effect of phosphorus fertilization and farm yard manure on productivity of succeeding wheat *(Triticum aestivum*) - Soyabean (*Glycine max.*). *Indian Journal of Agronomy*, **46**(3): 416-420.

Sharma, Vivek, Kanwar, Kamla, Dev, S.P. 2005. Efficacy of vermicompost for improving crop yield and nutrient uptake in wheat. *Journal of Soils and crops*, **15**(2): 269-273.

Shirpurkar, G.N., Bhoite, S.U., Gosavi, A.B. and Wagh, M.P. 2007. Effect of nitrogen levels on yield of rainfed wheat. *Agricultural Science Digest*, **27** (3): 231-232.

Shivankar, S.K., Joshi, R.P. and Shivankar, R.S. 2000. Effect of biiofertilizer and levels of N and phosphorus on yield and uptake of N and P by under irrigated condition. *Journals of Soil and Crop Science*, **10**(2): 292-294.

Shou, H.W., JinQin, H. and GuoRuiYing 2006. Characteristics of N, P and K uptake at different growth stages of spring wheat in the Huanghe-irrigated region of Ningxia. *Plant Nutrition and Fertilizer Science*, **12**(6): 789-796.

Shukla, R.P., Singh, R.P. and Yadav, D.S. 2006. Effect of zero and convectional tillage on nitrogen requirement of wheat (*Triticum aestivum*). *Annals of Plant physiology*, **20**(1): 131-132.

Singh, V.P.N., Uttam, S.K. 1994. Effect of plant growth regulators and fertility levels on yield of wheat. *Bhartiya Krishi Anusandhan Patrika*, **9**(1): 56-62.

Singh, Gurigbal and Brar, S.S. 1994. Tillage and nitrogen requirement of wheat (*Triticum aestivum*) sown after rice (*Oryza sativa*). *Indian Journal of Agronomy*, **39**(1): 162-163.

Singh, B. and Antil, R.S. 1996. Effect of Zn and N levels on dry matter yield and nutrient uptake by wheat**.** *Ann. Bio.*, **12**(1): 165-167.

Singh, V.P. and Prasad, A. 1998. Effect on nitrogen levels and weed control method on wheat under rain fed and irrigated condition of low hill and valley situation. *Ann. Agric Res.*, **19**(1): 72-79.

Singh, V.P. 1999. Effect of organic and inorganic sources of nutrients on rain fed wheat. (*Triticum aestivum*). *Indian Journal of Agronomy*, **44**(2): 347-352.

Singh, A.K., Amgain, L.P. and Sharma, S.K. 1999. Root characteristics soil physical properties and yield of rice as influenced by integrated nutrient management in rice-wheat system. *Indian J. Agro*., **45**(2): 217-222.

Singh, J. and Singh, C.M. 2000. Effect of potassium application in rice-wheat cropping system. *Indian Journal of Agronomy*, **45**(1): 12-20.

Singh, Babita., Singh, R.A.S., Tomar, S. and Trivedi, S.K. 2001. Effect of fertility levels and sulphur sources on yield and quality of wheat (*Triticum aestivum). Haryana J. Agron*, **17** (1&2): 142-150.

Singh, R. and Agarwal, S.K. 2001. Growth and yield of wheat as influenced by levels of FYM and nitrogen. *Indian J.Agron*., **46**(3): 462-467.

Singh, Ravindra, Agarwal, S.K. and Jat, M.L. 2002. Quality of wheat (*Triticum aestivum* L.) and nutrient status in soil as influenced by organic and inorganic sources of nutrients. *Indian Journal of Agricultural Science*, **72**(8): 456-460.

Singh, S.K. and Singh, K.P. 2003. Effect of long term use of fertilizers, lime and FYM on yield and nutrient uptake by wheat and soil properties. *Journal of Research, Birsa Agriculture University*, **15**(1): 85-87.

Singh, R. and Agrawal, S.K. 2004. Effect of organic manuring and nitrogen fertilization on productivity, nutrient use efficiency and economics of wheat (*Triticum aestivum*), *Indian Journal of Agronomy*, **49**(1): 49-52.

Singh, Jintendra and Singh, K.P. 2005. Effect of organic manure and herbicides on yield and yield attributes of wheat. *Indian Journal of Agronomy*, **50**(4): 289-291.

Singh, Randhir. and Singh, K.P. 2005. Nutrient uptake and quality of wheat as affected by organic manures and inorganic fertilizers. *Haryana Journal of Agronomy*, **21**(2): 207-208.

Singh, Gurkirpal, Singh, K.J., Sooch, S.S. and Walia, S.S. 2006. Role of phospho bacteria in enhancing efficacy of inorganic phosphorus in relation to growth and yield of wheat (*Triticum aestivum* L.). *Environment and Ecology*, **24**(1): 232-236. 7 ref.

Singh, D.K., Prasad, Kedar, Singh, Raghurey, pyare, Ram 2006. Studies on effect of FYM and gypsum on yield attributes and yield of wheat under different fertility level. *Plant Archives*, **1**: 189-191.5 ref.

Singh, G., Singh O.P., Singh, R.G.S., Mehata, R.K., Kumar, V. and Singh, R.P. 2006. Effect of integrated nutrient management on yield and nutrient uptake of rice (*Oryza sativa*) wheat (*Triticum aestivum*) cropping system in low lands of Eastern Uttar Pradesh. *Indian Journal of Agronomy*, **51**(2): 85-85.

Singh, Mahindra. and Yadav, B.L. 2006. Effect of different organic materials and zinc levels on yield and nutrient uptake by wheat irrigated with high RSC water. *Haryana Journal of Agronomy*, **22**(2): 139-141.

Singh, R. and Yadav, D.S. 2006. Effect of rice (*Oryza sativa)* residues and nitrogen on perfemace of wheat *(Triticum aestivum* L.) under rice-wheat cropping system. *Indian Journal of Agronomy*, **51**(4): 247-250.

Singh, R.K., Singh, S.K. and Singh, L.B. 2007. Integrated nitrogen management in wheat (*Triticum aestivum*). *Indian Journal of Agronomy*, **52**(2): 124-126.

Singh, F., Kumar, R. and Pal, S. 2008. Integrated nutrient management in rice-wheat cropping system for sustainable productivity. *Journal of the Indian society of soil science, vol* 56, No.2, pp 205-208.

Singh, R.V. and Rajeev Kumar 2010. Effect of organic and inorganic fertilizers on growth yield and quality and nutrients uptake of wheat under late sown condition. *Progressive Agriculture*, **10**(2): 341-344. 3 *ref.*

Singh, Ajay., Yadav, A.S. and Verma, S.K. 2010. Productivity, nutrient uptake and water use efficiency of wheat (*Triticum aestivum* L.) under different irrigation levels and fertility sources. *Indian Journal of Ecology*, **37**(1): 13-17.

Singh, C.M., Sharma, P.K., Kishor, Prem, Mishra, P.K., Singh, A.P., Verma, Rajhans and Raha, P. 2011. Impact of integrated nutrient management on growth yield and nutrient uptake by wheat (*Triticum aestivum* L.). *Asian Journal of Agricultural Research*, **5**(1): 76-82.

Singh, S.P. and Pal, M.S. 2011. Effect of integrated nutrient management on productivity quality, nutrient uptake and economics of mustard (*Brassica juncoa*). *Indian Journal of Agronomy*, **56** (4): 381-387.

Singh, Satpal, R.A., Kathwal, Rajesh and Thakral, S.K. 2013. Suitability of organic and inorganic sources of nitrogen on nutrient uptake and quality, soil physic-Chemical properties and economics of wheat cultivation. *Annals of Biology*, **29**(1): 50-52.

Singhal, S.K., Singh, R.D., Sharma, V.K., Sharma, S.K. 2012. Impact of integrated use of fertilizer and enriched compost on yield, nitrogen uptake by wheat and fractions of soil. *Indian Journal of Agricultural Research*, **46**(3): 262-268.

Srivastava, V.K., Kumar, Vipin, Singh, S.P., Singh, R.N. and Ram, U.S. 2008. Effect of various fertility levels and organic manures on yield and nutrient uptake of hybrid rice and its residual effect on wheat. *Environment and Ecology*, **26**(4): 1477-1480.

Sreenivas, C. H., Muraliahar, S. and Singh, R. 2000. Yield and quality of ridge guard fruit as influenced try different levels of inorganic fertilizer and vemicompost, Annuals, Agric. Res. 21:262-266.

Stalenga, J. 2007. Applicability of different indices to evaluate nutrient status of winter wheat in the organic system. *Journal of plant Nutrition*, **30**(1-3): 351-365.

Subbiah, R.V. and Asija, C.L. 1956. A rapid procedure for the estimation of available nitrogen in soil. *Science.* **25**: 172-174.

Sushila, R. and Giri, G. 2000. Influence of FYM nitrogen and biofertilizer on growth yield attributes and yield of wheat (*Triticum aestivum*) under limited water supply, *Indian, J. Agon*., **45**(3): 590-595.

Swarup, A and Yaduvanshi, N.P.S. 2005. Response of rice and wheat to organic and inorganic fertilizers and soil amendments under sodic- irrigated conditions. *International rice Research notes*, **28**(1): 40-45.

Tahir, Muhammad, Ayub, Muhammad, Javeed, H.M.R., Naeem, Muhammad, Rehman, Hasseb-ur, Waseem, Muhammad and Ali, Muqarrab 2011. Effect of different organic matter on growth and yield of wheat. *Pakistan Journal of Life and Social Sciences*, **9**(1): 63-66.

Thakaral, S.K., Kadian, U.S. and Kumar, S. 2003. Effect of different organic and inorganic fertilizer levels on yield and yield attributes of wheat. *Haryana, J. Agron*., **19**(1): 60-62.

Thakral, Mamta, Kajla, S.K., Pahuja, S.S., and Mehta, S.K. 2007. Yield and growth parameters of wheat as influenced by different sources of nutrition. *Annals of Biology*, **23**(2): 149-151.

Thakral, S.K. and Madan, Shashi 2008. Effect of nutrient management on quality, nutrient content and uptake in wheat. *National Journal of Plant Improvement*, **10**(2): 116-119.

Tisdale, S.L. Nelson, W.L. Beaton, J.D and Havlin, J.L. 1995. Soil fertility and fertilizer.Prevtice-Hall of India Pvt. Ltd., New Delhi.

Tripathi, M.K., Chaturvedi, S., Shukla, D.K. and Mahapatra, B.S. 2010. Yield performance and quality in Indian mustard (*Brassica juncia*) as affected by integrated nutrient management. *Indian Journal of Agronomy,* **55**(2): 138-142.

Tulasa Ram and Mir, S.S. 2006. Effect of integrated nutrient management on yield and yield attributing characters of wheat (*Triticum aestivum*). *Indian Journal of Agronomy,* **51**(3): 189-192.

Upadhyay, N.C., Rawal, S. and Khan, M.A. 2004. Organic potato production paper presented in national symposium on second generation problem and its remedies. November 26-27 Modipuram (Meerut).

Verma, G. and Mathur, A.K. 2009. Effect of integrated nutrient management on active pools of soil organic matter under maize-wheat system of a Typic Haplustept. *Journal of the Indian Society of Soil Science vd*. 57, No. 3, pp 317-322.

Verma, G., Mathur, A.K., Bhandari, S.C. and Kanthaliya, P.C. 2010. Long term effect of integrated nutrient management on properties of a typic haplustept under maize-wheat cropping system. *Journal of the Indian Society of Soil Science*, *vol*, 58, no. 3 pp 299-302.

Verma, L.N. 1995. Conservation and efficient use of organic sources of plant nutrients. In Thomson, P.K. (Ed.) *Organic Agriculture.* Pee kay Tree Crop Development Foundation, Cochin, India, pp 101-143.

Yadav, K.S., Singh, D.P., Sunya, S., Narula, N. and Lakshmi narayan, K. 2000. Effect of Azotobacter on yield and nitrogen economy in wheat (*Trticum aestvum*) under field condition. *Environment and Ecology***,** **18**(1): 109- 113.

Yadav, R.S., Yadav, P.C. and Dahama, A.K. 2003. Integrated nutrient management in wheat (*Triticum aestivum*) mungbean (*Phaseolus radiatus*) cropping sequence in arid region. *Indian Journal of Agronomy*, **48**(1): 23-26

Yadav, M.P., Mohd. Adlam and Kushwaha, S.P. 2005. Effect of integrated nutrient management in rice (*Oryza sativa*) wheat (*Triticum aestivum*) cropping system in Central Plain Zone of Uttar Pradesh. *Indian Journal of Agronomy*, **50**(2): 89-93.

. Yadav, D.S., Shukla, Sushant and Kumar, Briendra 2005. Effect of zero tillage and nitrogen level on wheat (*Triticum aestivum*) after rice (*Oryza sativa*). *Indian Journal of Agronomy*, **50**(1): 52-53.

Yadav, D.S., Kumar, V., Yadav. 2009. Effect of organic farming on productivity. Soil health and economics of rice (*Oryza sativa*)- wheat (*Triticum aestivum*) system. *Indian Journal of Agronomy*, **54**(3): 267-271.

Yawalkar, K.S., Agarwal, J.P. and Bokde, S. 1992. Manures and fertilizers. Kapoor Art press, New Delhi pp 29-77.

Yonglin, Song, ZaoHua, Yao, Feng Ming, Yuan, ShuXiang, Zhang and Lixia, Wang. 2001. Effect of application of fertilizer NPK combined with organic manure on growth characteristics and yield of winter wheat. *Beijing Agricultural Sciences*, **19**(5):15-17.

Zade, K.K. and Kaleem, Mohd. 2009. Growth, yield and economics of wheat (*Triticum aestivum* L.) as influenced by biofertilizers with nitrogen levels. *International Journal of Agricultural Sciences*, **5**(1): 211-213.

Zahedifar, M., Karimian, N., Ronaghi, A.,Yasrebi, J., Emam, Y. and Moosavi, A.A. 2011. Effect of phosphorus and organic matter on phosphorus status of winter wheat at different part and growth stages. *Journal of Plant Breeding and crop Science*, **3**(15): 401-402

Appendix-I

Weekly meteorological data during the experimental season Rabi (2011-2012).

Standard week	Temperature (^{0}C)		Rainfall (mm)	Relative Humidity (%)	
	Maximum	Minimum		Maximum	Minimum
49	27.28	11.0	0.00	88.28	52.57
50	22.94	5.8	0.00	85.42	61.14
51	20.7	3.9	0.00	84.42	50.57
52	22.9	2.9	0.00	83.75	34.87
1	15.71	9.57	15.50	75.35	64.71
2	16.35	5.28	0.00	75.35	43.42
3	15.14	7.42	7.75	80.35	61.71
4	19.85	5.14	0.00	74.5	27.92
5	20.14	6.1	0.00	76.21	26.57
6	19.42	6.85	0.00	72.78	34.78
7	20.35	8.94	0.00	66.92	33.21
8	25.85	10.5	0.00	64.78	37.78
9	25.93	8.93	0.00	71.5	31.88
10	26.35	10.5	0.00	71.78	21.92
11	27.00	12.28	19.25	76.35	29.64
12	30.21	13.71	0.00	68.28	24.07
13	32.85	16.92	0.00	75.42	24.42
14	34.78	19.35	0.00	67.14	30.64
15	27.16	18.21	34.75	68.57	45.14
16	32.92	19.64	2.15	63.71	32.57
17	34.14	19.71	0.60	58.57	30.07

Appendix-II

Weekly meteorological data during the experimental season Rabi (2012-2013)

Standard week	Temperature (^0C)		Rainfall (mm)	Relative Humidity (%)	
	Maximum	Minimum		Maximum	Minimum
49	23.9	5	0.00	88.2	42
50	22	7.5	31.5	86	53.9
51	19.7	5.4	0.00	98	63.9
52	15.2	4.3	0.00	93.9	78.1
1	11	1.2	0.00	90.2	74.7
2	19.3	4.3	3.2	93.4	58.7
3	18.7	7.7	25.3	93.6	74.9
4	19.4	5.7	0.00	95.5	65
5	21.9	7.7	34.6	94.9	68.2
6	20.1	8.9	15.5	97	71.5
7	21	10.1	64.1	95.7	59.7
8	22.9	10.1	2.3	95.4	61.6
9	25.6	9.7	0.00	95.3	49.1
10	29.5	10.3	0.00	95	42.7
11	28.8	10.4	0.00	96.2	46.5
12	30.6	12.8	0.00	94.9	45.6
13	28.3	11.8	7.4	94.1	52.3
14	32.9	12.9	0.00	86.4	30.5
15	35.8	16.4	0.00	79.3	29.5
16	35.2	15.1	0.00	64.3	32.4
17	34.14	19.71	0.6	58.57	30.07

Appendix-III

Analysis of variance for Plant height (cm) at different nutrient option at various stages

Source of variation	d.f	Mean sum of square							
		2011-12				2012-13			
		30	60	90	At harvest	30	60	90	At harvest
Replication	**2**								
Treatment	**10**	16.76	43.99	73.06	80.43	15.36	47.51	88.64	84.14
Error	**20**	0.85	0.85	0.50	0.33	0.73	0.29	0.81	0.20

Appendix-IV

Analysis of variance for Dry matter accumulation (g m^{-1}) at different nutrient option at various stages

Source of variation	d.f	Mean sum of square							
		2011-12				2012-13			
		30	60	90	At harvest	30	60	90	At harvest
Replication	**2**								
Treatment	**10**	5.46	481.86	1133.76	1874.56	6.47	471.10	1207.62	1981.59
Error	**20**	0.16	2.31	2.54	17.42	0.21	3.84	7.16	14.78

Appendix-V

Analysis of variance for effective tillers per meter row length at different nutrient option at various stages

Source of variation	d.f	Mean sum of square							
		2011-12				2012-13			
		30	60	90	At harvest	30	60	90	At harvest
Replication	**2**								
Treatment	**10**	33.48	75.32	239.54	215.79	45.84	95.87	231.32	180.76
Error	**20**	19.27	0.22	0.21	0.13	0.00	0.49	0.33	0.41

Appendix-VI

Source of variation	d.f	Analysis of variance for Leaf area index at different nutrient option at various stages					
		Mean sum of square					
		2011-12			2012-13		
		30	60	90	30	60	90
Replication	**2**						
Treatment	**10**	0.01	0.02	0.01	0.01	0.03	0.01
Error	**20**	0.00	0.00	0.02	0.00	0.00	0.02

Appendix-VII

Analysis of variance for yield attributing characters of wheat

Source of variation	d.f	Mean sum of square							
		Spike length (cm)		Spikelet's spike^{-1} (No.)		Grains spike^{-1} (No.)		1000-grain weight (g)	
		2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Replication	**2**								
Treatment	**10**	4.13	3.54	8.38	8.20	22.22	19.23	11.93	14.22
Error	**20**	0.07	0.05	0.06	0.16	0.47	0.35	0.25	0.25

Appendix-VIII

Analysis of variance for yield of wheat

Source of variation	d.f	Mean sum of square							
		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})		Biological yield (q ha^{-1})		Harvest index	
		2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Replication	**2**								
Treatment	**10**	68.46	72.22	109.43	101.88	342.39	339.26	2.91	3.94
Error	**20**	0.90	1.32	0.08	0.48	2.27	3.74	24.23	24.54

***Appendix*-IX**

Analysis of variance for N content, N uptake and total N uptake by grain and straw

Source of variance	d.f	Mean sum of square: N content (%) Grain 2011-12	N content (%) Grain 2012-13	N content (%) Straw 2011-12	N content (%) Straw 2012-13	N uptake (kg ha^{-1}) Grain 2011-12	N uptake (kg ha^{-1}) Grain 2012-13	N uptake (kg ha^{-1}) Straw 2011-12	N uptake (kg ha^{-1}) Straw 2012-13	Total uptake (kg ha^{-1}) 2011-12	Total uptake (kg ha^{-1}) 2012-13
Replication	**2**										
Treatment	**10**	0.06	0.10	0.02	0.02	406.06	609.28	88.72	108.32	869.74	1211.50
Error	**20**	0.00	0.00	0.00	0.00	9.63	29.27	2.62	3.05	27.88	49.92

***Appendix*-X**

Analysis of variance for P content, P uptake and total P uptake by grain and straw

Source of variance	d.f	Mean sum of square: P content (%) Grain 2011-12	P content (%) Grain 2012-13	P content (%) Straw 2011-12	P content (%) Straw 2012-13	P uptake (kg ha^{-1}) Grain 2011-12	P uptake (kg ha^{-1}) Grain 2012-13	P uptake (kg ha^{-1}) Straw 2011-12	P uptake (kg ha^{-1}) Straw 2012-13	Total uptake (kg ha^{-1}) 2011-12	Total uptake (kg ha^{-1}) 2012-13
Replication	**2**										
Treatment	**10**	0.00	0.00	0.00	0.00	15.98	16.97	7.62	10.79	49.17	56.76
Error	**20**	0.00	0.00	0.00	0.00	0.65	0.68	0.15	0.20	1.66	2.18

Appendix-XI

Analysis of variance for K content, K uptake and total uptake by grain and straw

Source of variance	d.f	Mean sum of square									
		K content (%)				K uptake (kg ha^{-1})				Total uptake (kg ha^{-1})	
		Grain		Straw		Grain		Straw			
		2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Replication	**2**										
Treatment	**10**	0.01	0.01	0.07	0.07	34.29	36.30	697.06	689.82	1028.49	1027.09
Error	**20**	0.00	0.00	0.00	0.00	1.07	1.47	13.60	13.57	7.57	7.88

Appendix-XII

Analysis of variance for Combined NPK uptake (Kg ha^{-1})

Source of variance	d.f	Mean sum of square	
		Combined NPK uptake (Kg ha^{-1})	
		2011-12	2012-13
Replication	**2**		
Treatment	**10**	4690.55	5493.20
Error	**20**	32.99	75.86

Appendix-XIII

Analysis of variance for Protein content by grain

Source of variance	d.f	Mean sum of square Protein content	
		2011-12	2012-13
Replication	2		
Treatment	10	2.39	3.95
Error	20	0.28	0.58

Appendix-XIV

Analysis of variance for available N, P,K content and Organic carbon

Source of variance	d.f	Mean sum of square							
		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K(kg ha^{-1})		Organic carbon (%)	
		2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Replication	2								
Treatment	10	306.81	311.96	3.93	4.48	44.64	48.28	0.00	0.00
Error	20	1.29	1.91	0.12	0.15	0.89	1.01	0.00	0.00

Appendix-XV

Analysis of variance for Soil pH

Source of variance	**d.f**	Mean sum of square **Protein content**	
		2011-12	**2012-13**
Replication	**2**		
Treatment	**10**	0.26	0.26
Error	**20**	1.03	0.11

Appendix-XVI

Analysis of variance for Cost of cultivation, Gross return, Net returns and B: C ratio

Source of variance	**d.f**	Mean sum of square							
		Cost of cultivation (kg ha^{-1})		**Gross return (kg ha^{-1})**		**Net returns (kg ha^{-1})**		**B: C ratio**	
		2011-12	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**	**2011-12**	**2012-13**
Replication	**2**								
Treatment	**10**	17285702.5	20965109.0	176541170.0	206261568.0	119207162.0	141650321.0	0.18	0.19
Error	**20**	2012316.65	2467801.69	1551251.26	3100823.03	1638217.01	6496523.08	0.01	0.03

Appendix-XVII

Common cost of cultivation price for wheat crop.

Particulars	**wheat crop (Rs. ha^{-1})**	
	2011-12	2012-13
Field preparation		
Presowing irrigation	1300	1400
Land preparation (1 ploughing STP 3 hrs.)	1050	1200
Harrowing and ploughing (4 hrs.)	1400	1600
Lay out (2 labour)	250	300
Sowing		
Seed	3120	3000
Furrow opening and planking	625	750
Bunding and channel preparation	625	750
Cost of fertilizer 100%		
Urea	1259	1363
DAP	2739	2804
MOP	533	567
Irrigation	3250	3750
Organic manure 1t		
FYM	250	300
Pressmud	380	400
Vermicompost	2500	3000
Herbicide	650	680
Harvesting and threshing		
Harvesting	3250	3750
Threshing	4100	4400

Appendix-XVIII

Price of inputs/ outputs used

S.N.	Particular	Cost (Rs.)	
a.	**Inputs**	2011-12	2012-13
	Tractor with implements	350/hrs	400/hrs
	Labour	125/manday	150/manday
	Seed	26/kg	26/kg
	Urea	300/bag	325/bag
	DAP	1050/bag	1075/bag
	MOP	400/bag	425/bag
	FYM	250/t	300/t
	Pressmud	350/t	400/t
	Vermicompost	2500/t	3000/t
	Azosprillium	40/kg	50/kg
	Irrigation	130/hrs	140/hrs
b.	**Outputs**		
	Wheat grain	1300/q	1350/q
	Wheat straw	250/q	300/q

Abstract

Name: Nishant **Id. No.:** 2014 **Degree:** Ph. D.
Year of admission: 2011-12 **Major:** Agronomy **Advisor:** Dr. Vivek
Thesis Title: "**Integrated Nutrient Management for Sustainable Wheat (*Triticum aestivum* L.) Production in Western U.P.**

Wheat (*Triticum aestivum* L.), the 2nd most important food crop of the world and India next to rice account for 31.5 % of the food grain basket of the country. Wheat is the backbone of food security of India. It covers an area of 29.25 m ha with total production of 94.90 m t and average productivity of 29.89 q/ha.The total area of wheat in the world is around 222.60 m ha with production of 716.16 m t. The normal world productivity is 32.17 q ha^{-1}.Wheat crop contributes substantially to the national food security by providing more than 50 % of the calories to the people who mainly depend on it. The common bread wheat occupies more than 90% of total wheat area and along with 10% area under *Triticum durum.* Non judicious use of chemical fertilizer over a long term in agriculture had shown the adverse effect of soil health and crop yield. Highly productive soils have started showing signs of declining productivity with increasing cropping intensities. Capacity of soil to replenish nutrient level in soil is declining and therefore use of chemical fertilizer increasing day by day. Indiscrimate uses of fertilizer adversely affecting the Physico-chemical properties of the soil resulting in stagnation in productivity. Therefore we use integrated nutrient management system it is a combine application of organic and inorganic along with bio-fertilizer. The traces of micronutrients which are essential for plants are not supplied by chemical fertilizers but organic manures supply micronutrients by the application of organic manures increase the organic matter content in the soil which increase the water holding capacity in soil and improve the physico-chemical property of soil. The beneficial impact of organic manure on physical, biological and chemical property of soil.

A field experiment was conducted in wheat during *rabi* season during 2011-12 and 2012-13 on sandy loam soil at crop research center of Sardar Vallabh Bhai Patel University of Agriculture and Technology, Meerut. Experiment was laid out in a randomized block design with three replications. Studies were conducted with eleven treatments viz., 100% NPK, 75 % NPK + 3 ton ha^{-1} FYM + Azosprillium, 50% NPK + 6 ton ha^{-1} FYM + Azosprillium, 25% NPK + 9 ton ha^{-1} FYM + Azosprillium, 75 % NPK + 1 ton ha^{-1} pressmud + Azosprillium, 50 % NPK + 2 ton ha^{-1} pressmud + Azosprillium, 25 % NPK + 3 ton ha^{-1} pressmud + Azosprillium,75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium, 50 % NPK + 2 ton ha^{-1} vermicompost + Azosprillium, 25 % NPK + 3ton ha^{-1} vermicompost + Azosprillium, Control.

The highest growth characters were recorded with 100 % RDF through inorganic source of nutrient which were statistically similar to the treatment of 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium and significantly higher than the rest of the treatments and control. Among the different combination of organic manures with inorganic source of nutrients, 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium recorded significantly higher yield attributes and yield along with higher gross return and net return. Higher nutrient content and nutrient uptake over control with inorganic fertilizer. On the basis present study, it may be concluded that integrated use of organic source of nutrient can enhance the productivity of wheat.

At maturity 100% NPK and 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium attained the plant height 77.75 and 77.25 cm respectively. 100% NPK and 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium accumulated 243.3 and 236.85 g/m of dry matter at maturity. Yield attributes (spike length, grains per spike, spikelet's $spike^{-1}$, 1000-grain weight etc), grain, straw and biological yield, and harvest index (HI) markedly reduced in control plot. The mean grain yield obtained were 42.64q ha^{-1}, and 41.72 q ha^{-1} in 100% NPK and 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium respectively. 100% NPK fetched highest gross return of Rs 73478 ha^{-1}, net return of Rs 48211 ha^{-1} with B: C ratio of 1.90 while the lowest (Rs 43778 ha^{-1}, Rs 23143 ha^{-1} and 1.12) with control plot. Although application of 100% NPK yielded more among all the nutrient management options but it was found at par with 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium in grain yield, gross return and net return. Therefore for the sustainability of soil health 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium proved better. Thus 75 % NPK + 1 ton ha^{-1} vermicompost + Azosprillium may be suggested for good performance of wheat crop and sustainability of soil health and crop yields in future.

(Vivek) **(Nishant)**

VITAE

Name : **Nishant**

Date of Birth : **15 june 1986**

Place of Birth : **JANIPUAR KHURDH**

JAUNPUR (U.P)

ACADEMIC QUALIFICATION:-

- 2011 - Join in Ph.D. Agronomy with major in Agronomy and minor in Soil Science and completed the entire course required for the degree in Sardar Vallabbhai Patel University of Agriculture & Technology, Meerut (U.P.).
- 2009-2011 - M.Sc. (Ag.) Agronomy in Narendra Dev University of Agriculture & Technology, Kumarganj, Faizabad (U.P.).
- 2008-2009 - Work as Asst. Cane development officer in Khargon (M.P.).
- 2007 - Passed B.Sc. (Ag.) Hons. examination with Second division from Udai Pratap Autonomous College, Varanasi (U.P.) .
- 2003 - Passed Intermediate with Second division from I.S Inter College Allahabad (U.P.).
- 2001 – Passed High school with second division from I.S Inter College Allahabad (U.P.).

MAILING ADDRESS:-

NISHANT S/O Mr. AVADH RAJ

VILL + POST : JANGIPURKHURDH

Distt. : JAUNPUR (U.P.)

Mob. No. : 7417340741

E-mail : nishu.nishant455@gmail.com

Pin code : 222001