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AN ON-FARM STUDY ON EFFECT OF ORGANIC SUPPLEMENT FOR WHEAT PRODUCTION IN NATORE DISTRICT, A RAINFED AREA OF BANGLADESH

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ABSTRACT

This experiment was conducted to investigate the effects on application of organic matter with ½ recommended dose of chemical fertilizers on wheat in order to adaptation research of climate change in rainfed area of Bangladesh to achieve higher yield and yield attributes through sustainable balancing of soil physical, chemical and organic matter. The experiment was conducted in the fields of "*Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN) Project*" which is a collaborative project under the supervision of CARITAS Bangladesh at Boraigram, Natore, Rajshahi-6000 during the Rabi season 2014 to 2015. The experiment was designed with two treatments: i) Farmyard Manure (FYM) and ii) Poultry Litter (PL) treatments, which were laid out with local farmer's practices along with irrigation and tillage. There were two replications of combination for both the treatments. According to the farmer's practices, FYM and PL treatment was assigned in the mother plot and the two replications were assigned in the different area and different plots on the treatment. The plot size was $400m^2$ except mother plots ($200m^2$). The treatment combinations were designed as ½ recommended chemical fertilizer (Urea: 180 kg/ha, TSP: 140 kg/ha, MOP: 40 Kg/ha and Gypsum: 80 kg/ha) + FYM (3 ton/ha) and ½ recommended chemical fertilizer + PL (3 ton/ha). The highest 1000- grains weight of (BARI GAM-24) was obtained 62.97gm and 55.86gm in FYM and PL treatment plots, respectively. The 1000- grains weight of FYM treatment was statistically higher than PL treatments. Analysis of the data revealed that the treatments showed multi-location variation in 1000- grains weight among FYM plots as well as PL treatment plots in the present research. The results showed that grain and straw yields of wheat were significantly influenced by the treatments in location-based. The highest grain yield was obtained same at 4.40t/ha and 4.40t/ha in FYM and PL plot. Meanwhile other recorded data were 3.90, 4.10, 3.80, 3.70, 4.00t/ha and 3.80, 4.00, 3.90, 4.10t/ha in FYM and PL treatments, respectively. The experiment showed that the amount of soil organic matter was significantly influenced by the FYM and PL treatment plots in farmland of rainfed area. Use of organic matter improves soil environment which has aspect on adaptation research due to climate change in Natore, a rainfed area in Bangladesh. FYM and PL both responded positively to the organic matter with the use of ½ recommended dose of chemical fertilizers that helped to increasing yield and yield attributes of wheat crop in farmland. The research could play a role for farmers to find an adaptation technique in drought prone region at the northern part of the country as well as can improve the soil condition.

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THE AUTHOR

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LIST OF ABBREVIATIONS

TA	Treatment Katashcol	**H**	Hydrogen
TB	Treatment Kalikapur	**CEC**	Carbon Electric Conductivity
TC	Treatment Bhabanipur	**meq**	Metter Square
TD	Treatment Sreekhondi	**NH4**	Amino acids
TE	Treatment Ramagari	**CO_2**	Carbon dioxide
TF	Treatment Kachutia	**OM**	Organic Matter
TG	Treatment Katashcol	**SOM**	Soil Organic Matter
TH	Treatment Kalikapur	**kg**	Kilogram
TI	Treatment Bhabanipur	**ha**	Hector
TJ	Treatment Sreekhondi	**WFS**	World Food Summit
TK	Treatment Ramagari	**DAE**	Department of Agricultural Extension
TL	Treatment Kachutia	**NGO**	Non Government Organization
GDP	Gross domestic product	**IFOAM**	International Federation of Organic Agriculture Movements
BBS	Bangladesh Bureau of Statistics	**RARS**	Refractory anemia with ringed sideroblasts
FYM	Farmyard Manure	**SAFBIN**	Strengthening Adaptive Farming in Bangladesh, India and Nepal
PL	Poultry Litter	***et al.***	Associated.
%	Percentage	**PM**	Poultry manure
MoP	Muriate of Potash	**UN**	Urea nitrogen
IPCC	Intergovernmental Panel on Climate Change	**NUE**	Nitrogen use efficiency
GOB	Government of Bangladesh	**WHC**	Water holding capacity
GOI	Government of India	**Ch**	Chicken manure
NAPA	National Automotive Parts Association	**Sf**	Flower residue
FAO	Food and Agricultural Organization	**BWC**	Biogenic waste compost
MoEF	Ministry of Environment & Forests	**gm**	Gram
BADC	Bangladesh Agricultural Development Corporation	**IPNM**	Integrated Plant Nutrient Management
mm	Millimeter	**GMI**	Green manure incorporation
MOA	Ministry of Agriculture	**EM**	Effective micro-organism
UNEP	United Nations Environment Programme	**DTPA**	Pentetic acid or diethylene triamine pentaacetic acid
IFPRI	International Food Policy Research Institute	**Cu**	Copper
OECD	Organization for Economic Co-operation and Development	**NIFA**	Nuclear Institute for Food and Agriculture
BARI	Bangladesh Agricultural Research Institute	**DAS**	Days after sowing
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database (FAOSTAT)	**ICARDA**	International Center for Agricultural Research in the Dry Areas
^{o}C	Degree Celsius	**AEZ**	Agro-ecological zone
ABA	Abscisic acid	**SRDI**	Soil Research Development Institute
CIMMYT	International Maize and Wheat Improvement Center	**BMD**	Bangladesh Metrological Department
ASI	Anthesis Silking Interval	**m^2**	Miter square
C	Carbon	**g/kg**	Gram per kilogram
N	Nitrogen	**mg/kg**	Milligram/kilogram
P	Phosphorus	**TSP**	Triple Supper Phosphate
K	Potassium	**MOP**	Muriate of Potash
S	Sulfur	**$ZnSO_4$**	Zinc Sulphate
Zn	Zinc	**cm**	Centimeter
B	Born	**TGW**	thousand grain weight

CHAPTER I

INTRODUCTION

1.1. Agriculture in Bangladesh

The agriculture sector is the largest contributor to GDP, income and employment generation and a vital factor in achieving food self-sufficiency that works as a tool to reduce rural poverty and promote sustainable economic development. The component of the sector includes crops, fisheries, livestock and forestry. The share of agriculture to the GDP was around 57% in the 1970s that was lessened to about 21 percent in 2007 (BBS, 2010). The contribution to GDP by agriculture is about 20% of which crops, fisheries, livestock and forestry account for 10, 4, 3 and 1.5%, respectively (BBS, 2010). The system of crop production is highly labor intensive and the country is, as well, labor abundant where about three fifths of the population engages in farming of which 57% of them is engaged in the crop sector (Haque, 2011, p.1). The sector also supplies raw materials for many of the industrial sectors. In a nutshell, agriculture is the main wheel of economic growth in Bangladesh. Therefore, increasing food and agriculture production have always been considered as major concerns of Bangladeshi policy-makers.

Bangladesh is a densely populated non-industrialised country in the world. Its economy is vulnerable and characterised by high population growth, low natural resource base and highly prone to natural disasters. As a result, a large number of people could not afford subsistence level of income for meeting their basic needs, thus living below the poverty line. Despite scarcity of resources and natural disasters, the situation of poverty has been improving significantly over the years. As the economy primarily dependent on agriculture, about 80 percent of the total population live in rural areas and are directly or indirectly engaged in a wide range of agriculture activities (BBS, 2010; Rahama and Schmitz, 2007).

As an agricultural country, Bangladesh produces major agricultural crops, such as rice, wheat, jute, potato, pulses, oilseed, sugarcane, tea, tobacco, spices etc. Though crop production system in Bangladesh is enriched by wide range of bio-diversity as well as favorable natural environment, but rice dominates the crop sector, that covers more than 70% of the total cropped area. As a result, growth in the agricultural sector essentially mirrors the performance of rice production. The country's food production has increased from 11.0 million tons in 1971 to about 30 million tons in 2007. The country is, at present, about to achieve self sufficiency in cereal production (in terms of rice only) (Hossain, 2009). There is no other better option than to increase production per unit of land as well as cropping intensity. Thus, to increase production and cropping intensity, the most important gain will be the faster development of sustainable agricultural as well as variety development (Islam, 2010).

Agriculture sector plays an important role in the overall economic development of Bangladesh and it is regarded as the lifeline of Bangladesh economy. It is also an important social sector concerned with issues like food and nutritional security, income generation, and poverty reduction. The contribution of agriculture sector in GDP stood at 20.29 percent in FY 2009-10. According to the provisional estimation of BBS, the overall contribution of the broad agriculture sector at constant price was 19.95 percent of GDP in FY 2010-11. Within the broad agriculture sector in FY 2010-11, the contribution of agriculture and forestry and fisheries were estimated at 15.52 percent and 4.43 percent respectively while the contribution of the three sub-sectors namely crops and vegetables, livestock and forestry were 11.24 percent, 2.57 percent and 1.71 percent respectively. Though the direct contribution of agriculture sector has decreased slightly, its indirect contribution to the overall growth of GDP is significant.

The growth of broad service sector, particularly the growth of wholesale and retail trade, hotel and restaurants, transport and communication sector was strongly supported by the agriculture sector. Besides, about 43.6 percent of the total labour forces of the country are engaged in agriculture sector (MES, 2009, BBS). In FY 2010-11, Bangladesh earned US$ 1316 million by exporting agricultural products which was 5.74 percent of total export earning (US $22924 million). In addition to the exports of main agricultural commodities such as, raw jute, jute goods, tea, frozen foods, the Government has taken steps to increase exports of non-traditional agricultural commodities.

1.2. Climate change impact and Agriculture of Bangladesh

Bangladesh is one of the most vulnerable countries to climate change because of geographic exposure, low income and greater reliance on climate sensitive sectors, particularly agriculture. People, exposed to the most severe climate-related hazards are often least able to cope with the associated impacts due to their limited adaptive capacity and according to Islam *et al.* (2011), will become even more susceptible in future. The country experiencing different types of natural disasters almost every year because of the global warming as well as climate change impacts, these are: Floods / Flash Floods (Almost 80% of the total area of the country is prone to flooding). Cyclones and Storm Surges (South and South-eastern Parts of the country were hit by Tropical Cyclones during the last few years). Salinity Intrusion (Almost the whole Coastal Belt along the Bay of Bengal is experiencing Salinity problem). Extreme Temperature and Drought (North and North-western regions of the country are suffering because of the Extreme Temperature problem).

Climate change has already impacted on the life and livelihoods of the people in the coastal areas and in the arid and semi-arid regions of Bangladesh (MoP, 2011). In particular, the effects of climate change on agriculture and other sectors are already evident. The agricultural sector is most likely to face significant yield reduction in future due to climate variability (Islam *et al.,* 2011). Most importantly, crop agriculture is the most vulnerable to climate change among different sectors of the Bangladesh economy. One major determinant of fluctuations in crop yield is year-to year changes in climatic variables (Hazell, 1984; Anderson and Hazell, 1987). Over the last several decades, global warming has been observed on local, regional, and global scales (Boyles and Raman 2003; Du *et al*., 2004; Macdonald *et al.,* 2005; Piao *et al.,* 2010; Wu and Zhao 2010; Qiu *et al.,* 2012). The IPCC

(Intergovernmental Panel on Climate Change) (2007) report presents a detailed evaluation of long term worldwide observations on climate change and a sound physical analysis of the potential trends of change in climate. The report concludes that global climate is very likely to get warmer in the near future.

As scientific evidence becomes more convincing that increasing concentrations of greenhouse gases will warm the planet (IPCC, 2007). It has become ever more important to understand the impacts of global warming. The impacts on agriculture are among the largest and the best documented. Bosello and Zhang (2005) stated that the relationships between climate change and agriculture are complex and manifold. They involve climatic and environmental aspects, social and economic responses. These last can take either the form of autonomous reactions or of planned economic or technological policies. This picture is complicated further: indeed climate change and agriculture interdependencies evolve dynamically over time, they often span over a large time and space scale and are still surrounded by large uncertainties.

1.3. Drought

It is prognosticated that, under climate change scenario evapo-transpiration will increase significantly, especially during the post-monsoon and pre-monsoon seasons, in the backdrop of diminishing rainfall in winter and already erratic rainfall variability over time and space (Karim *et al.,* 1998). As a consequence, severity of moisture stress, particularly in the north-western districts mentioned in earlier sections, will increase leading to drought conditions. An earlier estimate suggests that the area severely affected by drought in Rabi season could increase from 4000 km^2 to 12000 km^2 under severe climate change scenario (Huq *et al.,* 1996). High index of aridity in winter, especially in the western parts of the country may be compensated by increased withdrawal from the surface water sources.

If that is the case, despite the minimum flow in the Ganges as provided by the Ganges Water Sharing Treaty (GOB-GOI, 1996) it would be extremely difficult to provide adequate freshwater flows in the downstream of the Ganges dependent areas, particularly during the dry season. The issue of drought has been reiterated in the Bangladesh NAPA document. It is reported earlier that, combating excessive aridity will require either augmented inflows of the Ganges from the upstream or increased ground water withdrawal in those areas (Halcrow *et al.,* 2001b).

Production of agricultural crops in Asian LDCs is very much influenced by drought stress that occurs during crop growth. Drought poses the most important environmental constraint to plant survival, distribution and crop productivity, causing no table economical losses. Recent plant breeding technique shave assisted this to some extent, with the selection and development of crop cultivars well adapted to the drought that exists throughout Asian LDCs. However, drought stress continues to impose limitation on crop yield, especially in cereals crops. Areas vulnerable to drought in Bangladesh are shown in (Fig. 2), and (Fig: 3) the areas affected by Rabi drought is graphically presented.

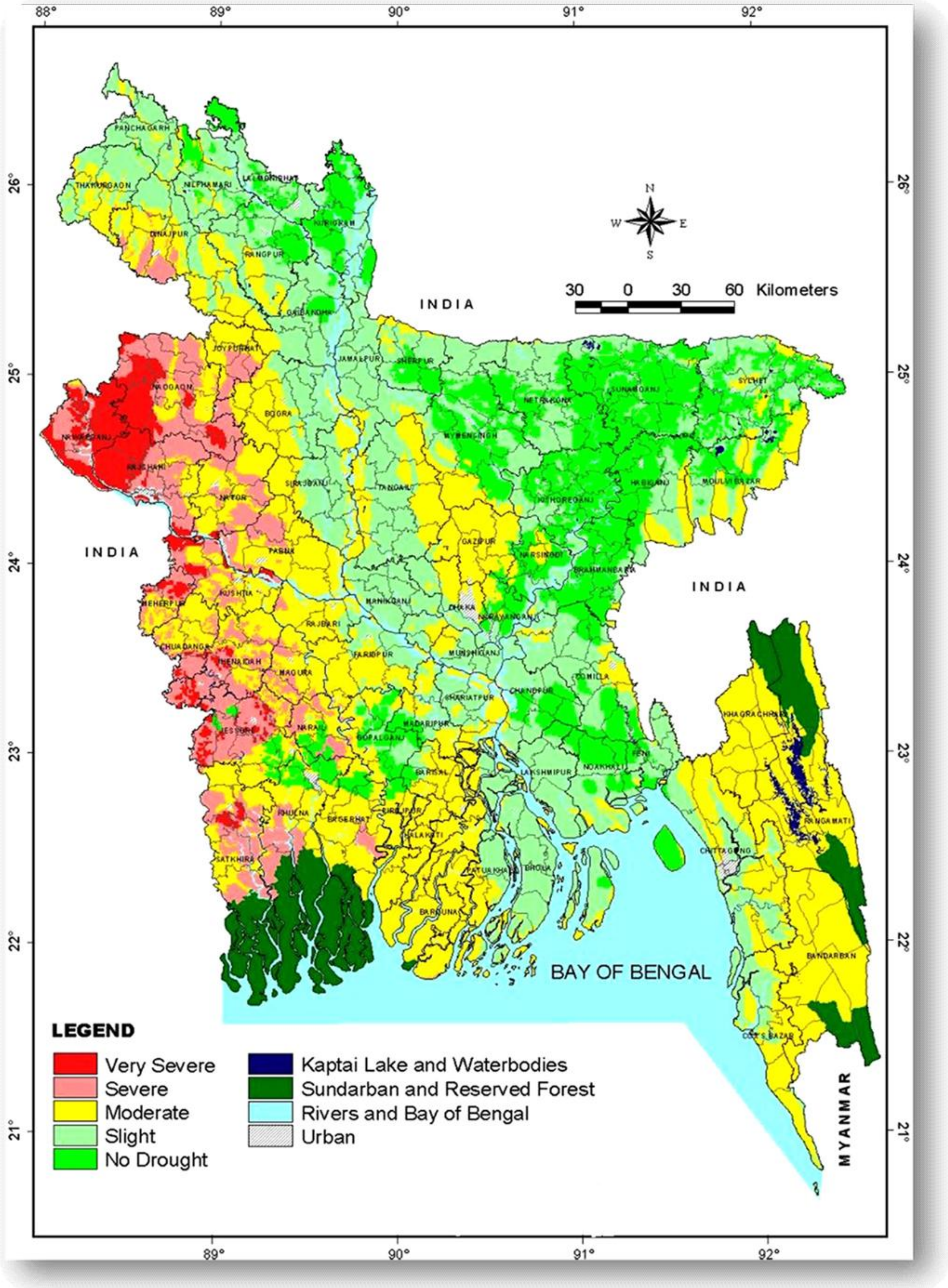


Fig:1.1. Drought in Bangladesh

(Source: (http://www.apipnm.org/swlwpnr/reports/y_sa/z_bd/bdmp265.htm).

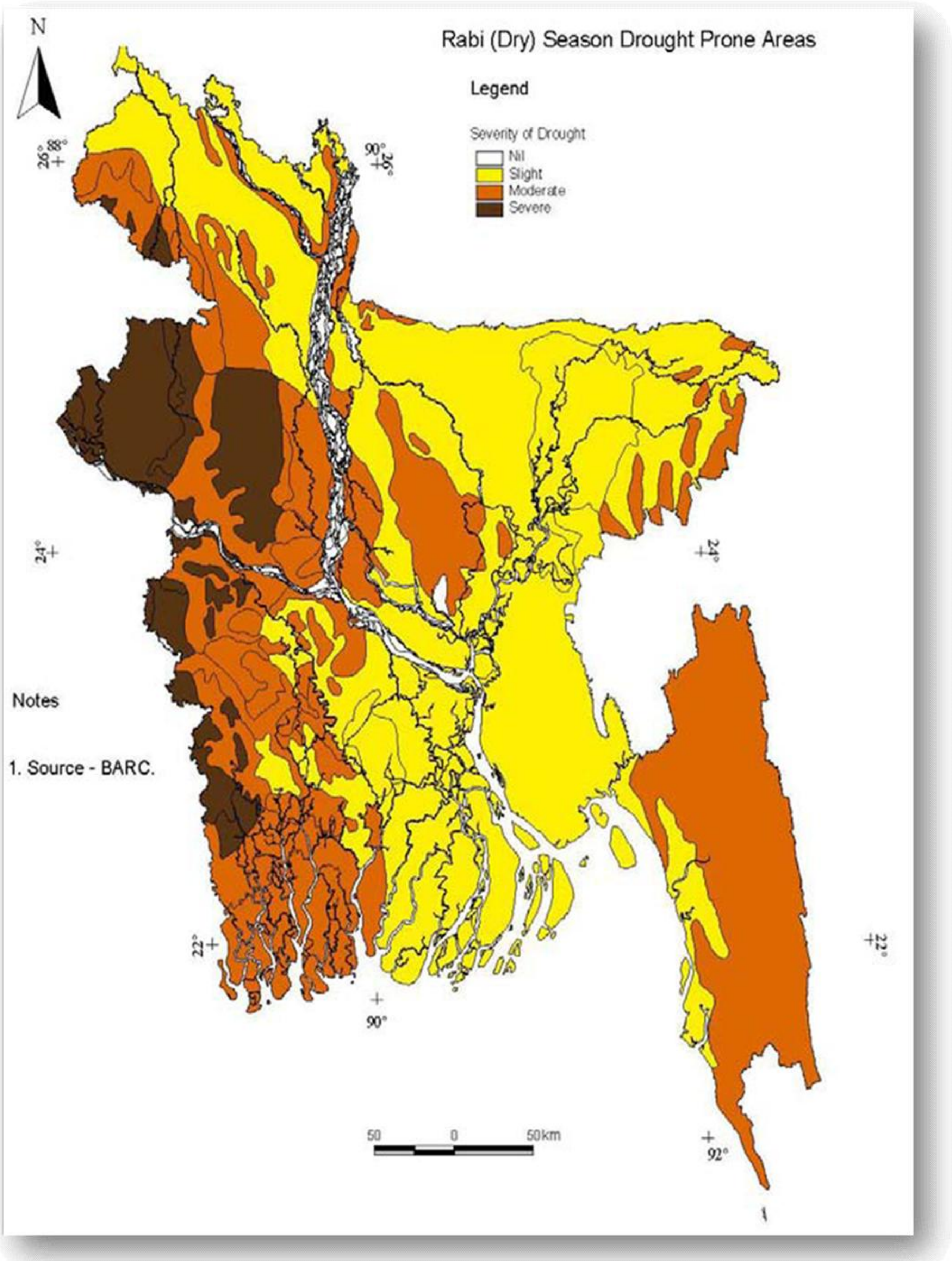


Fig: 1.2 Drought in Bangladesh (Robi Season)

1.4. Food Security

Impact of climate change on crop production raises questions about ability to adaptation to achieve food security in Bangladesh because of the uneven allocation or distribution of resources and damages of crops due to recurrent climatic incidents of floods, drought and salinity. The children and women among the marginal people and poor are the major victims to it who are trying to adapt naturally to such impacts but vulnerability to natural disasters and limited resources hindering them to solve their problem and food security. The marginal people and poor are expected to suffer most mainly by salinity and flood in Bangladesh (FAO, 2007).

Significant alterations in climatic variables will affect food security and agricultural production through their adverse impacts on all components of local, national and global food systems. More intense and more frequent extreme weather events such as flood and droughts, increasing abnormalities in rainy season patterns and rising sea levels are already having instant impacts on food production, incidence of food emergencies, food distribution infrastructure, human health and livelihood assets and opportunities, in both urban and rural areas of Bangladesh (MoEF, 2011). Impacts of gradual changes in average rainfall and temperatures are likely to be disruptive in Bangladesh, whether negative and positive, and may include:

- Degradation of ecosystem functioning and loss of biodiversity of natural habitats,
- Changes in land suitability for different varieties of crops and pasture,
- Loss of cultivable land due to associated salinity and increased aridity, rise in sea level and groundwater depletion,
- Changes in the productivity, community composition and distribution of marine resources,
- Changes in the productivity and health of forests,
- Changes in the good quality water sources for inland fish, livestock and crop production,
- Changes in the vectors and incidence of different types of diseases and pests,
- International and internal migration and
- Changes in health risks among people.

1.5. Rainfall

Agriculture is the most vulnerable sector as its productivity totally depends on climatic factors like temperature, rainfall, light intensity, radiation and sunshine duration, which are predicted to be erratic. Rainfall is one of the major climatic factors for crop production. All crops have critical stages when it needs water for their growth and development. Moreover excessive rainfall may occur flooding and water logging condition that also lead to crop loss. It was found that 1mm increase in rainfall at vegetative, reproductive and ripening stages decreased Aman rice production by 0.036, 0.230 and 0.292 ton respectively. Scarcity of water limits crop production while irrigation coverage is only 56% as delivered by the Bangladesh Agriculture Development Corporation (BADC).

The rainfall dominated climate of Bangladesh receives the heaviest rainfall in the world (Mirza *et al.*, 2008) and differs from other tropical regions because of the strong influence of the Indian Ocean and the Himalayas. High temperatures, heavy rainfall and seasonal variation are the unique characteristics that distinguish the climate of Bangladesh from that of other tropical regions. However, the locations of rainfall origination including the characteristics remain unclear in different rainy periods (Partal and Kahya, 2006). The Bangladeshi climate is comprised of four seasons: pre-monsoon (March–May), monsoon (June–August), post-monsoon (September–November) and winter (December–February). The pre-monsoon, monsoon and post-monsoon seasons are basically the rainy seasons (Islam *et al.*, 2008). Monsoon rainfall accounts for approximately 85% of the total rainfall while occurrences of wet days are rare in the dry season. This monsoon rainfall is caused by monsoon depressions in the Bay of Bengal (Rahman *et al.*, 1997). This makes Bangladesh a highly humid zone with a mean annual rainfall of 2488 mm. The pre-monsoon period is characterized by warm temperatures (27 °C on average) and the occurrence of thunderstorms with rainfall ranging from 15 mm/year in the western central region to more than 80 mm/year in the northeast region. This pre-monsoonal rainfall and thunderstorms are dominated by the moist air from the Bay of Bengal. The effect of the Bay of Bengal coupled with that of the Himalayas creates extremely high rainfall levels during the monsoon season (Mirza and Hossain, 2004) and (Sanderson and Ahmed, 2009). Annual rainfall varies significantly throughout the country with a range of 1270–5000 mm. Shahid and Khairulmain, (2009) showed that inter-annual rainfall is highly variable (coefficient of variation 16–24 %) across the entire country, which they classified into 6 zones based on rainfall variability. High rainfall variability together with low rainfall in the northern part made it “drought prone”, whereas the south western coastal region is a comparatively “humid area” with low variability and high rainfall.

Rainfall is one of the substantial weather indicators of climate change (Stringer, 1995). Rising temperatures across the globe likely result in changes in precipitation and atmospheric moisture through a more active hydrological cycle, leading to increases in water holding capacity throughout the atmosphere at a rate of about 7% per °C (IPCC, 2007). Climate change is acting as a trigger for changing rainfall patterns which can have significant impacts on the sowing and harvesting times of crops (Mirza and Hossain, 2004 and Abrol *et al.* 2003). The main rice varsities such as Aus and Aman are sown and harvested between the pre-monsoon and post-monsoon periods, which account for more than 95% of total annual rainfall. Although the harvesting and sowing periods of the crops vary spatially depending on the agro-climatic conditions of the area (Mirza and Hossain, 2004), the farming system is strongly dependent on the timely arrival of monsoon rain and its distribution (Ahasan *et al.* 2010).

Rising temperatures in combination with rainfall anomalies due to climate change strongly influence soil moisture. This may have a negative impact on the major crops of the country by inducing drought (Ahmed, 2006). Recently, in 2010, low rainfall (30% below average levels) during the monsoon and excessive rainfall in the post-monsoon caused extensive damage in the agricultural sector. The lack of rainfall created agricultural drought in the country while excessive rainfall at the beginning of the post-monsoon period provoked flash floods. In 2007, more than 9 million people were affected by severe flooding caused by heavy rainfall [http://www.prothom-alo.com (accessed on 1 July 2011)]. Rice and wheat production decreased by approximately 3.5 × 106 metric tonnes because of low rainfall during the 1994–2005 period (Rahman *et al*, 1997). Traditional crop cultivation methods changed and production costs increased because of increased temperatures and rainfall changes during the harvesting and sowing periods of crops. These changes in climate are leading to crop failure and greater demands for capital (labor, money, fertilizer, etc.) to produce food for the large population in some coastal areas of the country (Hossain *et al*, 2010).

Therefore, knowledge of the spatial and temporal variability of rainfall patterns are crucial in adaptation planning for Bangladesh, as rain-fed agriculture not only accounts for around 23% of the Gross Domestic Product (GDP) but also constitutes 68% of the total employment of Bangladesh (Islam *et al.*, 2008 and MOA, 2011). A deeper understanding of the characteristics and distribution of rainfall patterns will support water management, agricultural development and disaster management and planning in Bangladesh in the context of global climate change (Rahman *et al,* 1997; Rafiuddin *et al,* 2010 and 2007).

1.6. Adaptation in Agriculture

Crop agriculture in Bangladesh is highly susceptible to variations in the climate system. It is anticipated that crop production would be extremely vulnerable under climate change scenarios, and as a result, food security of the country will be at risk. Despite being highly vulnerable, very little efforts have so far been made to understand potential of agricultural adaptation in Bangladesh. Ahmed, (2000) made an early attempt to analyse the adaptation potential of the country's crop agriculture in a warmer world. (Faisal and Parveen, 2004) examined food security aspect and implications of climate change; however adaptation potentials were not discussed. A brief account of adaptation types, based on IPCC typology of adaptation (UNEP, 1996).

1.7. Limitations of Agricultural adaptation

It is reported that the existing institutions had inherent inefficiencies, lack of foresight in planning for the future, poor coordination among relevant institutions, poor information assimilation capacity and lack of trained and motivated personnel (Ahmed, 2000). As a result, those often proved to be ineffective. The central government could not successfully utilize the full potential of the local government and the latter could not assume the full responsibility of implementing local-level planning due to weaknesses in governance system. This made it difficult to implement development activities at the grassroots.

All these are possible barriers to successful adaptation, which might have direct implications in agricultural sector. People's lack of understanding might also be considered as a possible barrier. Lack of understanding on far-reaching implications of certain actions considered by one can jeopardize adaptation options taken by many. Resorting to alternative livelihood options could be of immense help if understood their merits properly and planned early. Capacity building might be a pre-requisite to enhance people's understanding.

Poverty might be identified as another potential barrier. Many people would not be able to take advantage of crop insurance due to acute poverty. It was argued that, in order to overcome the limitations of adaptation the first step should be to strengthen the institutions which would enable and facilitate the farming communities to go for adaptation measures (Ahmed, 2000). Weaknesses in the current legal framework were also considered to be a limitation. Weak institutional coordination, especially among large numbers of institutions dealing with agriculture and support facilities, might also be identified as a limitation. Strengthening of the agricultural extension services was recommended as an institutional adaptation towards safeguarding future agricultural activities.

Financing investments in agriculture may appear a major issue, especially amongst poor farmers (Warrick and Ahmad, 1996). Requirements for cash investment soon after a major flood event limit cultivation of cash crops such as vegetables (brinjal) and spices (chilli), as observed in Jamalpur District. Early investments in relatively highlands for seedbeds could not be possible, even though the benefits of doing so were known to the farmers of the same region (Choudhury *et al.*, 2004). Lack of adequate credit facilities is reported as major constraints of coping in agriculture (Ericksen *et al*., 1996; Asaduzzaman *et al.,* 2005).

1.8. History of wheat production in Bangladesh

Immediately after independence in 1971, a series of disastrous harvests (attributable largely to unfavorable weather) led to widespread food shortages in Bangladesh. This forced the government to appeal to the international community for emergency relief assistance. Massive imports of cereals, edible oils and dairy products became a regular feature of the economy, and Bangladesh developed a reputation as one of the world's most impoverished nations (IFPRI, 1997). From March to December 1974, Bangladesh faced an acute food shortage as the price of rice increased sharply in the world market (OECD-FAO, 2009) and production decreased (Alamgir, 1980). World rice prices increased sharply from 1971 to 1975, resulting in food shortages in Bangladesh (OECD, 2008). Rice production declined (Index Mundi, 2012a) because of disruptions to virtually all agricultural activities during the War of Liberation in 1971 and various natural disasters, such as floods, droughts, cyclones and rapid population growth (Sobhan, 1979; Alamgir, 1980; Sen, 1982; Hugo, 2006). At that time, it was realized that rice alone could not meet the food requirements of the country (Banglapedia, 2006). Wheat was therefore chosen as an alternative winter food crop. Two Mexican varieties ('Sonora 64' and 'Penjamo 62') were tested first in the northern part of Bangladesh in 1965 (BARI, 2010). Their spectacular performance encouraged scientists to introduce wheat more generally to this part of the country. By the time of independence (1971), Bangladesh had become highly dependent on wheat imports while dietary preferences were changing such that wheat was becoming a highly desirable food supplement to rice. In the first half of the 1980s, domestic wheat production rose to more than 1 million tons year21, but was still only 7–9 % of total food grain production (BARI, 2010).

1.9. Climate change and its impact on global wheat production

Recurrent food crises combined with the recent global financial problems, volatile energy prices, natural resource depletion and climate change have combined to undercut and threaten the livelihoods of millions of poor people worldwide. Wheat accounts for a fifth of humanity's food and is second only to rice as a source of calories in the diets of consumers in developing countries and is first as a source of protein (Braun *et al.,* 2010). Wheat is an especially critical foodstuff for _1.2 billion people classified as 'wheat-dependent'; 2.5 billion are classified as 'wheat-consuming' and live on ,US$2 day21. There are also _30 million poor wheat producers and their families for whom wheat is the staple crop (FAOSTAT, 2012). Demand for wheat in the developing world is projected to increase 60 % by 2050 (Rosegrant and Agcaoili, 2010). The International Food Policy Research Institute projections indicate that world demand for wheat will rise from 552 million tons in 1993 to 775 million tons by 2020 (Rosegrant *et al.*,1997).

At the same time, climate change-induced temperature increases are likely to reduce wheat production in developing countries (where around 66 % of all wheat is produced) by 20–30 % (Esterling *et al.*, 2007; Lobell *et al.,* 2008; Rosegrant and Agcaoili, 2010). The Intergovernmental Panel on Climate Change (IPCC), 2007 noted that global climate change will have a major impact on crop production. CIMMYT and ICARDA (2011) estimated that 20–30 % wheat yield losses will occur by 2050 in developing countries as a result of a predicted temperature increase of 2–3 8C. On a global scale, these yield losses will not be fully compensated by yield gains in high-latitude regions (Canada, Russia, Kazakhstan and Northern USA), estimated at 10–15 % (OECD-FAO, 2009), since major wheat producers such as France have already reported yield reductions due to increasing temperatures (Charmet, 2009).

1.10. Global warming and its impact on wheat production in Bangladesh

The Geophysical Fluid Dynamics Laboratory transient model (Manabe *et al.,* 1991) projected that, in Bangladesh, temperatures would raise 1.3 8^{o}C by 2030 and 2.6 8^{o}C by 2070^{o}C, compared with mid-20th-century levels. The study also estimated little change in winter precipitation and an increase in precipitation during the monsoon season (Ahmed and Alam, 1999). On the other hand, the annual mean temperature of Bangladesh is 25.75 8^{o}C and is expected to rise by 0.21 8^{o}C by 2050 (Karmakar and Shrestha 2000). Karttenberg *et al.*, (1995) stated that crops may be exposed to more thermal stress in the near future since global warming is expected to increase temperatures by 2 8^{o}C by the middle of the 21st century. The Organization for Economic Co-operation and Development (OECD) estimated a rise in temperature of 1.4 8^{o}C by 2050 and 2.4 8^{o}C by 2100 in Bangladesh (OECD, 2003).

The current assessment for Bangladesh by the IPCC (2007) predicts warming of 1.5–2.0 8^{o}C by 2050, with 10–15 % increased rainfall by 2030 and a 12 % increase in evaporation by 2030. Using data from 34 meteorological climate sites in Bangladesh, Islam and Islam, (2009) estimated that maximum and minimum February temperatures had increased by 0.62 and 1.54 8^{o}C, respectively, over the past 100 years for all of Bangladesh. Poulton and Rawson (2011) reported that temperature in Bangladesh increased over the past two decades at 0.035 8^{o}C year21. If this trend continues, by 2050, temperatures will have increased over 1990 levels by 2.13 8^{o}C.

Yusuf, *et al.,* (2008) stated that between 1961 and 2007, mean south-west monsoon (June–October) as well as post monsoon (October–November) temperature increased by 0.8 8^{o}C. They also noticed that annual mean maximum temperature had risen by 0.6 8^{o}C while, more alarmingly, both the annual mean minimum and the winter (December–February) mean minimum temperature increased by 0.3 8^{o}C over the same period. Bangladesh is a deltaic land of _144 000 km^{2} bordered by the Himalayas to the north and the Bay of Bengal to the south.

Its South Asian position extends from 20845′N to 26840′N and from 88805′E to 92840′E. Fifty per cent of the country's land elevation is within 5 m of sea level. About 68 % of the country is vulnerable to flooding while 20–25 % of the area is inundated during normal flooding. It has a complex coastline of _710 km and a long continental shelf with a shallow bathymetry. The Bay of Bengal forms a funnel shape towards the Meghna estuary. Because of this, its storm surge is the highest in the world (Islam and Islam, 2009). Water stressed wheat, in response to flooding, suffers considerable changes in its metabolic profile, particularly proteins (Noorka and Silva, 2012). Flooding can therefore alter the nutritional profile of this crop.

1.11. Effect of drought on wheat production

1.11.1. Physiological effects of drought on wheat production

Many important physiological and biochemical processes in plants are impaired by drought stress, resulting in a decrease in growth, yield and grain quality of crops (Fig: 1.1). Drought stress induces changes in a number of physiological processes in plant, including photosynthesis, membrane integrity, enzyme stability, praline and ABA (Flexas *et al*., 2004; Schoper *et al.,* 1987; Valentovic *et al.,* 2006; Westgate and Boyer, 1986).

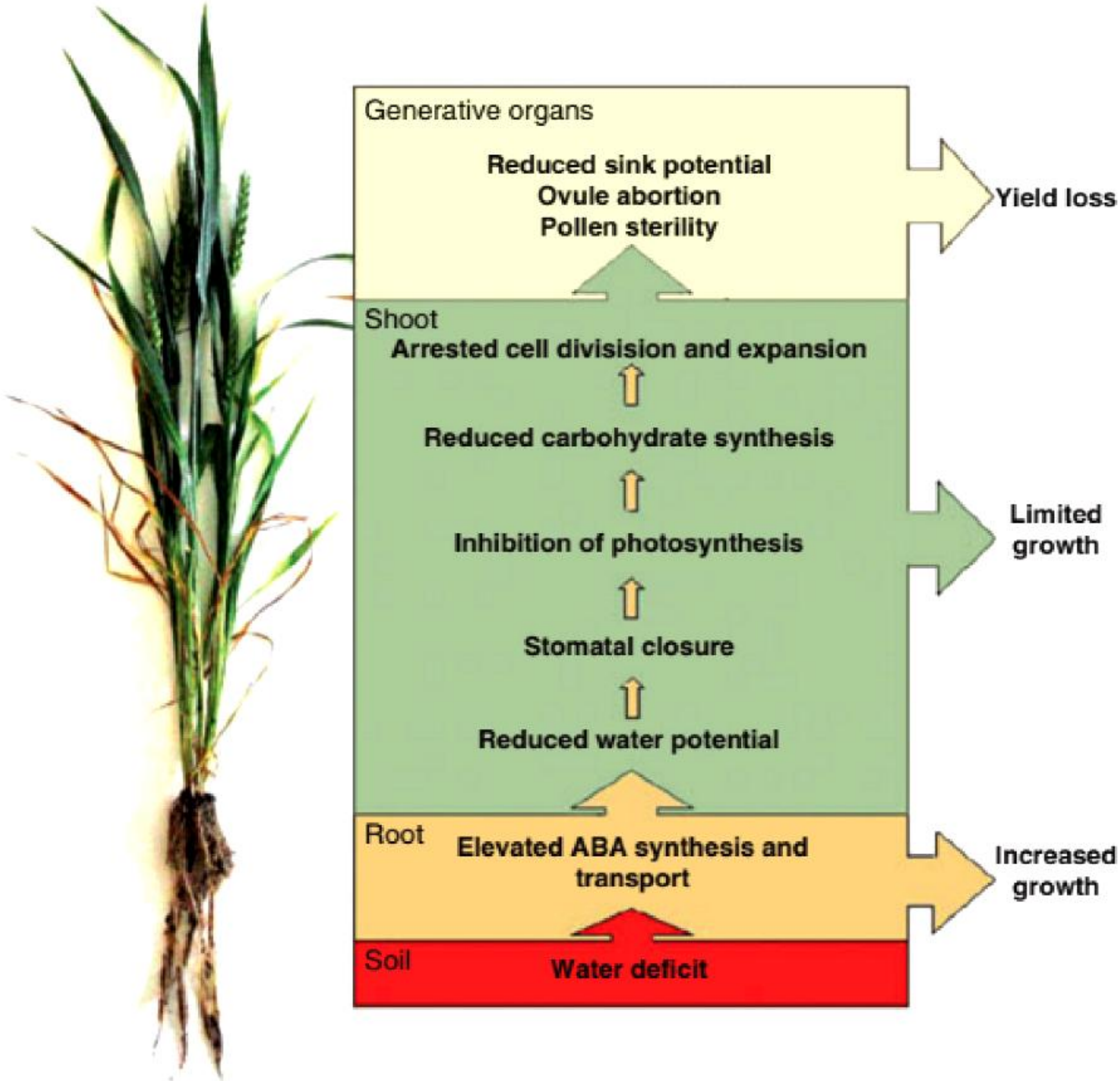


Fig: 1.3. Drought-induced abscisic acid (ABA) - dependent plant responses, (Barnabás *et al.,* 2008).

1.11.2. Pre-and post-anthesis growth

Depending on the cereal species and on the geographical location of plant cultivation, drought may occur during the phase of vegetative/generative transition in the shoot apical meristem. The appropriate matching of the pattern of in florescence development and the time of flowering to the temporal variation in water availability is recognized as one of the most important traits conferring adaptation to drought (Bidinger *et al.,* 1987; Passioura, 1996). Although grain crops show sensitivity to drought during floral initiation and the pre-meiotic differentiation of floral parts (Barlow, *et al.,* 1977; Winkel *et al.,* 1997), the effects of drought on floral meristem are among the least understood aspects of crop reproductive development underwater-limited conditions (Saini and Aspinall, 1981). In cereals, apical morphogenesis is sensitive to water deficit. Drought stress during flower induction and inflorescence development leads to a delay in flowering (anthesis), or even to complete inhibition (Mahalakshmi and Bidinger, 1985; Winkel *et al.,* 1997; Wopereis *et al.,* 1996).

1.11.3. Root growth

A well-developed root system as a constitutive trait is favorable in many environments. It enables the plant to make better use of water and minerals and it is an important component of drought tolerance at different growth stages (Blum, 1996; Weerathaworn *et al*., 1992). The potential quantity of accumulated water depends on the extent of root proliferation in the soil volume. Patterns of resource allocation change when water is limited: root tissues tend to grow more than the leaf tissues. When drought stress occurs during early growth stages considerable changes occurs in the root/ shoot ratio (Nielsen and Hinkle, 1996). A longer phase of growth of late genotypes is associated with greater biomass, both above and below ground; this leads to higher root length density in the soil and, consequently, a greater potential productivity (Blum, 1996). It was assumed that vigorous root growth occurs at the expense of grain production, despite the advantage of improved water acquisition in dry soils (Bruce *et al*., 2002). Increases in grain yield under drought, resulting from selection for drought tolerance, are associated with a smaller root biomass in the upper 50cm of the root profile in a tropical maize population (Bolanos *et al*., 1993). Recent research at the International Maize and Wheat Improvement Center (CIMMYT) has investigated the possibility of measuring the root capacity to assess the absorptive area of the roots and to use this as a selection parameter for enhanced drought tolerance. Special emphasis has been placed on determining whether a greater number of brace roots and the extensive development of fine roots (both indicated by a large capacity) favor the formation of above-ground biomass (Edmeades *et al*., 2000).

1.11.4. Genetic variation in tolerance to drought stress

Drought is one of the variables that cannot be easily manipulated in the field, and there by crops are often selected on the basis of their responses to drought in a particular region. Some degree of drought tolerance may therefore already exist in rice, maize and wheat since selection for performance under drought stress conditions will have screened out any genotypes susceptible to drought stress. It was demonstrated that some of the genetic variation in drought tolerance exists among rice, maize and wheat genotypes in studies of several genotypes sown under drought stress conditions (Bagci *et al.,* 2007; Fukai *et al.,* 1999; Kamara *et al.,* 2003). A reduction in several yield components was observed in some genotypes, in cluding biomass, yield contributing characteristics and grain per yield plant. However no such responses were observed in other, more drought tolerance genotypes.

Drought can strike at any time, but plants are most prone to damage due to limited water during the flowering stage. There are many traits that can lead to a more robust plant under moisture limited conditions, but synchrony between male and female flowering time is particularly important. In maize, the synchrony is called the Anthesis Silking Interval (ASI). Male and female flowers are physically separated, and silks are particularly prone to desiccation. Plants may delay silk production after pollen is shed, but the longer the delay, the fewer grains develop. In addition to ASI, the regulation of carbohydrates is of interest to researchers working on drought tolerance, because the diminished supply of carbohydrates to the developing floral and seed organs that occur sunder drought reduces seed set.

Again, stress at early kernel development has a much greater negative effect on final yield than stress at a later stage (kernel filling). Abundant evidence shows that ABA is involved in turning on many stress-responsive genes, and that it plays a key role in cell growth regulation, especially during flowering. Therefore, genes involved in ASI, genes in the carbohydrate production pathway, and genes in the ABA production pathway or genes affected by ABA itself, can be very important for the development of drought resistant maize plants (http://www.maizegenetics.net/drought-tolerance). CIMMYT assumes that 50% of yield losses worldwide are duet o drought stress before flowering. Stress during flowering is considered to be more important for two reasons: firstly, maize is particularly susceptible to drought at this stage.

The grain yield can be reduced to nearly zero by severe stress during a relatively short period at flowering (Edmeades and Deutsch, 1994; Kiniry *et al.*, 1989). According to Bolanos and Edmeades (1996), the ability to produce a near under stress is the most important characteristic associated with drought tolerance. Secondly, at the flowering stage, the season is too far advanced to consider replanting or adjustment of cropping patterns. It was distinguished between constitutively expressed genes and stress-adaptive genes (Blum, 1997). If stress-adaptive genes of beneficial traits exist in the breeding material, then they are expressed only when the stress is sufficiently severe (Boyer, 1996).

1.12. Effect of soil organic matter in crop production

1.12.1. Effect of soil organic matter on soil properties

Organic matter affects both the chemical and physical properties of the soil and its overall health. Properties influenced by organic matter include: soil structure; moisture holding capacity; diversity and activity of soil organisms, both those that are beneficial and harmful to crop production; and nutrient availability. It also influences the effects of chemical amendments, fertilizers, pesticides and herbicides.

1.12.2. Inefficient use of rain water

Dry lands may have low crop yields not only because rainfall is irregular or insufficient, but also because significant proportions of rainfall, up to 40 percent, may disappear as runoff. This poor utilization of rainfall is partly the result of natural phenomena (relief, slope, rainfall intensity), but also of inadequate land management practices (i.e. burning of crop residues, excessive tillage, eliminating hedges, etc.) that reduce organic matter levels, destroy soil structure, eliminate beneficial soil fauna and do not favour water infiltration. However, water “lost” as runoff for one farmer is not lost for other water users downstream as it is used for recharging groundwater and river flows.

Where rainfall lands on the soil surface, a fraction infiltrates into the soil to replenish the soil water or flows through to recharge the groundwater. Another fraction may run off as overland flow and the remaining fraction evaporates back into the atmosphere directly from unprotected soil surfaces and from plant leaves. The above-mentioned processes do not occur at the same moment, but some are instantaneous (runoff), taking place during a rainfall event, while others are continuous (evaporation and transpiration).

To minimize the impact of drought, soil needs to capture the rainwater that falls on it, store as much of that water as possible for future plant use, and allow for plant roots to penetrate and proliferate. Problems with or constraints on one or several of these conditions cause soil moisture to be one of the main limiting factors for crop growth. The capacity of soil to retain and release water depends on a broad range of factors such as soil texture, soil depth, soil architecture (physical structure including pores), organic matter content and biological activity. However, appropriate soil management can improve this capacity.

Practices that increase soil moisture content can be categorized in three groups:

- ➔ those that increase water infiltration;
- ➔ those that manage soil evaporation; and
- ➔ those that increase soil moisture storage capacities.

All three are related to soil organic matter. In order to create a drought-resistant soil, it is necessary to understand the most important factors influencing soil moisture.

1.12.3. Increased soil moisture

Organic matter influences the physical conditions of a soil in several ways. Plant residues that cover the soil surface protect the soil from sealing and crusting by raindrop impact, thereby enhancing rainwater infiltration and reducing runoff. Surface infiltration depends on a number of factors including aggregation and stability, porecontinuity and stability, the existence of cracks, and the soil surface condition. Increased organic matter contributes indirectly to soil porosity (via increased soil faunal activity). Fresh organic matter stimulates the activity of macrofauna such as earthworms, which create burrows lined with the glue-like secretion from their bodies and are intermittently filled with worm cast material.

Organic matter contributes to the stability of soil aggregates and pores through the bonding or adhesion properties of organic materials, such as bacterial waste products, organic gels, fungal hyphae and worm secretions and casts. Moreover, organic matter intimately mixed with mineral soil materials has a considerable influence in increasing moisture holding capacity. Especially in the topsoil, where the organic matter content is greater, more water can be stored.

The quality of the crop residues, in particular their chemical composition, determines the effect on soil structure and aggregation. Blair *et al.*, (2003) report a rapid breakdown of medic (*Medicago truncatula*) and rice (*Oryza sativa*) straw residues resulting in a rapid increase in soil aggregate stability through the release of many soil-binding components. As these compounds undergo further breakdown, they will be lost from the system resulting in a decline in soil aggregate stability over time. The slow release of soil binding agents from flemingia (*Flemingia macrophylla*) residues resulted in a slower but more sustained increase in the stability of soil aggregates. This indicates that continual release of soil-binding compounds from plant residues is necessary for continual increases in soil aggregate stability to occur.

Elliot and Lynch, (1984) showed that soil aggregation is caused primarily by polysaccharide production in situations where residues have a low N content. There is a strong relationship between soil carbon content and aggregate size. An increase in soil carbon content led to a 134-percent increase in aggregates of more than 2 mm and a 38-percent decrease in aggregates of less than 0.25 mm (Filho, Muzilli and Podanoschi, 1998). The active fraction of soil C (Whitbread, Lefroy and Blair, 1998) is the primary factor controlling aggregate breakdown (Bell *et al*., 1999).

In addition, although they do not live long and new ones replace them annually, the hyphae of actinomycetes and fungi play an important role in connecting soil particles (Castro Filho, Muzilli and Podanoschi, 1998). Gupta and Germida (1988) showed a reduction in soil macro aggregates correlated strongly with a decline in fungal hyphae after six years of continuous cultivation. The in-soil storage of water depends not only on the type of land preparation but also on the type of cover or previous vegetation on the soil. Effect of burning vegetation on the amount of water stored in the soil.

The addition of organic matter to the soil usually increases the water holding capacity of the soil. This is because the addition of organic matter increases the number of micropores and macropores in the soil either by “gluing” soil particles together or by creating favourable living conditions for soil organisms. Certain types of soil organic matter can hold up to 20 times their weight in water (Reicosky, 2005) and (Hudson, 1994) showed that for each 1% increase in soil organic matter, the available water holding capacity in the soil increased by 3.7 percent. Soil water is held by adhesive and cohesive forces within the soil and an increase in pore space will lead to an increase in water holding capacity of the soil.

1.12.4. Reduced soil erosion and improved water quality

The less the soil is covered with vegetation, mulches, crop residues, etc., the more the soil is exposed to the impact of raindrops. When a raindrop hits bare soil, the energy of the velocity detaches individual soil particles from soil clods. These particles can clog surface pores and form many thin, rather impermeable layers of sediment at the surface, referred to as surface crusts. They can range from a few millimetres to 1 cm or more; and they are usually made up of sandy or silty particles. These surface crusts hinder the passage of rainwater into the profile; with the consequence that runoff increases. This breaking down of soil aggregates by raindrops into smaller particles depends on the stability of the aggregates, which largely depends on the organic matter content. Increased soil cover can result in reduced soil erosion rates close to the regeneration rate of the soil or even lower, as reported by (Debarba and Amado, 1997) was found for an oats and vetch/maize cropping system.

Soil erosion fills surface water reservoirs with sediment, reducing their water storage capacity. Sedimentation also reduces the buffering and filtering capacity of wetlands and the flood-control capacity of floodplains. Sediment in surface water increases wear and tear in hydroelectric installations and pumps, resulting in greater maintenance costs and more frequent replacement of turbines. Sediments can also reach the sea (Plate 23), harming fish, shellfish and coral. Eroded soil contains fertilizers, pesticides and herbicides; all sources of potentially harmful off-site impacts.

When the soil is protected with mulch, more water infiltrates into the soil rather than running off the surface. This causes streams to be fed more by subsurface flow rather than by surface runoff. The consequence is that the surface water is cleaner and resembles groundwater more closely compared with areas where erosion and runoff predominate. Greater infiltration should reduce flooding by increased water storage in soil and slow release to streams. Increased infiltration also improves groundwater recharge, thus increasing well supplies. Bassi, (2000) reported significant reductions in water turbidity and sediment concentration over a period of ten years (1988–1997) in different catchment areas in southern Brazil. These reductions were caused by increases in the incidence of planting perennial crops (banana and pasture) on hillsides, thereby decreasing erosion potential. Total sediment loss decreased by 16 percent and the cost of fertilizers declined by 21 percent; an indication of the previous loss of fertilizers with the eroded soil. Guimarães, Buaski and Masquieto, (2005) illustrate the same effect for one specific catchment.

Erosion may also have long-lasting secondary consequences through effects on plant growth and litter input (Gregorich *et al.,* 1998). If erosion suppresses productivity, thereby limiting replenishment of organic matter, the amount of organic matter may spiral downwards in the long term. Soil cover protects the soil against the impact of raindrops, prevents the loss of water from the soil through evaporation, and also protects the soil from the heating effect of the sun. Soil temperature influences the absorption of water and nutrients by plants, seed germination and root development, as well as soil microbial activity and crusting and hardening of the soil. Roots absorb more water at higher soil temperatures up to a maximum of 35 °C.

Higher temperatures restrict water absorption. Soil temperatures that are too high are a major constraint on crop production in many parts of the tropics. Maximum temperatures exceeding 40 °C at 5 cm depth and 50 °C at 1 cm depth are commonly observed in tilled soil during the growing season, sometimes with extremes of up to 70 °C. Such high temperatures have an adverse effect not only on seedling establishment and crop growth but also on the growth and development of the micro-organism population. The ideal root zone temperature for germination and seedling growth ranges from 25 to 35 °C. Experiments have shown that temperatures exceeding 35 °C reduce the development of maize seedlings drastically and that temperatures exceeding 40 °C can reduce germination of soybean seed to almost nil. Mulching with crop residues or cover crops regulates soil temperature. The soil cover reflects a large part of solar energy back into the atmosphere, and thus reduces the temperature of the soil surface.

1.12.5. Increase plant productivity

Plant productivity is linked closely to organic matter (Bauer and Black, 1994). Consequently, landscapes with variable organic matter usually show variations in productivity. Plants growing in well-aerated soils are less stressed by drought or excess water. In soils with less compaction, plant roots can penetrate and flourish more readily. High organic matter increases productivity and, in turn, high productivity increases organic matter.

1.12.6. Increase fertilizer efficiency

The two major soil fertility constraints of the West African savannah and in the sub humid and semi-arid regions of SSA are low inherent nutrient reserve and rapid acidification under continuous cultivation as a consequence of low buffering or cation exchange capacity (Jones and Wild, 1975). Generally, these constraints are tackled by applying chemical fertilizers and lime. However, the application of inorganic fertilizers on depleted soils often fails to provide the expected benefits. This is basically because of low organic matter and low biological activity in the soil.

The chemical and nutritional benefits of organic matter are related to the cycling of plant nutrients and the ability of the soil to supply nutrients for plant growth. Organic matter retains plant nutrients and prevents them leaching to deeper soil layers. Microorganisms are responsible for the mineralization and immobilization of N, P and S through the decomposition of organic matter (Duxbury, Smith and Doran, 1989). Thus, they contribute to the gradual and continuous liberation of plant nutrients. Available nutrients that are not taken up by the plants are retained by soil organisms. In organic-matter depleted soils, these nutrients would be lost from the system through leaching and runoff.

Phosphate fixation and unavailability is a major soil fertility constraint in acid soils containing large amounts of free iron and aluminium oxides. In comparing the P-sorption capacity of surface and subsurface soil samples (Uehara and Gilman, 1981) provided indirect evidence that soil organic matter can reduce the P-sorption capacity of such soils. This implies that for high P-fixing soils, i.e. oxide-rich soils derived from volcanic and ferro-magnesian rocks, management systems that are capable of accumulating and maintaining greater amounts of calcium-saturated soil organic matter in the surface horizon would increase P availability from both organic and fertilizer sources.

Weak acids, such as the organic acids in humus, do not relinquish their hydrogen (H) easily. H is part of the humus carboxyl (-COOH) under acidic conditions. When a soil is limed and the acidity decreases, there is a greater tendency for the H+ to be removed from humic acids and to react with hydroxyl (OH-) to form water. The carboxyl groups on the humus develop negative charge as the positively charged H is removed. When the pH of a soil is increased, the release of H from carboxyl groups helps to buffer the increase in pH and at the same time creates the CEC (negative charge). With an increase in organic matter, the soil recovers its natural buffer capacity; this means an increase in pH in acid soils.

CEC is linked closely to the organic matter content of the soil. It increases gradually with time where organic residues are retained, first in the topsoil and later also at greater depth. Crovetto, (1997) reported an increase in CEC of 136 percent (from 11 to 26 meq/100 g of soil) as a consequence of humus increase in the topsoil after 20 years of residue retention. To overcome acidity, lime is usually incorporated in the soil. The crop residues release organic acids that cause the lime to penetrate deeper into the profile much more rapidly than when applied on bare soil. Thus, it is no longer necessary to mix lime intensively into the soil, which is appropriate for farming systems based on reduced or zero tillage.

1.12.7. Reduced water logging

Previous examined the water storage capacity of soils under improved organic management. However, in case of water logging, organic matter plays also an important role. The bioturbating activity of the macrofauna leaves various so-called conducting macropores in the soil, which are responsible for the drainage of water to deeper soil layers. Chan *et al.* (2003) found a significant reduction in water logging after three years under no tillage compared with conventional tillage.

1.12.8. Increased yields

Agronomic practices that influence nutrient cycling, especially mineralization and immobilization, result in an immediate productivity gain or loss, which is reflected in the economics of the agricultural system. Crop yields in systems with high soil organic matter content are less variable than those in soil that are low in organic matter. This is because of the stabilizing effects of favourable conditions of soil properties and microclimate. Improvements in crop growth and vigour stem from direct and indirect effects.

1.12.9. Reduced herbicide and pesticide use

Some people are concerned that intensified systems with reduced or zero tillage will increase herbicide use and in turn lead to increased contamination of water by herbicides. According to (Fawcett, 1997) total herbicide use in the United States of America declined during the period of adoption of no-tillage systems. He concludes that herbicides are important, but that farmers using conventional tillage methods use similar amounts of herbicides to no-tillage farmers.

In Honduras, a strong decline in the use of herbicides has been observed farmers who no longer burn their fields prior to preparation spend less money on herbicides. Farmers who have adopted the Quezungual system spend less on herbicides and make savings, both in terms of land preparation and total costs. It is becoming evident that the need for herbicide use diminishes over time in well managed no-tillage cropping systems. The principal reason is that the system reduces the existing seed bank in the soil by the synergy of two activities: reduction of the production of new seeds through avoidance of flowering and fruit setting; and reduction of seeds that are brought to the surface by tillage practices. With direct seeding, the reservoir of seeds differs from conventional tillage because:

- the weed seeds remain on the soil surface, where they are susceptible to attacks from insects, birds and soil organisms and to atmospheric influences;
- the soil remains covered by residues, which prevents light reaching the seeds and thus reduces germination;
- weed seeds already at certain depths are not brought to the surface again, where they could germinate;
- perennial weeds are no longer redistributed by equipment.

The result is that the soil weed seed store diminishes in time and, consequently, the weed problem also diminishes, as does the need to use herbicides. The concentration of soil organic matter in the topsoil layer plays an important role in the absorption of herbicides. When the concentration of organic matter in the topsoil decreases, contamination of the environment by herbicides is likely to increase. Enhanced levels of organic matter cause enhanced adsorption of pesticides, followed by gradual degradation. Herbicides, like other pesticides, can be used by micro-organisms as a substrate to feed on (Haney, Senseman and Hons, 2002). Herbicides are broken down in soil and water by micro-organisms into natural acids, NH_4 -, amino acids, carbohydrates, phosphate and CO_2 (Schuette, 1998). As microbes cause more rapid degradation of pesticides, enhancing microbial activity may reduce leaching of pesticides.

Many herbicides, including glyphosate and paraquat, which are the most common herbicides used in reduced-tillage systems, are bound tightly to clay and organic matter by electrostatic forces and hydrogen bonding. Once they are bound to soil organic matter, the herbicides become inactive and no longer affect plants. Moreover, they can form insoluble complexes with metals in the soils. This also contributes to their rare stability in the soil and low potential for leaching into groundwater's (Ahrens, 1994a, 1994b). Some studies have shown that there is no reason to believe that glyphosate may cause any unexpected damage to the environment (Torstenson, 1985). However, other studies illustrate negative effects on soil life or its functions. Farming systems that increase soil organic matter content (e.g. no tillage) reduce the probability of environmental contamination by herbicides.

1.12.10. Increased biodiversity

Conventional agriculture tends to reduce aboveground and belowground diversity. Thus, it brings about significant changes in the vegetation structure, cover and landscape. The change in vegetal cover during the conversion of forest and pastures to cropping affects plants, animals and micro-organisms. Through increasing specialization of certain plant species (food and fibre crops, pasture and fodder crops, and tree crops) and livestock species, some functions may be affected severely, e.g. nutrient cycling and biological control. Some non-harvested or associated species profit from the change and become pests. Associated species can be managed to a certain extent. Through appropriate crop rotations, crop–livestock interactions and the conservation of soil cover, a habitat can be created for a number of species that feed on pests. This will in turn attract more insects, birds and other animals. Thus, rotations and associations of crops and cover crops as well as hedgerows and field borders promote biodiversity and ecological functions. Because of the complexity and richness of soil biodiversity, the effects of crop and pasture management are less well understood. However, the effects on certain functional groups and, hence, specific soil functions are being recognized increasingly as vital for agricultural productivity and system sustainability. Soil has the ability to restore its life-support processes provided that the disturbance is not too drastic and that sufficient time is allowed for such recovery. Organic matter and biodiversity of soil organisms are the driving factors in this restoration. Decreases in numbers and types of soil organisms and available substrate (organic matter) lead to a decrease in resilience, which in turn can result in a downward spiral of degradation.

1.12.11. Resilience

Resilience can be defined as the ability of a system to recover after disturbance (Elliot and Lynch, 1994). Soil resilience depends on a balance between restorative and degrading processes. Factors affecting resilience can be grouped in two categories: endogenous and exogenous. Endogenous factors are related to inherent soil properties (rooting depth, texture, structure, topography and drainage) and microclimate and mesoclimate. Exogenous factors include land use and farming system, technological innovations and input management (Lal, 1994). Hence, appropriate agricultural practices can influence these factors in order to enhance soil resilience. Organic matter and soil organisms play important roles in conserving and improving soil properties that are related to soil resilience. In addition to creating more pores through biological activity, organic matter plays an important role in the formation and stabilization of soil aggregates through bonds between the organic matter and the mineral soil particles. Soil aggregation can take place through two binding agents:

- waste products of bacteria – polysaccharides;
- fungal and bacterial hyphae

The preservation of aggregate stability is important in order to reduce surface sealing and increase water infiltration rates (Whitbread, Lefroy and Blair, 1998). With increased stability, surface runoff is reduced (Roth, 1985).

1.13. Aspect of Organic farming

Organic farming is accurate for integrated production systems and recent increase in the organic farming has created a new market for fertilizers permitted for use in organic farming and when some products are allowed in organic agriculture, commercial opportunities become available (Rodrigues *et al.,* 2006). Organic manure is a key component of the soil and crop yield because it carries out many functions in agro ecosystem (Weil and Magdoff, 2004). Organic outputs are beneficial for the overall health of the agri-environment (Defra, 2002). But organic manure management and storage are major problem in the organic farming (Petric *et al.,* 2009).

Organic fertilizers including farmyard, sheep and poultry manures may be used for crop production as a substitute of the chemical fertilizers. Poultry manure may be used as an organic amendment to restore degraded soils (Sanchez- Monedero *et al.,* 2004). The poultry manure is relatively a cheap source of both macro and micronutrients and can increase soil nitrogen, soil porosity and improve soil microbial activity. As poultry waste contains a high concentration of nutrients so addition of small quantity of poultry manure in an integrated nutrient management system could meet the shortage of FYM to some extent (Ghosh *et al.,* 2004).

Similarly animal waste and green manures are used to replace nitrogen and other elements and to build up soil organic matter content (Lampkin, 2002). Municipal solid waste compost, farmyard manure and chemical fertilizers are beneficial for wheat growth, soil composition and soil bacterial characteristics under arid climate (Cherifa *et al.,* 2009) while progressive accumulation of soil organic matter could increase the risk of soil nitrogen losses (Aronsson and Torstensson, 1998). Similarly press mud can serve as a good source of organic manure (Bokhtiar *et al.,* 2001) however integrated use of press mud and urea 1:1 ratio at 180 kg ha^{-1} is beneficial for crop production (Sharma *et al.,* 2002).

Wheat is one of the cereal crops which are most commonly grown in organic farming systems (Burnett and Rutherglen, 2008). Economic value of certified organic grains have been lashing many transition decisions related to the organic farming (Delate and Camberdella, 2004) while chemical fertilizers consume a large amount of energy and money. However, an organic farming system with or without chemical fertilizers seems to be possible solution for these situations (Prabu *et al.,* 2003). The integration of organic and synthetic sources of nutrients not only supply essential nutrients but also has some optimistic relations leading to increased crop yield and reduced environmental threats (Ahmad *et al.,* 1996).

1.13.1. Scope of organic wheat cultivation in Bangladesh

Organic wheat cultivation is a holistic system that focuses on improvement of soil health, use of local inputs, and relatively high-intensity use of local labor, fits admirable for rural Bangladesh in many ways. The rural Bangladesh offers much remuneration that would make organic cultivation (rice, wheat, vegetables etc.) methods relatively easy to implement (Sarker and Itohara, 2008)**.**

- **Rich varietal diversity**
- **Surplus labor forces**
- **Abundance of local inputs**

1.13.4. Challenges for organic wheat cultivation in Bangladesh

The most serious constraints to organic wheat production in Bangladesh is a biotic stresses, the unusual warming trends during grain filling period are causing yield declines. There are other challenges that are specific to the highly productive rice–wheat cropping system predominant in the Gangetic flood plains. The total factor productivity of this system is declining due to depletion of soil organic carbon. Addition of organic matter to soil through green manure and crop residue recycling, balanced fertilization, integrated nutrient management, diversification of rice-wheat system are some of the possible remedial measures to improve total factor productivity (Chatrath *et al*., 2007).

Another major challenge for expansion of organic wheat in Bangladesh is policy problem. Organic farming movement was launched in Bangladesh in the early 1980's, but unfortunately, the sector has failed to draw the proper attention of policymakers. With a huge population to feed, the policymakers in the area of agriculture were more concerned about food security through increased production. But the actual definition of the term "food security" covers more area than to the increase in food production (WFS, 1996), According to (World Food Summit, 1996), "Food security" not only means the availability of foods but also the physical and economic access of all people, at all times to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. However, the policy area of Bangladesh generally views food security in terms of some important components like availability, access and utilization of foods.

The Government is committed to the continued development of agriculture in order to maintain food supply to the growing population, provide income and employment for rural people, and protect the environment. With this goal the Department of Agricultural Extension (DAE) has developed New Agricultural Extension Policy in 1996 where one specific policy objective was to reduce environmental degradation from July 1995 to June 2010. But the policy never got translated into programs and actions.

DAE did not yet take sufficient initiatives to promote organic farming which has already become popular to scientists and researchers throughout the world, and has already got considerable attention from both government sectors and the NGOs of many South Asian countries like India, Nepal, and Sri Lanka. Though, few NGOs are promoting organic farming in Bangladesh but their attention is focused on high value vegetables and aromatic rice. Thus, for expansion of organic wheat cultivation proper attention is needed by the agricultural policy makers. In addition, due to the lack of certification, farmers in Bangladesh have been missing the real essence of price premium of organic produce. Thus, similar to other organic crops it is essential to develop certification system for organic wheat that will ensure easy access of Bangladesh's organic wheat in the developed countries where it has high demand. As the Government of Bangladesh does not have any patronization for organic farming, the concerned NGOs can develop private certification bodies providing the option of individual and group certification as recommended by IFOAM.

In this regard, careful attention must be paid to the ability of farmers in determining the cost of certification. The concerned NGOs can also make a bridge between the organic wheat farmers and exporters for smooth marketing of the organic wheat. They can even lobby with the exporters to pay a percentage of the certification costs. This type of certification program may create a good environment of exporting organic wheat to the developed countries and help in poverty reduction of the poor farmers in Bangladesh.

1.14. Importance of wheat cultivation

Wheat (*Triticum aestivum* L.) is one of the world's third most important cereal crops (the other two are maize and rice) and it has the widest distribution of any cereal. The crop is primarily grown for its grain, which is consumed as human food. It is the first important cereal crop in Turkey and now accounts for about 75% of the total cereal production with coverage of 11.9 million hectares (Anonymous, 2008). It is a viable substitution to meet the requirement of cereal. So, it is essential to increase the production of wheat to meet the food requirement of ever increasing population and consequently it will help achieve food security.

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops followed by rice and it is as well as staple food and has the large acreage among all the field crops in the world (FAO, 2010). About two third of the total world's population consume wheat as staple food (Majumder, 1991). The crop is grown under different environmental condition ranging from humid to arid, subtropical to temperate zone. Dubin and Ginkel, (1991) reported that the largest area of wheat cultivation in the warmer climates exists in the South-East Asia including Bangladesh, India and Nepal.

In Bangladesh, wheat is the second most important cereal crops that contribute to the national economy by reducing the volume of import of cereals for fulfilling the food requirements of the country (Razzaque *et al.*, 1992). Wheat grain is rich in food value containing 69.60% carbohydrate, 12.00% protein, 1.72% fat 17.20% and minerals (BARI, 2006). Wheat cultivation has been increased manifolds to meet up the food shortage in the country. The area, production and yield of wheat have been increasing dramatically during the last two decades, but its present yield is too low in comparison to that of some developed countries like Japan, France, Germany and UK producing 3.76, 7.12, 7.28, and 8.00 t ha-1, respectively (FAO, 2000). In Bangladesh, the position of wheat is second in respect of total area (0.80 million hectares) and production (2.80 million ton) after rice and the average yield is only 3.44 t ha-1 (BBS, 2010) but it can be increased up to 6.8 t ha-1 (RARS, 2010). Low yield of wheat in Bangladesh, is not an indication of low yielding potentiality of this crop, but may be attributed to a number of reasons, viz., unavailability of quality seeds of high yielding varieties, limitation in adoption of modern and improved agronomic practices, such as optimum seed rate, delay sowing after harvesting transplanted aman rice, judicious application of irrigation, fertilizer management and other inputs. In order to break the above yield barriers, sustain the productivity and obtain sufficiency in food, the overall management system of crop needs to be improved especially through the nutrient management of the crop. Proper utilization of different sources of nutrients in context of crop-soil productivity must be explored for sustaining the productivity.

The sources of nutrients for crops are nutrient reserve in soil, organic and inorganic fertilizers. None of the sources is complete and therefore, no one is sufficient to sustain soil fertility and productivity. Combination of organic and inorganic fertilizers is being stressed now-a-days. The application of different fertilizers and manures influences the physical and chemical properties of soil and enhance the biological activities. Organic fertilizer enhances soil porosity by increasing regular and irregular pores and causes a priming effect of native soil organic matter. Application of both chemical and organic fertilizers is need for the improvement of soil physical properties and quick supply of essential plant nutrients for higher yield. The combined effect of organic manure and inorganic fertilizer on crop yield was also reported by many workers (Davarynejad *et al*. 2004; Singh and Singh, 2000).

1.15. Rational and objective of Research

The "Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN)" is a collaborative project lead by Caritas Austria under the supervision of Caritas Bangladesh at Northern part of Bangladesh. Assessment of less organic matter, less fertility and water holding capacity of Soil on wheat production in rainfeed area aspect of climate change and their effects on production of wheat. The study will be helpful to assess the soil nutrient level and water holding capacity in relation to or vegetation; it is easy to predict its interaction with climatic factor such as, temperature, wind, moisture, rainfall as these factors directly affect the physico-chemical properties of soil. Study of soil chemistry helps in the evaluation of soil fertility.

Our present study was conducted with the objectives of an on-firm research to study the combined effect of farmyard manure with ½ recommended dose of chemical fertilizers and poultry litter with ½ recommended dose of chemical fertilizers on the growth and yield of wheat as whole phenology and yield attributed characteristics of wheat after treatment.

CHAPTER II

REVIEW OF LITERATURE

Organic Matter (OM) is the most important factor of the soil on crop production. FYM and PL with ½ recommended doses of chemical fertilizers used treatments may have considerable effect on growth, yield and cost of production of wheat. Many workers have given much attention in conducting research works with effect of organic and inorganic fertilizer on growth and yield of wheat under rainfeed conditions. Some of the related works are reviewed here.

Effect of farmyard manure (FYM) and inorganic fertilizers on the yield of maize in wheat-maize system on eroded inceptisols in northern Pakistan. (Ali1, *et al.*, 2015).

Crop productivity of eroded lands is very poor due to removal of top fertile soil losing organic matter and plant nutrients. Crop productivity of such marginal lands needs to be restored in order to meet the food requirements of increasing population (Ali1, *et al.*, 2015). To study the effect of inorganic fertilisers alone and in combination with farm yard manure (FYM) under wheat-maize-wheat system. The fertiliser treatments consisted of farmer's practice. Inorganic fertilisers and combined application of inorganic and organic. The results of FYM for wheat crop gave significantly higher grain as well as stover yields over the other two treatments. The increases in grain yield respectively averaged over sites. It also proved economically over the other treatments at all the sites giving higher net returns. It could be concluded that FYM applied to wheat crop has carryover effect on maize crop in wheat maize cropping system and can restore the crop productivity of eroded lands.

Organic farming of rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) cropping system: a review (Ram, *et al*, 2011).

Sustainability problem caused by factor productivity decline due to indiscriminate use of chemical fertilizers and pesticides in rice-wheat cropping system can be solved with production of the cropping system under organic farming. Organic farming enhances soil organic carbon, available phosphorus content and microbial population / enzymatic activity of soil thus making it sustainable for organic crop production (Ram, *et al.*, 2011). Use of different organic amendments in combinations and in a cumulative manner can meet the nutrient requirement of organic rice and wheat in rice-wheat cropping system. The main weed control strategies used in organic farming of rice-wheat cropping system is often combine cultural or husbandry techniques with direct mechanical and thermal methods. Pests are generally not a significant problem in organic system, since healthy plants living in good soil with balanced nutrition are better able to resist pest and disease attack. However, commercial production of biopesticides containing different bacteria, fungi and viruses has been undertaken to control certain insects, pests and diseases in organic crop production systems. Owing to positive influence of organic components in rice-wheat cropping system, it is therefore, be assumed that those farmers who adopted organic management practices, found a way to improve the quality of their soil, or at least stemmed the deterioration ensuring productive capacity for future generations.

Economizing nitrogen fertilizer in wheat through combinations with organic manures in Kashmir, Pakistan (Abbasi, and Tahir, 2011).

Integrating fertilizer N with organic manures is an important management strategy for sustainable agriculture production systems in subhumid, rainfed soils low in organic matter (Abbasi, and Tahir, 2011) was evaluate the effects of combined use of farmyard manure (FYM), poultry manure (PM), and urea nitrogen (UN) on crop productivity, nitrogen use efficiency (NUE) and soil properties. The results showed that combined application of UN, FYM and PM in 75:25 ratios produced comparable grain yields was respectively. Results of this study confirmed that UN+FYM and UN+PM in 75:25 ratios saved 25% (30 kg) of N fertilizer and represented a successful and sustainable management strategy for wheat production in the mountainous ecosystems.

Effect of integrated use of organic and inorganic nitrogen sources on wheat yield, (Shah, *et al.*, 2010).

The integrated use of organic and inorganic fertilizers on the yield of wheat was evaluated in a field experiment at Nuclear Institute for Food and Agriculture (NIFA), the organic sources used were farmyard manure, poultry manure and city waste. The results was showed that integrated use in different proportion increased the plant height, spike length, grain per spike and 1000-grain weight. Application of half N from urea with 25% N from either FYM and 25% poultry manure or city waste proved beneficial and reduced 50% fertilizer cost.

Effect of organic and inorganic nitrogen fertilizer on wheat plant under water regime (Shaaban, 2006).

The effect of soil moisture regime 80(M1), 60(M2) and 40% (M3) of soil water holding capacity (WHC), two sources of organic fertilizer chicken manure (Ch) and sun flower residue (Sf) and different levels of organic and inorganic nitrogen on hydro physical properties of loamy sand soil and wheat yield. The organic residues improved bulk density, total porosity, macro and micro pores, soil water retention and soil hydraulic conductivity compared with untreated soil. The interaction between irrigation regime and fertilization significantly increased grain and straw yield. Irrigation treatments no significant effect on soil physical properties.

Wheat in two soils with organic amendments, (Malik, *et al.*, 2013)

The experiment was conducted with a sandy loam or a silt loam soil to examine the effects of farmyard manure (FYM), poultry litter (PL) and biogenic waste compost (BWC) at 10 g dw /kg soil on microbial biomass and activity and growth and nutrient uptake by wheat. All three amendments increased microbial biomass C, N and P, dehydrogenase activity, plant growth and nutrient uptake with a greater effect by FYM and PL than by BWC. All amendments increased plant growth and nutrient uptake. It is concluded that organic amendments can stimulate microbial growth and nutrient uptake as well as plant growth and nutrient uptake.

Feasibility of replacing chemical fertilizer by using organic fertilizer in wheat (*Triticum aestivum*) considering yield contributing characters and yield (Akhter, *et al.*, 2006).

This experiment was comprised of 10 treatments, organic matter and chemical fertilizer as recommended dose accept control plot among the treatments all chemical fertilizers as recommended dose and cowdung + compost + ½ chemical fertilizer were found superior considering all yield contributing characters and yield. The longest spike (19.86 cm), maximum number of spikelets spikes-1 (20.33), maximum number of filled grains spike-1 (34.00), highest grain yield (3.71 t/ha) and highest straw yield (5.78 t/ha) was attained from T1 and the shortest spike (14.33 cm), minimum number of spikelets spikes-1 (14.18), minimum number of filled grains spike-1 (21.53), lowest grain yield (2.06 t/ha) and lowest straw yield (4.49 t/ha) was recorded from T0.

The effect of drought stress on grain yield, yield components and some quality traits of durum wheat (*Triticum turgidum* ssp. durum) cultivars (Kilic and Yagbasanlar, 2010).

Drought, one of the environmental stresses, is the most significant factor restricting plant production in the majority of agricultural fields of the world. Wheat is generally grown on arid-agricultural fields. Drought often causes serious problems in wheat production areas (KILIÇ and YAĞBASANLAR, 2010). A field study was fourteen wheat cultivars were grown under well watered and natural drought conditions. Morphological traits were measured at anthesis and yield, yield components and quality traits were evaluated at ripening time. The flowering period was negatively associated with grain yield, while grain filling period, chlorophyll content, number of grains per spike and spikelets per spike were positively associated with grain yield under drought conditions.

More researchers observed on wheat production by used organic manure with chemical fertilizers:

Babu, *et al.,* (2000) observed that application of FYM, NPK fertilizers poultry manure and FYM + N all resulted significantly higher grain and straw yields than the control and FYM + N produced the highest rice yield , longest and heaviest panicle, heaviest grain weight and highest net returns in both Rabi and KRF-1.

Mannan, *et al.*, (2000) reported that manuring with cowdung up to 10 t/ha in addition to recommended inorganic fertilizers with the rate of N application improved grain and straw yields and quality of transplant aman rice over inorganic fertilizers alone.

Laxminarayana, (2000) cited that application of 100% NPK + poultry manure @ 5 t/ha gave the highest grain yields of rice among the treatments and the lowest grain yield was obtained with 100% N treated plot. Jeegardeeswari, *et al.,* (2001) reported that grain yield of rice was the highest (5500 kg/ha-1) in the green manure + NPK treatment and FYM and urban compost with or without K fertilizer showed higher K uptake compared to green manuring.

In Himalyas India, Integrated use of chemical fertilizers and farm yard manure enhanced the grain yields significantly for maize and wheat in comparison to use of chemical fertilizers, i.e., 100% NPK+lime .Based on five year moving average values, the application of 100% NP resulted in reduction of grain yield of maize and wheat crop by 67 and 19% respectively during 1994 to 1998 compared with 1973 to 1977 (Sharma and Subehia, 2003).Similarly During (2007),an increase from 83.9% to 108.7% in maize grain yield was recorded by integration nutrients at University of Arid Agriculture Rawalpindi (Sial, *et al.,* 2007). Three times higher maize biomass was obtained when the crop was fertilized with compost along with NPK, than that produced by non treated plots Combined application of organic and inorganic fertilizer (60:90:60:05 kg NPK Zn ha-1 + 20 t FYM ha-1) significantly increased maize grain yield by 89% over the farmer practice (60-90-60-0 kg NPKZn ha-1) Bishnu *et al.,* (2001).

Integrated use of organic and mineral fertilizer, i.e., 25 % N from FYM and 75 % from urea produced significantly higher wheat grain and straw yield than 0:100 and 50:50 combination of N from FYM and urea (Hassan *et al.,* 1989). Thind *et al.,* (2002) and Mugwe, *et al.* (2009) found that organic manure and N increased the yields of maize and wheat significantly. Ashoka, *et al.,* (2009) observed that application of RDF + 25Kg ZnSo4+10Kg FeSo4+35Kg vermicompost significantly increased corn growth parameters viz, plant height, Total dry matter and yield. Similarly, Ahmed, *et al.,* (2002) reported that plant height and leaf area was significantly increased by combined use of organic and unorganic nitrogen in wheat.

Integrated nutrient supply of organic and inorganic sources is of great importance for maintaining of productivity. The basic concept underlying the principle of IPNM is the maintance and improvement in soil fertility for sustained enhanced crop productivity through optimizing all possible sources of plant nutrients. The major possible sources of organic manures are farmyard manure and crop residues green manure etc. Farmyard manure is the best organic source but its quantity is limited because of burning of dung as fuel and reduction of farm animals with introduction of mechanical farming, so it is important to use both sources in conjunction to overcome the problem of soil health, sustainability, high price of chemical fertilizers etc.

The beneficial effect of combined use of organic and inorganic fertilizers is well established Organic manures not only increase nitrifying activities of micro-organisms and also reduce N losses by increasing CEC of soil (Gasser,1964) The addition of plant litter/leaves can improve the structure, permeability, and stability of soil (Walsh and Voigt, 1977). Green manuring maintain and improve soil structure by addition of organic matter and minimize N, P, K fixation in all types of soils (Repetto, 1986, Gill *et al.,* 1998) and Guar, (1994) reported that application of organic material increase the ability of microorganisms to produce polysaccharides, which improve soil structure while humus enhance the utilization of fertilizer nutrients by plants and also decrease leaching losses by increasing water holding capacity of the soil.

An experiment was conducted at Agriculture College & Research Institute, Coimbatore, Tamil Nadu, to study the effect of different organic sources of nutrients with and without green manure in rice on growth and yield parameters. Treatments consisted of green manure incorporation (GMI) and without GMI were assigned to main plot. Treatments in the sub-plot consisted of farm yard manure (FYM), poultry manure (PM) and vermicompost, along with control (no manure) were replicated three times in a split plot design. The study revealed that in situ incorporation of green manure recorded higher values of growth parameters viz., plant height, LAI, dry matter production, number of tillers/m2, root length, root volume and root weight compared to without GMI. Among the manures application, similar trend was observed with poultry manure application compared to vermicompost, FYM and control. Green manure+poultry manure recorded the highest grain and straw yield with high yield attributing characters viz., panicle length, total number of grains/panicle, number of filled grains/panicle and lesser sterility percentage compared to other combinations.

Negassa, *et al*., (2001) also observed that the use of 5t compost/ha alone and integration with low rates of N, P fertilizers were economically best for maize production and 85 kg N ha-1 can be saved (Khalid, *et al.*, 2005) investigated that FYM + crop residues can substitute 50% NPK for wheat production and their residual effect was equivalent to 50 % of the recommended dose of NPK as chemical fertilizer on the yield of succeeding crop in rice-heat cropping system. Integrated use of NPK with organic manure and effective micro-organism (EM) resulted in highest seed cotton yield, i.e., 2470 kg ha-1, while OM + EM + 1/2 NPK yielded statistically similar yield to that obtained with full dose of NPK fertilizer (Kaleem *et al*., 2005).

Hadda, *et al.*, (2006) also observed that wheat grain yield was increased significantly with soil and nutrient management practice over the farmer practices under wheat-maize cropping system in rainfed sub-mountainous region of Punjab India. The increase in grain maize yield increase was 13% over farmer practice with 75% RDF+FYM 10 t/ha. Ayoola and Adeniyan (2006) also recorded that Crop yields were statistically the same under NPK alone and NPK + poultry manure but significantly higher than both poultry manure alone and control in both locations.

The grain and straw yield increased significantly with different treatments and highest yield was obtained with application of 7.5 t/ha poultry manure. The NPK uptake was positively influenced by different treatments. Poultry manure was found best source of N and increased the organic matter content, N, P, K and CEC of post harvest soil.

Thind, *et al*. (2002) conducted a long term field experiment in Punjab, India on different organic amendments and N rates on yield of maize and nutrient uptake. They observed after 23rd and 24th harvest of crop, organic manure and N increased the yield of maize and wheat significantly. The residual effect of organic manure on succeeding wheat yield was higher in FYM treated plots followed by dhincha, Moong, guar, cowpeas treated plots. Available N, P & K contents of soil were also increased in FYM treated plots. Organic manures also improved DTPA-Zn content of soil.

Chaudhary, *et al.,* (2005) evaluated long term application of FYM on soil micronutrient status on wheat in Hisar, India and reported that application of FYM significantly increased DTPA extractable and total content of micronutrients at all depths. The time of application of FYM also affected the content of soil micronutrients. DTPA extractable and total content of micronutrients were higher when FYM was applied in winter as compared to summer. The DTPA-extractable soil Zn, Fe and Mn concentration increased from 0.41 to 1.08 mg /kg, from 10.3 to 17.7 mg /kg, respectively with increasing OM content, thus showing the importance of soil OM in micronutrients availability.

Availability of Mn, Zn and Cu was also increased with application of FYM (Venknatesh, *et al.,* 2004). Gondeb and Mazzar, (2005) also reported that the application of organic mineral fertilizer increased available soil Zn content. Rupa, *et al.,* (2003) reported that the effect of added FYM was more evident on the Ox-Zn fraction and the percentage utilization of Zn by wheat was the maximum with the addition of FYM alone in comparison to other treatment combinations. Application of 7.5 mg Zn /kg soil showed the maximum increase in different fractions of soil Zn and significantly increased the Zn utilization by wheat as compared to other Zn levels. Karaca, (2004) concluded from an incubation study for six month at Ankara University, Turkey that application of organic wastes increased DTPA-Extractable Zn.

Behera, *et al.,* (2008) observed higher DTPA-Zn concentration in soil when Zn was applied and reduced with increase in soil depth. Grain and Stover yield of maize ranged from 1.10 to 2.43 t/ha, and 1.22 to 2.46 t/ha respectively under different treatments. Sorbed Zn and Zn associated with organic matter contributed significantly toward Zn uptake by maize (Behera, *et al.,* 2008).

Kumar, *et al*., (1987) studied the partitioning of dry matter, accumulation in aestivum and durum wheat under irrigated and non-irrigated field condition. They observed that leaf weight increased up to 75 days after sowing and stem weight increased up to 105 days after sowing (DAS) and then declined. They also observed difference between durum and aestivum wheat in assimilating to grain at pre and post.

The findings of Akhter, *et al.,* (2013) comprised of 10 treatments, Feasibility of replacing chemical fertilizer by using organic fertilizer in wheat (*Triticum aestivum*) considering yield contributing characters and yield were recorded on different growth characters and yield. Among the treatments all chemical fertilizers as recommended dose (T1) and cowdung + compost + ½ chemical fertilizer (T8) were found superior considering all yield contributing characters and yield.

CHAPTER III

MATERIALS AND METHODS

The study was conducted at the experimental field of **"Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN)"** is a collaborative project lead by Caritas Austria under the supervision of Caritas Bangladesh, EC Project Number: DCI-FOOD 2010/230-309 at Boraigram, Natore, Rajshahi-6000 during the Rabi season (from 05 Nov 2014 to 15 March 2015) with a view to evaluating the interaction of different organic matter (FYM and PL) with ½ recommend chemical fertilizers dose. Effect of organic matter in soil on wheat (cv. BARI GAM-24) growth, yield and yield attributes in rainfed area. A significant response of wheat to different organic matter (FYM and PL) treatments was observed. In this chapter, details of different materials used, methodologies used for the experiment and processing the data have been presented.

3.1. Description of the experimental site

3.1.1. Location

The experimental site is located in the agro-ecological zone (AEZ) FAO-3 that lies between 24.3083°N latitude and 89.1708°E longitude. The experimental field listed in (**Table: 3.1 and Fig: 3.1**).

Table: 3.1. Different agro-ecological zone of the experimental field

Plot name	Agro-ecological zone (AEZ)- FAO 3
TA -TG	24.29403°N latitude and 89.06396°E longitude
TB -TH	24.29824°N latitude and 89.07021°E longitude
TC -TI	24.28639°N latitude and 89.04483°E longitude
TD-TJ	24.28959°N latitude and 89.05444°E longitude
TE-TK	24.29414°N latitude and 89.04015°E longitude
TF-TL	24.32510°N latitude and 89.07806°E longitude

*Data from, SAFBIN project at Natore, (Caritas, Bangladesh).

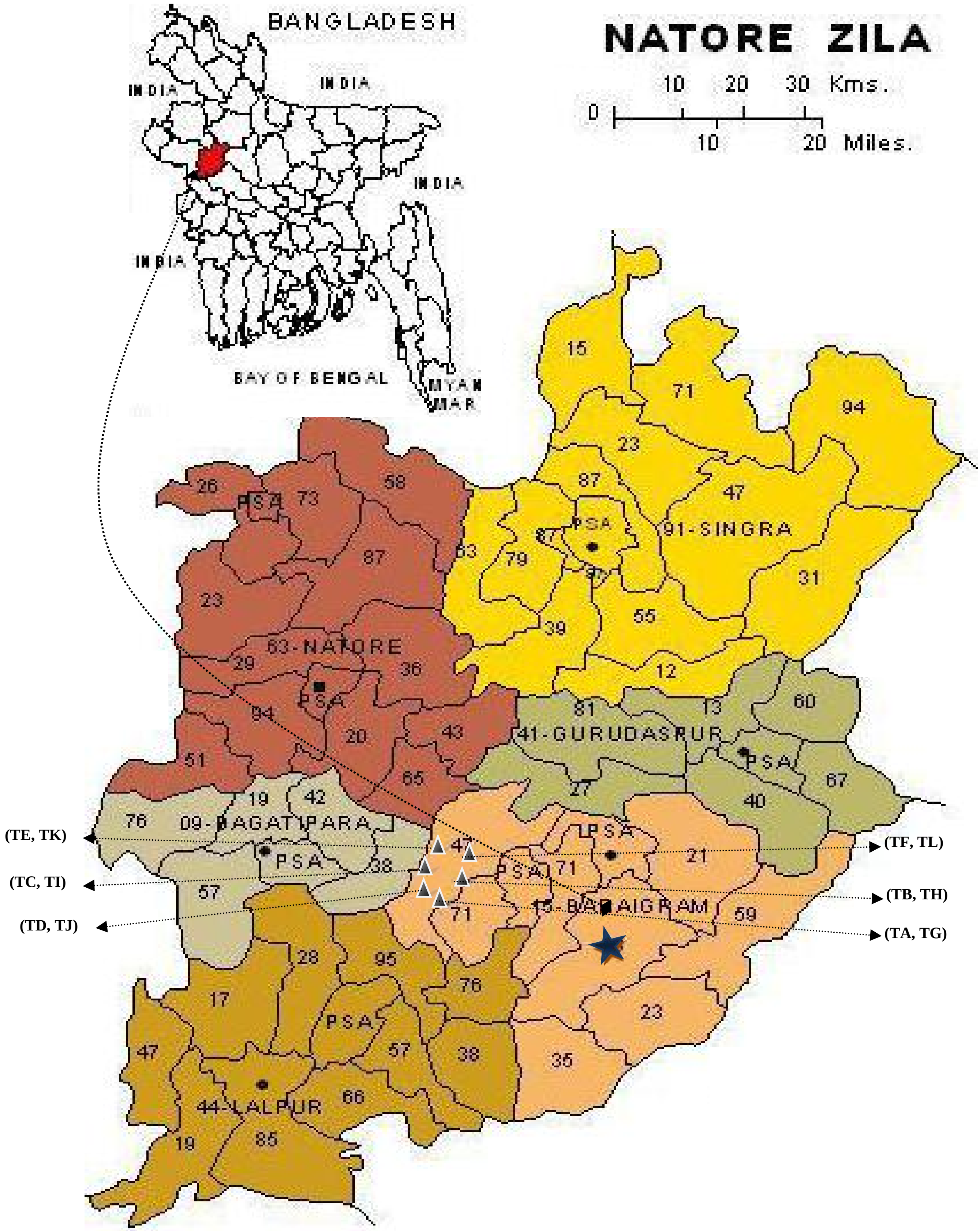


Fig: 3.1. Location map of experimental fields on wheat.

3.1.2. Soil

The soil of the experimental field belongs to Lower Atrai Basin with silt loam underlain by sandy loam. The organic matter content of the experimental soil was 1.06%. Some physical properties of the soil were determined which are listed in (**Table: 3.2**).

Table: 3.2. Some properties of the soil in the Natore District

Sand (%)	Silt (%)	Clay (%)	Textural class	pH	OM (%)	Total N (%)	Particle density (g cm-3)	Bulk density (g cm-3)	Soil porosity (%)	Water Holding capacity (%)	Bacterial Colony g-1 soil
54.32	38.25	7.43	Sandy loam	8.20	1.06	0.118	1.67	1.21	79.33	36.41	3.86×10^7

*Data from, Soil Research Development Institute (SRDI), Dhaka, Bangladesh.

3.1.3. Climate

The climate of the experimental site falls under the sub-tropical, which is characterized by high temperature, high humidity, and average rainfall of 1862 mm with occasional gusty winds in kharif season (April - September). Whereas, less rainfall associated with moderately low temperature exits during the rabi season (October–March). Weather information on rainfall, temperature, relative humidity, at the experimental site during the period of the study is presented in (**Table: 3.3**).

Table: 3.3. Weather data of the experimental site during the cropping period (December 2014 to March 2015).

Parameters	Months			
	December	January	February	March
Rainfall (mm)	10.6	11.3	17.5	24.8
Mean maximum air temperature (°C)	25.8	24.5	27.7	33.1
Mean minimum air temperature (°C)	17.8	11.0	11.0	13.1
Mean average relative humidity (%)	78	78	71	63

*Data from, Bangladesh Metrological Department (BMD), Dhaka.

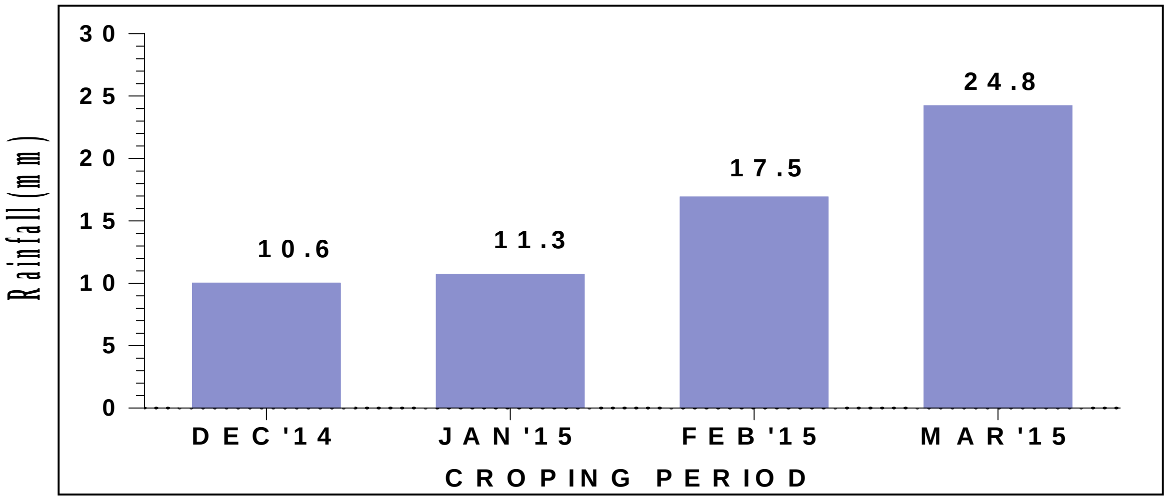


Fig: 3.2. Rainfall (mm) during the cropping period

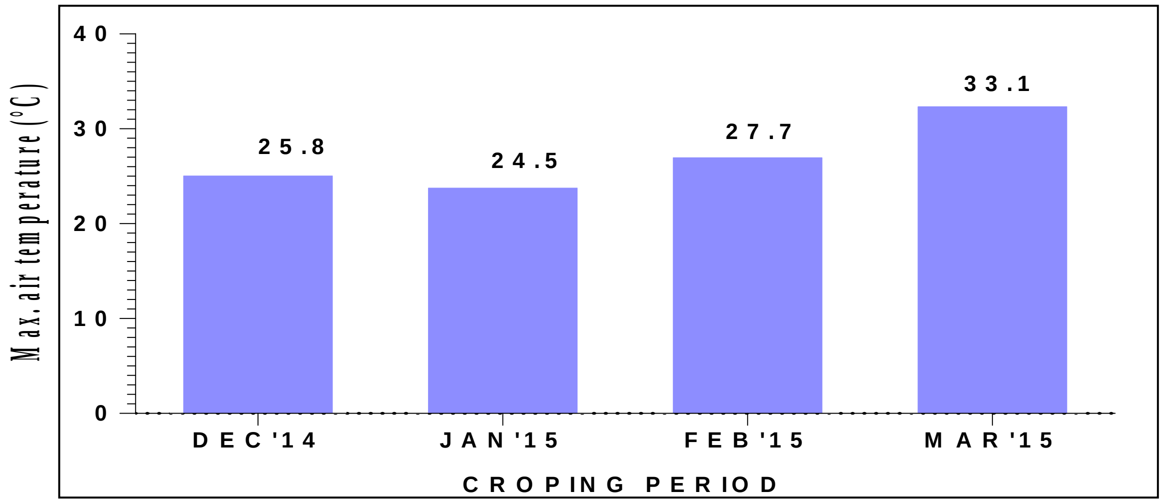


Fig: 3.3. Max. Air temperature (°C) during the cropping period

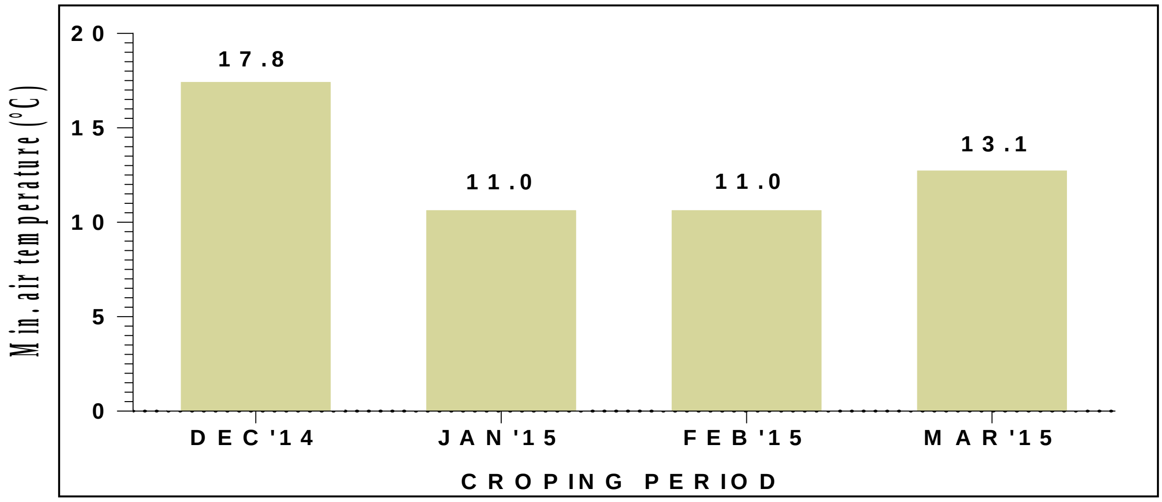


Fig: 3.4. Min. air temperature (°C) during the cropping period

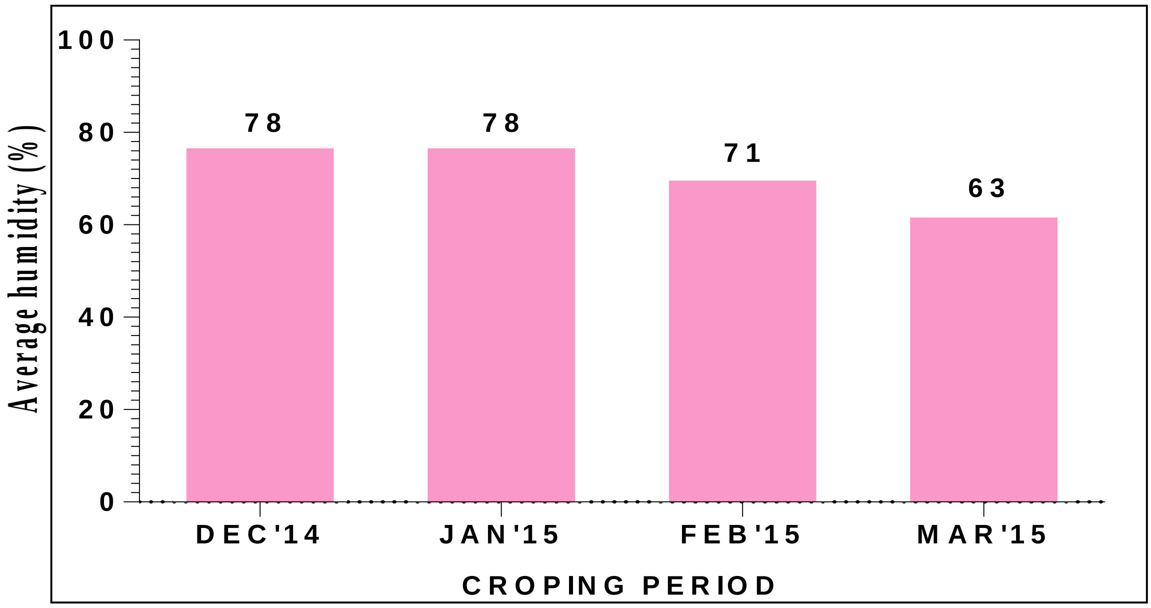


Fig: 3.5. Mean average relative humidity (%) during the cropping period

3.2. Land Preparation

The land of the experimental field was first opened on the experimental field is different filed of shown in (**Table: 3.4**) November 2014 with a tractor. Then the field was dried for some days to reduce moisture content. Later on, the land was ploughed (with farmer practices) and cross ploughed three times with a power tiller to obtain a good tilth condition. The size of plot was 400 m^2 except mother plot (200 m^2) FYM and PL. All the weeds and stubbles were removed from the field and thus, the land was made ready for sowing. Prior to sowing the whole experiment at field was mother plot only divided into FYM and PL plots the same places. In all plots the big clods was broken into small and incorporated the basal dose of organic matter and ½ chemical Fertilizer of recommended dose.

Table: 3.4. Opened on the experimental field for land preparation

Treatment	TA - TG	TB - TH	TC - TI	TD - TJ	TE - TK	TF - TL
FYM	08/11/14	05/11/14	05/11/14	08/11/14	10/11/14	09/11/14
PL	08/11/14	05/11/14	08/11/14	08/11/14	23/10/14	06/11/14

3.3. Treatment design of the experimental area

The experimental plots were laid out with local farmer's practices the three irrigation and tillage for FYM and PL treatments. There were two replications of combination of both the treatments. According to the farmer's practices, FYM and PL treatment was assigned in the mother plot and the two replications were assigned in the different area and different plots on the treatment. All of these events were randomly chosen to avoid any biasness towards the selection. For all hydrological information and soil information, the weather station at Bangladesh Metrological Department and Soil Research Development Institute, near the experimental site was consulted.

3.4. Selection of wheat variety

There are many varieties of wheat available in Bangladesh. Some of these are developed by different wheat research organizations in Bangladesh and some are developed by foreign research organizations. Bangladesh Agricultural Research Institute (BARI) developed some modern high yielding varieties of wheat. The selected variety of wheat for the study was *Prodip* (BARI GAM-24). This variety was developed by Bangladesh Agricultural Research Institute (BARI). This is temperature tolerant variety. *Prodip* was released in 2005 and matures at 105-110 days. The average yield of *Prodip* is (3.5-4.5) t/ha listed in (**Fig: 3.6**).

Fig: 3.6. *Prodip* (BARI GAM-24)

Table: 3.5. Calendar of intercultural operations for the experimental plots

Activities	Date											
	TA	**TB**	**TC**	**TD**	**TE**	**TF**	**TG**	**TH**	**TI**	**TJ**	**TK**	**TL**
Sowing	08/11/14	05/11/14	07/11/14	08/11/14	13/11/14	09/11/14	08/11/14	08/11/14	11/11/14	08/11/14	02/11/14	06/11/14
Thinning	18/03/15	15/11/15	17/11/15	18/11/15	23/11/15	19/11/15	18/11/15	18/11/15	21/11/15	18/11/15	22/11/15	16/11/15
1st Weeding	18/03/15	15/11/15	17/11/15	18/11/15	23/11/15	19/11/15	18/11/15	18/11/15	21/11/15	18/11/15	22/11/15	16/11/15
1st Irrigation	25/11/14	25/11/14	28/11/14	28/11/14	08/11/14	27/11/14	25/11/14	25/11/14	01/12/14	28/11/14	27/10/14	24/11/14
2nd Weeding	28/12/14	20/12/14	25/12/14	27/12/15	05/12/14	15/12/14	28/12/14	20/12/14	30/12/14	07/01/15	21/11/14	12/12/14
2nd Fertilizer	28/12/14	20/12/14	25/12/14	27/12/15	05/12/14	15/12/14	28/12/14	20/12/14	30/12/14	07/01/15	21/11/14	12/12/14
2nd Irrigation	28/12/14	20/12/14	02/01/14	07/01/15	05/12/14	15/12/14	28/12/14	20/12/14	30/12/14	27/01/14	21/11/14	12/12/14
3rd Irrigation	26/01/15	18/01/14	02/01/14	07/01/15	07/01/14	26/01/15	06/01/15	18/01/15	11/01/15	07/01/15	10/01/14	03/01/15
Harvesting	01/03/15	10/03/15	02/03/15	10/03/15	15/03/15	10/03/15	01/03/15	08/03/15	05/03/15	10/03/15	11/03/15	08/03/15

3.5. Treatments

1. Farm Yard Manure (FYM @ 3 ton/ha) + ½ Chemical fertilizers of recommended dose
2. Poultry Litter (PL @ 3 ton/ha) + ½ Chemical fertilizers of recommended dose

Table: 3.6. Physiochemical analysis of the farmyard manure (FM) and poultry litter (PL)

Parameters	Units	FYM	PL
Total nitrogen (N)	$g{\cdot}kg^{-1}$	24.00	44.00
Total phosphorus (P)	$g{\cdot}kg^{-1}$	1.10	8.50
Total potassium (K)	$g{\cdot}kg^{-1}$	19.60	37.00
Zinc (Zn)	$mg{\cdot}kg^{-1}$	82.00	624.00
Boron (B)	$mg{\cdot}kg^{-1}$	13.00	46.70
Sulfur (S)	$mg{\cdot}kg^{-1}$	2.70	6.20

*Analyses performed at the Soil Science Department of Federal University of Lavras, (Passos *et al.*, 2014).

3.5.1. Irrigation treatments:

FYM: 17-21 DAS (Day after sowing) + 50-55 DAS + 75-80 DAS (**Table: 3.5**).
PL: 17-21 DAS+ 50-55 DAS + 75-80 DAS (**Table: 3.5**).

3.5.2. Fertilizer doses

A common ½ chemical fertilizer of recommended dose was applied as:
Dose: Urea: 180 kg/ha, TSP: 140 kg/ha, MOP: 40 Kg/ha and Gypsum 80 kg/ha.

Two third Nitrogen (N) and total amount of other fertilizers were applied at sowing and the remaining Nitrogen (N) was top dressed after second irrigation.

3.6. Sowing of seeds and application of fertilizer

Wheat seeds were weighed for different plots at the rate of 120 kg/ha. Seeding was done by after land preparation. Field was formed and seeding was done by prior land preparation. Field was consisted by rows depending on the crop on raised. Line to line was 20cm. For sowing the seeds in rows 2-3 cm deep line were made manually by using single tine and rakes. Before sowing seeds the respective doses of fertilizers were applied in the line.

3.8. Cultural practices

A pre-sowing irrigation was applied for proper seed germination. A high yielding variety BARI Gom–24 (*Prodip*) was sown in the experimental plots on 5 December 2012 with the help of farmers practice at the rate of 120 kg/ha. Seeding was done by land preparation with line to line. Field was formed and seeding was done with prior land preparation. Field was formed line to line accommodating wheat. Field depth was 12-13 cm. Irrigation water was applied to fields. Ploughing, seeding, and leveling were done through one local farmers practice and used in farmer's practice for broadcast sowing. Fertilizers were applied at the rate of $N^{100}+P^{26}+K^{40}+S^{20}+B^{1}$ kg/ha. Two–thirds of N and total amount of other fertilizers were applied at sowing and the remaining N was top dressed after first irrigation. At maturity, 12 samples of FYM and PL treatment on 15 March 2015 were harvested. After threshed and cleaned, grain yields were recorded at 12% moisture content. The data on other plant characteristics during growth and harvesting time from each of the experimental plot were recorded, as spike, plant height; spike length, gloom size, spike size, effective tillers, spike lets/spike, grains/spike, spike weight, leaf area, thousand grain wt (TGW), and grain yield were recorded. Data were subjected to analysis of variance to sort out significant difference among treat.

3.9. Intercultural operations

3.9.1. Thinning and weeding

After sowing the seeds, continuous observation was maintained to keep required number of plants in each treatment. During sowing slightly higher number of seeds were sown than the requirement so that the seed germination will remain same in all places, but due to the high germination rate of the seed in some places more plants were grown. In these places thinning were done after 10 days of sowing.

Weeds grown in the experimental plots were uprooted by weeding. First weeding was done 10 days after sowing. Subsequent weeding was done followed by application of irrigation water. There was no significant infestation of pests and diseases in the fields and hence no control measure for this purpose was required. Various intercultural operations were undertaken during the crop growing period as presented in (**Table: 3.3**).

3.9.2. Harvesting and crop sampling

The crop was harvested on 15 March 2015 after 113 days of sowing when the spikes were completely ripped. At the time of harvesting 1 m² area was harvested. Randomly 20 plants were collected for taking experimental data. The harvested crop of each treatment was bundled separately and tagged properly. Harvest dated on represent (**Table: 3.5**) calendar of intercultural operations for the experimental fields.

3.10. Experimental data recording

After recording of data, on plant height, length of spike and number of spike of each plant, the plant material were dried in the sun. Threshing, cleaning and drying of grains and straws of each plot were done carefully. Finally, the grain and straw yields and yield contributing parameters were recorded separately. The following data were recorded at various stages of the growth of wheat:

i. **Plant height:** It was measured as cm from ground surface to tip of the spike for 20 randomly selected plants from each treatment at before harvest.

ii. **Tillers per plant:** Tillers that had at least one visible leaf were counted. It includes both productive and non-bearing tillers.

iii. **Leaf area:** It was measured as cm^2 from length and wide of the leaf for 40 randomly selected plants from each treatment at before harvest.

iv. **Spikes per plant:** It was that at a visible spike of the plant for 20 randomly selected plants from each treatment at harvest.

v. **Spike length:** Spike length was recorded as cm from the basal code of the rachis to the apex of each spike.

vi. **Spikelets per spike:** Total number of spikelets in a spike was counted. It included both sterile and spikelets.

vii. **Spike weight:** It was measured as gm from whole spike for 50 randomly selected plants from each treatment at harvest.

viii. **Gloom size:** It was measured as cm from the five spikes for 20 randomly selected plants from each treatment at harvest.

ix. **Peduncle length:** It was measured as cm from last stem node to below of the spike for 20 randomly selected plants from each treatment at harvest.

x. **Grains/spike:** It was measured as g from after husking visible grain was counted of the spike for 20 randomly selected plants from each treatment at harvest.

xi. **Grains weight/spike:** It was measured as g from ground surface to tip of the spike for 20 randomly selected plants from each treatment at harvest.

xii. **Spikes/m^2:** It was measured visually count number of the spike for selected plot from each treatment at harvest.

xiii. **Grain weight/m²:** It was measured as mg from whole grains of the spike for selected plot from each treatment at harvest.

xiv. **Husk weight/spike:** It was measured as mg from whole husk of per spike for 50 randomly selected from each treatment at harvest.

xv. **Weight of 1000 grains:** It was measured from as gm after husking visible grain was counted selected plot from each treatment at harvest.

xvi. **Grain yield:** Grains obtained from each plot including the total grains of m^2 the respective plot were dried in the air oven (75^oc) with 72 hours and weighed to determine the grain yield/plot and was expressed in t/ha

xvii. **Straw yield:** Straw obtained from each plot including the straw of 20 tillers of the respective plot was dried in the air oven and weighed to determine the straw yield/plot and was expressed in t/ha

xviii. **Biological yield:** Sum of grain yield and straw yield are termed as the biological yield of a crop. The biological yield of wheat was measured for each plot and expressed in t/ha

xix. **Harvest index:** The harvest index was calculated by the following formula (Gardner *et al*., 1985):

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.17. Statistical analyses of crop data

The growth and yield parameters of wheat recorded during the study were tabulated for statistical analyses and they were subjected to analysis of variance (ANOVA) was done with Graph Pad Prism 6 program. Differences among means were tested by Least Significant Differences (LSD) at $P<0.05$.

CHAPTER IV

RESULTS AND DISSCUSSION

Analysis of variance (ANOVA) indicates statistically significant effects of FYM and PL as an additive on growth and yield parameter of wheat. The result obtained from this study have been presented, interpreted and discussed in this chapter and detailed below:

4.1. Effect of treatments on plant height

Statistical analysis showed that the results of effect on different FYM and PL treatments on plant height of wheat in our experimental plot of TA, TB, TC, TD, TE, TF and TG, TH TI, TJ, TK, TL; respectively. The statistical Analysis is presented in Table 4.1 and Table 4.2 and plotting are showed in bar diagram **Fig: 4.1 to 4.20** from FY and PL plots, respectively. The tallest plant (100±0.96cm) in FYM plots was found in the treatment TF, and the smallest plant (92±0.18cm) was obtained by the treatment TC. In comparison, tallest plant height was found 106±0.96cm in the treatment PL from TI plot and the smallest plant height (87±0.18cm) was obtained by the treatment TH.

For Phenology, leaf area index and grain yield are the most important traits affected by fertilizer under rainfed condition. The plant height found in the present study was higher in both the treatments of FYM and PL (**Fig: 4.1**) than the investigations obtained by Rehman *et al.* (2010). Same as, Channabasanagowda *et al*. (2008) recorded lower plant height than our average plant height of wheat. In other case, Islam *et al.* (2014) showed that plant height was increased during fertilization with FYM and PL in wheat.

Furthermore, Hanuman *et al.* (2014) was found that plant height and yield attributes of wheat crop showed apparent influence of the varying levels of fertilizers and significant improvement in uptake of these nutrients was might be due to extra amount of nutrients supplied by fertilizer and FYM, which ultimately providing conductive physical environment facilitating better root growth and absorption of nutrients from the native as well as applied sources which favored the highest nutrient uptake (Bharadwaj *et al.,* 1994; Singh and Singh, 2012). Statistically, we found in our present investigation on plant height revealed higher than observed by Hanuman *et al.* (2014). He obtained that it was significantly affected by the treatments showed significant variation on plant height for FYM and PL plots.

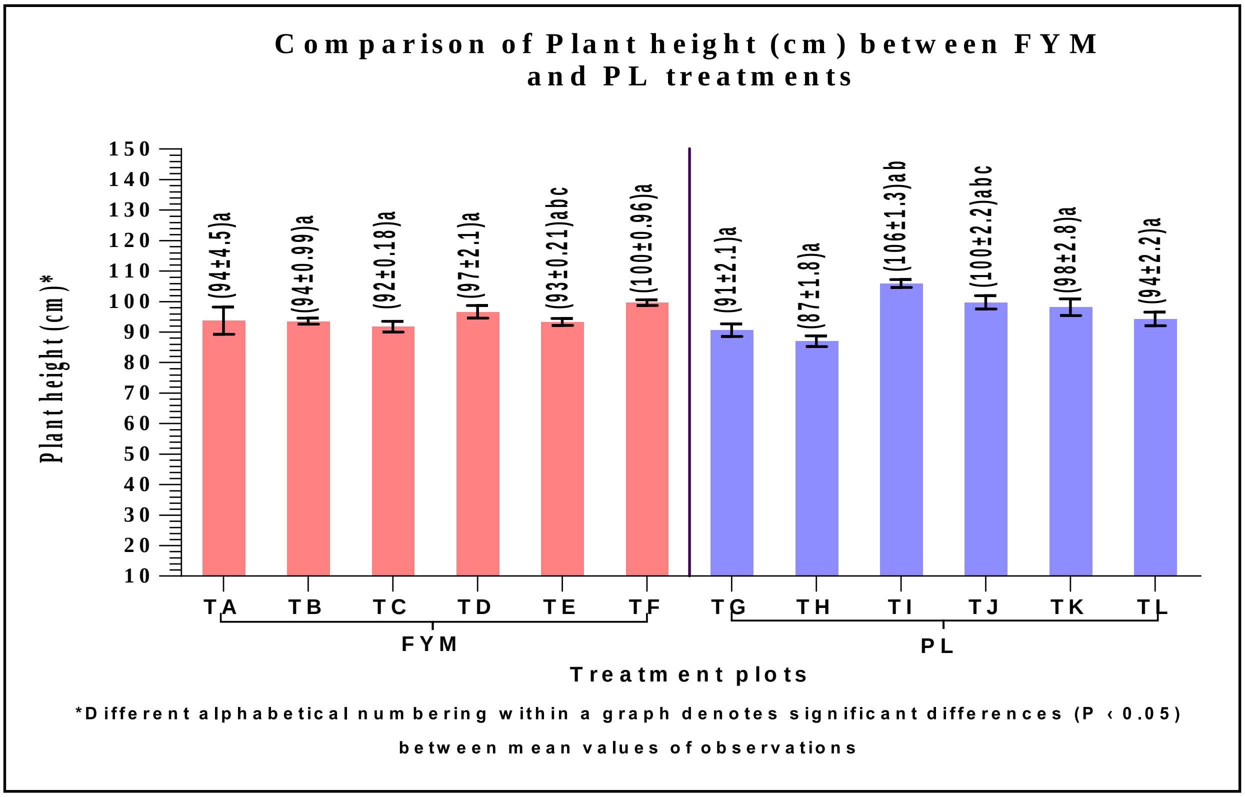
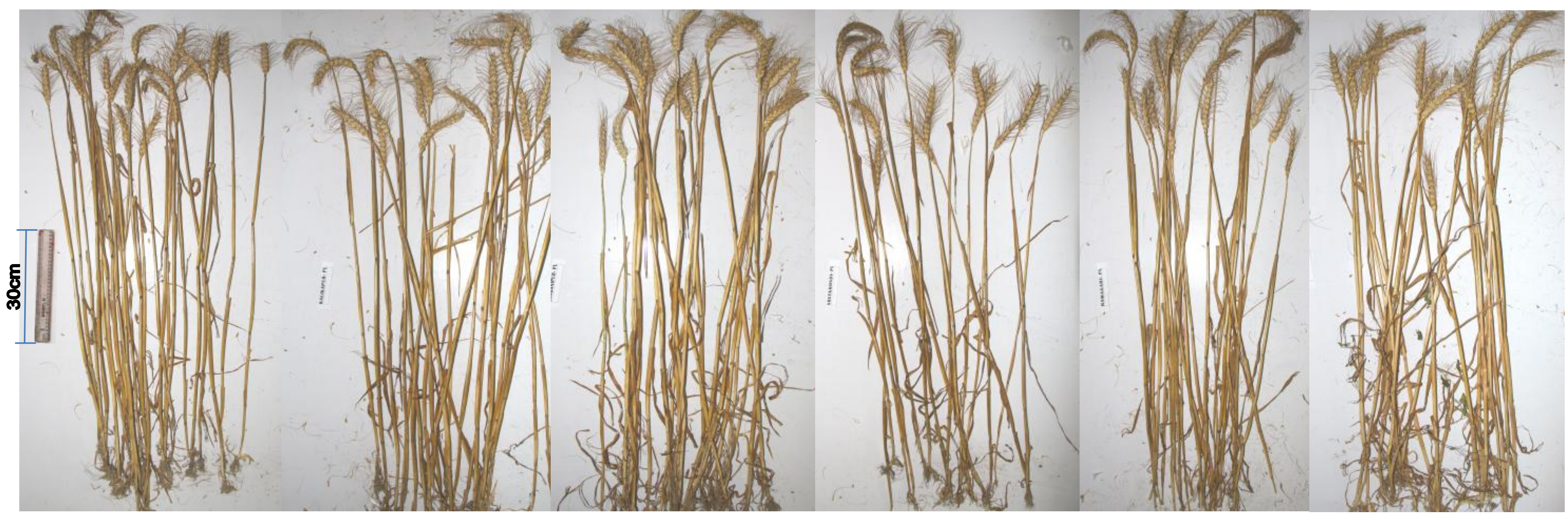


Fig: 4.1. Plant height (cm) for interaction between FYM and PL treatments

Fig: 4.2. Investigation of experimental site before harvesting on wheat crop.

TA TB TC TD TE TF

Fig: 4.3. Plant height (cm) for interaction between FYM treatments



TG TH TI TJ TK TL

Fig: 4.4. Plant height (cm) for interaction between PL treatments

Table 4:1. Yield and yield contributing parameters of wheat as used by Farm yard manure (FYM) and Poultry litter (PL) of organic matter (MO) during 2014-2015

Treatment		Plant height (cm)*	Tillers per plant*	Leaf area (cm^2)*	Spikes per plant*	Spike length (cm)*	Spikelet's per spike*	Spike weight (gm)*	Gloom size (cm)*	Peduncle length (cm)*
Treat. No.		**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**
FYM	**TA**	94±4.50a	6.4±0.32a	32±1.50a	6.4±0.32a	12±0.19a	20±0.28a	2.4±0.099a	7.7±0.21a	16±0.28a
	TB	94±0.99a	6.8±0.24a	32±1.10a	6.8±0.24a	11±0.27a	20±0.25a	2.8±0.12a	7.7±0.26a	15±0.46a
	TC	92±0.18a	7.0±0.43a	25±0.86b	7.0±0.43a	11±0.17ab	18±0.28b	2.5±0.11a	7.1±0.18a	17±0.34a
	TD	97±2.10a	6.0±0.29a	29±1.20a	6.0±0.29a	9.3±0.36b	15±0.58b	2.1±0.11ab	5.5±0.38b	15±0.35ab
	TE	93±0.21abc	6.2±0.39a	42±1.80ab	6.2±0.39a	11±0.38ab	22±0.45ab	2.1±0.097ab	7.4±0.25ab	17±0.53ab
	TF	100±0.96a	6.4±0.41a	26±0.99ab	6.4±0.41a	9.2±0.27ab	16±0.31abc	2.6±0.10ab	9.0±0.25b	16±0.21ab
PL	**TG**	91±2.10a	6.5±0.29a	35±1.80a	6.5±0.29a	10±0.29a	19±0.40a	2.6±0.12a	7.0±0.22a	15±0.41a
	TH	87±1.80a	6.2±0.33a	37±1.50a	6.2±0.33a	11±0.23a	21±0.24a	2.6±0.12a	7.9±0.23a	17±0.49a
	TI	106±1.30ab	6.2±0.38a	28±1.40b	6.2±0.38a	11±0.19a	19±0.24ab	2.6±0.14a	8.6±0.15ab	17±0.30ab
	TJ	100±2.20abc	6.9±0.39a	29±1.30ab	6.9±0.39a	10±0.26a	18±0.41ab	2.4±0.14a	7.6±0.16ab	14±0.20bc
	TK	98±2.80a	6.8±0.38a	31±1.00ab	6.8±0.38a	11±0.16a	19±0.28a	2.4±0.11a	8.3±0.22ab	17±0.38ab
	TL	94±2.20a	6.5±0.32a	32±1.50a	6.4±0.32a	12±0.19a	20±0.28a	2.4±0.099a	7.7±0.21a	16±0.28a

*Treatments denoted by the same letter in a column were not significantly different ($P<0.05$) using the LSD test.

Table 1:2. Yield and yield contributing parameters of wheat as used by Farm yard manure (FYM) and Poultry litter (PL) of organic matter (MO) during 2014-2015

Treatment		Grains/spike*	Grains weight/spike (gm)*	Spikes/m²	Grain weight/m² (gm)	Husk weight/spike (mg)*	1000- grain weight (gm)	Yield (t/ha)
Treat. No.		10	11	12	13	14	15	16
FYM	TA	30 ±1.20a	1.7±0.07a	192	392.00	0.66±0.03a	55.12	3.90
	TB	30 ±1.10a	2.1±0.10b	232	414.70	0.66±0.02a	62.97	4.10
	TC	26±0.99ab	1.8±0.08a	295	447.30	0.63±0.03a	53.73	4.40
	TD	28±1.10a	1.6±0.09ab	188	382.40	0.52±0.03ab	55.54	3.80
	TE	39±1.80a	1.6±0.07ab	187	377.90	0.51±0.02ab	56.32	3.70
	TF	28±1.00a	2.0±0.08ab	226	407.20	0.68±0.03ab	54.21	4.00
PL	TG	35±1.70a	1.9±1.00a	195	414.50	0.66±0.03a	51.81	3.80
	TH	36±1.50a	1.9±1.00a	220	445.30	0.66±0.02a	53.33	4.00
	TI	29±1.30ab	1.8±1.00a	195	442.40	0.78±0.06a	52.82	4.40
	TJ	30±1.40ab	1.6±1.10a	226	287.10	0.77±0.06a	47.06	2.80
	TK	31±1.10b	1.7±0.08a	213	466.30	0.69±0.05a	51.87	3.90
	TL	30 ±1.20a	1.7±0.07a	192	392.00	0.69±0.03a	55.86	4.10

*Treatments denoted by the same letter in a column were not significantly different (*P*<0.05) using the LSD test.

4.2 Effect of treatments on spike length

The results obtained from the experimental findings showed that different organic matters of FYM and PL had an effect on spike length. We found highest and lowest length of spike for FYM were in TA (12±0.19cm) and TD (9.3±0.36cm) and for PL were in TH (11±0.23cm) and TL (8.9±0.29cm) (**Fig: 4.5**). In an experiment, Ibrahim *et al.* (2008) observed that, organic amendments had positive but variable effects on spike length but was non-significant. From the present investigations on spike length in comparison with Ibrahim *et al.* (2008) showed better than our present treatments. Dixit & Gupta (2000); Selvakumari *et al.* (2000), and Khoshgoftarmanesh and Kalbasi (2002) had also concluded that crop growth may be improved by the use of organic materials.

In other case, Muhammed *et al.* (2013) showed that spike length was significantly increased during the experiment which was not better than our present treatment with both FYM and PL. Statistical analysis of the data revealed that it was significantly affected by the treatments showed significant variation on spike length for FYM and PL plots.

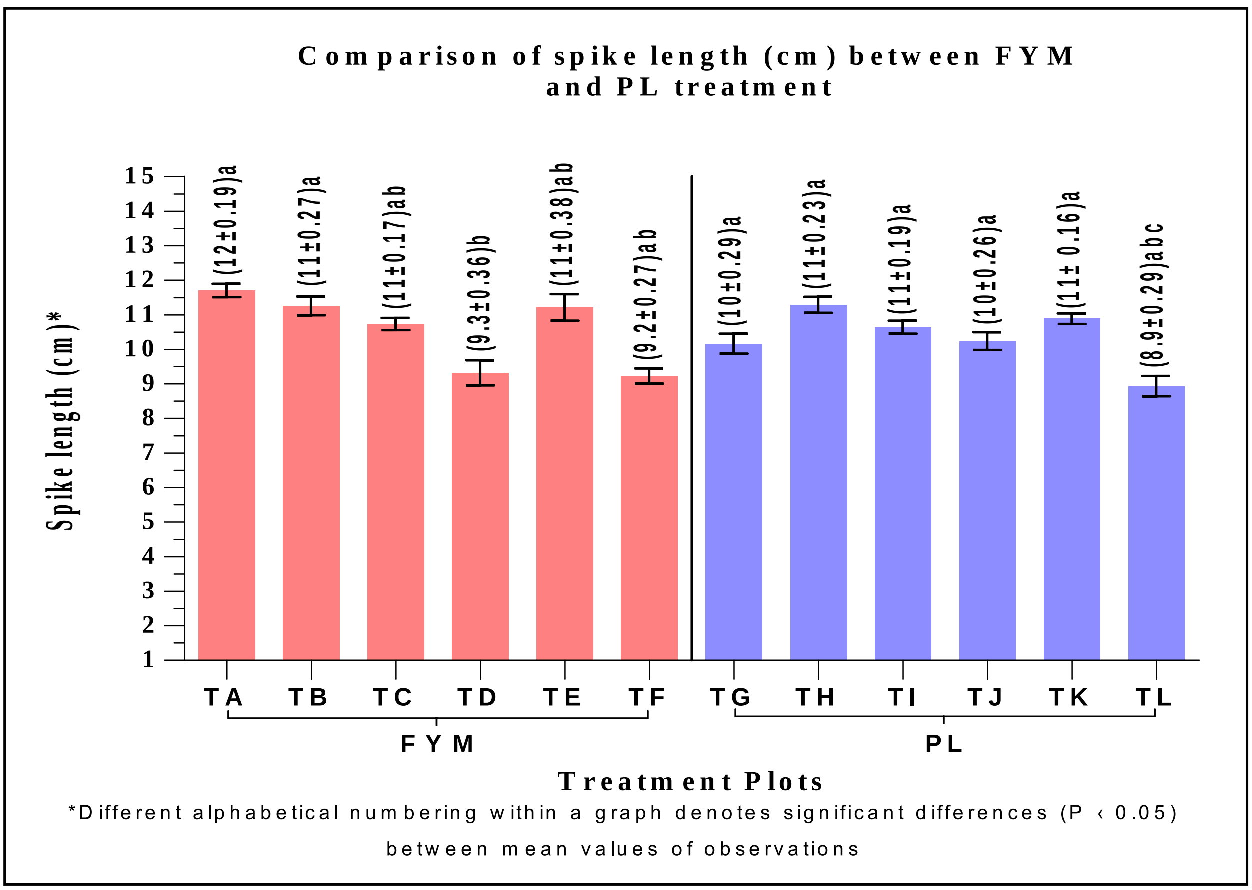


Fig: 4.5. Effect of treatments on spike length (cm)*

4.3. Effect of treatments on peduncle length

The results obtained from the experimental findings showed that different organic matters of FYM and PL had an effect on peduncle length. It was found that highest and lowest peduncle length from TE, plot is 17±0.53 cm and from TD, is 75±0.35 cm in FYM and for treatments PL were found (TH, 17±0.49 cm and TJ, 14±0.20 cm); respectively (**Fig: 4.6**). In a previous experiment, Malik *et al.* (2009) was found significant differences in peduncle length of wheat. Same as, our present treatments showed the treatment had effect on length of peduncle. In other case, Tayel *et al.* (2014) showed significant effects on the peduncle length of wheat which was lower than our present treatments on peduncle length.

Regarding to the investigation from another experiment by Mansour *et al.* (2014) has a promotive effect on the peduncle length. Our present investigation showed that the peduncle length was significantly lower than the result explained by Mansour *et al.* (2014). Statistical analysis of the data revealed that peduncle length was significantly affected by the treatments of FYM and PL plots.

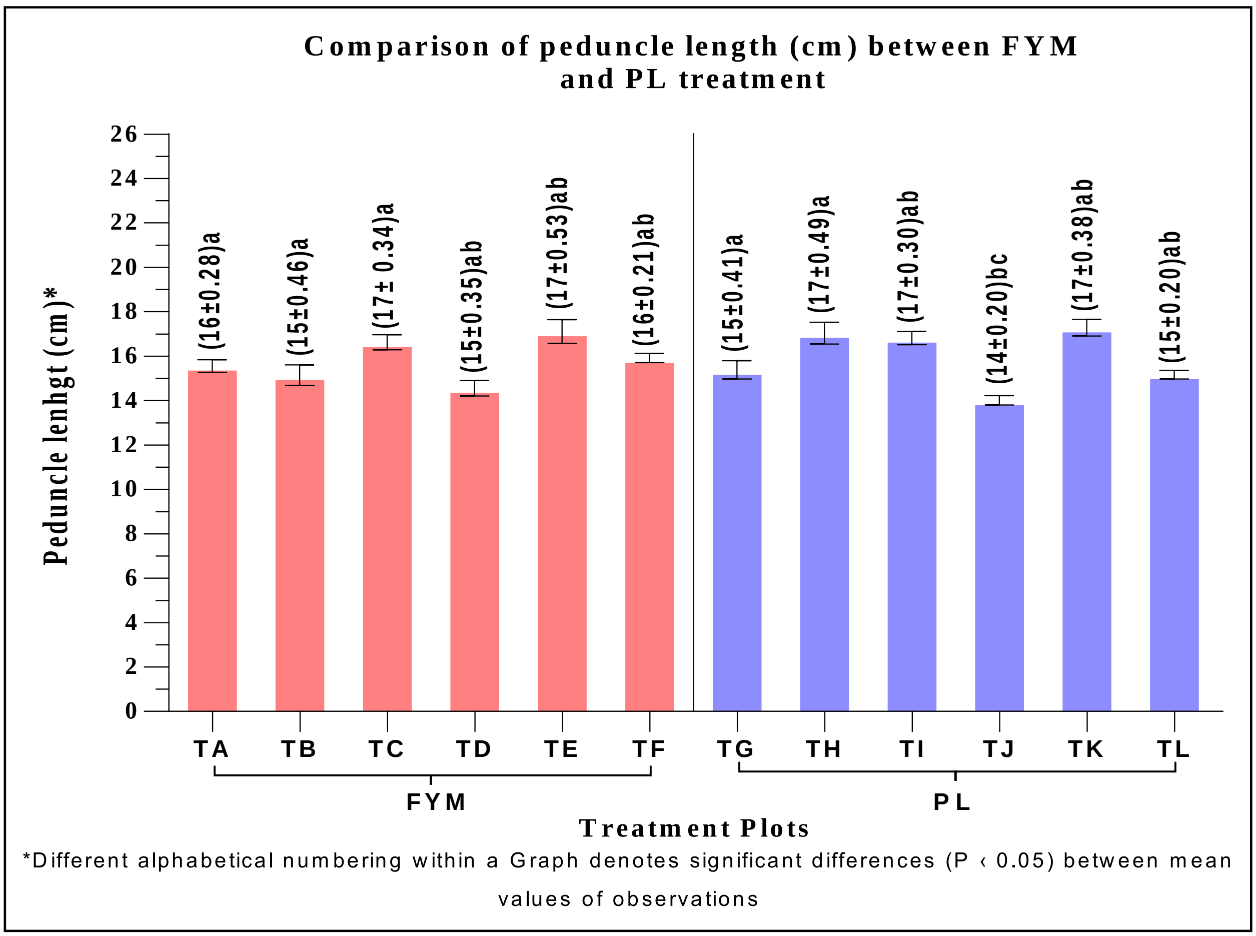


Fig: 4.6. Effect of treatments on peduncle length (cm)

4.4. Effect of treatments on tillers per plant

The results obtained from the experimental findings showed that, tillers per plant had no significantly variation influenced by different organic matters of FYM and PL. Maximum tillers were found 7.0±0.43 (TC, plot of FYM) and minimum tillers per plant were found 6.0±0.29 (TD plot of PL). Treatments of PL were found maximum 6.9±0.39 and minimum 6.28±0.33 tiller per plant (TJ and TH) (**Fig: 4.7**). For instance, Aslam *et al.* (2011) in an experiments had found that average data of combined use treatments of organic manures had significant difference among themselves. The highest number of tillers per plant was obtained with the application of PL alone followed by FYM+PL and PL+PM ???, with a significant difference among them. Dilshad *et al.* (2010) found that using FYM along with ½ chemical fertilizers produced statistically similar number of productive tillers of wheat as with full dose of fertilizer. Advantage of using organic manures combinations on number of wheat tillers was also reported by Channabasanagowda *et al*. (2008).

In other case, Muhammed, *et, al.*, (2013) was showed number of tillers per plant significantly affected and findings of maximum number of tillers per plant by FYM and PL. Our present investigation was found that this parameter was not significantly affected by the treatments and statistical analysis of the data showed similar number of tillers for FYM and PL plots.

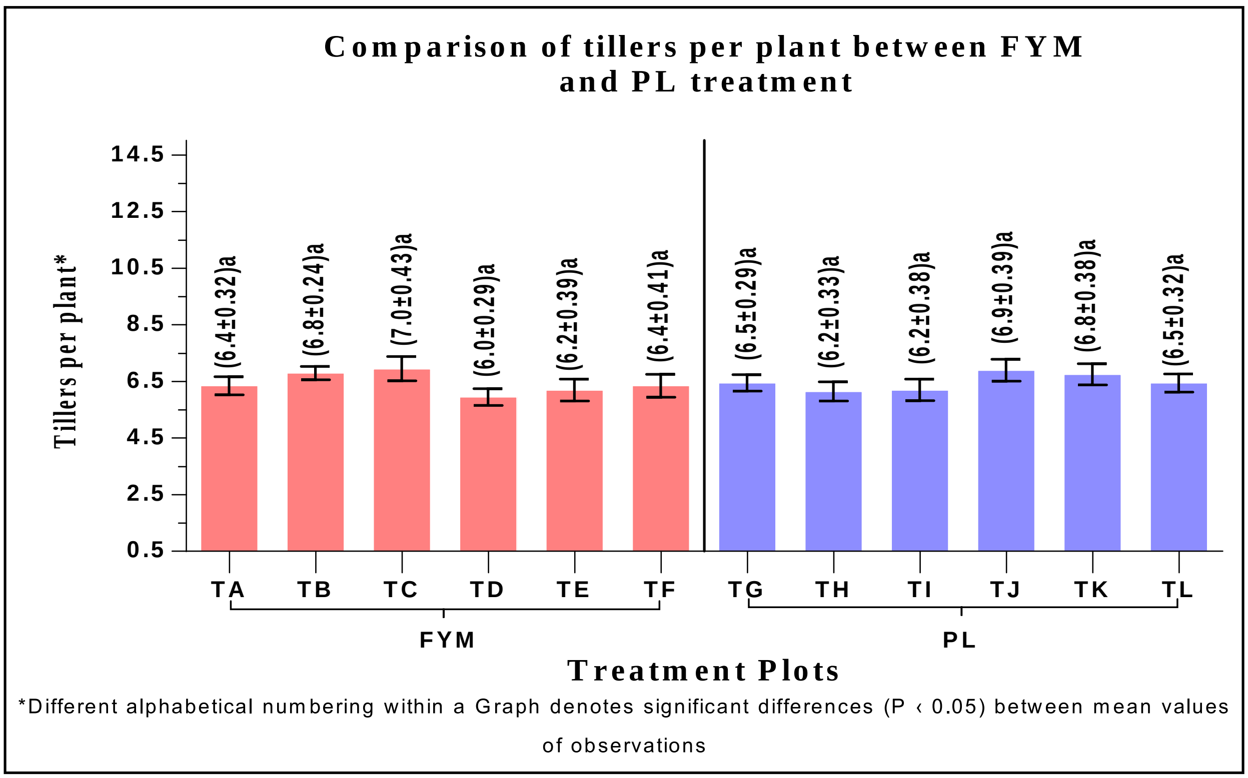


Fig: 4.7. Effect of treatments on tillers per plant

4.5. Effect of treatments on leaf area

Wheat plants are exposed to numerous biotic and abiotic stresses which are of a significant effect on the growth and cause changes in the normal physiological functions of the plants (Tas and Tas, 2007; Barnabas *et al.,* 2008). Temperature is one of the most important environmental factors that affects growth and development of plants (Noohi *et al.,* 2009) and adversely affects wheat growth in many important production regions and is a major limitation to wheat productivity worldwide (Mohammadi *et al.,* 2004; Reynolds and Trethowan, 2007). Heat stress reduces the leaf area (Warrington *et al.*, 1977) and duration of vegetative growth (Noohi *et al.,* 2009 and Saini, 1988) and leaf number (Acevedo, *et al.*, 1990). The results obtained from the present experiment showed that, different organic matters of FYM and PL showed varied measurement in leaf area. Maximum leaf area was found from treatment of FYM and PL (TE, 42±1.8 cm^2 and TH, 37±1.5cm^2, respectively) and minimum leaf area were found (TC, 25±0.86cm^2 and TI, 28±1.4cm^2). (**Fig: 4.8**) represent the leaf area for different treatment.

In other case, Almeselmani, and Deshmukh (2012) were found on their experiments that there were significant variation in leaf area index of wheat. As like them, in our present treatments, statistical analysis of the data exposed that leaf area was significantly affected by the treatments for FYM and PL plots.

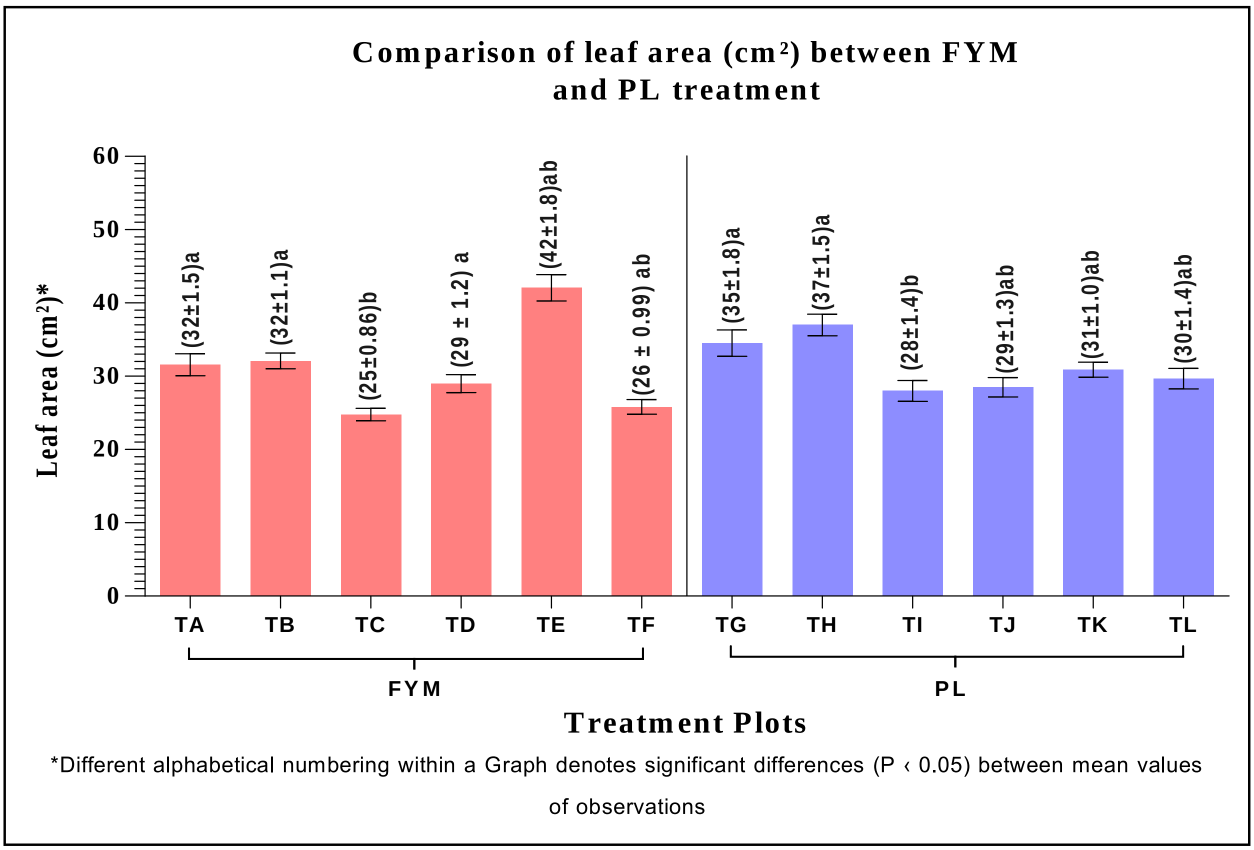


Fig: 4.8. Effect of treatments on leaf area (cm^2)

4.6. Effect of treatments on spike average weight

The results obtained from the experimental findings showed that different organic matters of FYM and PL had an effect on spike weight. It was found that highest and lowest weight of spike was in FYM (TB, 2.8±0.12g and TE, 2.1±0.097g) and in treatments of PL were found (TL, 2.7±0.09g and TK, 2.4±0.14g), respectively (**Fig: 4.9**). Moreover, Badawy *et al.* (2011) had tested three times field experiment on wheat and they continually use organic fertilizer which statistically showed influenced average weight of spike, but our present investigation were found better than Badawy *et al.* (2011). Also, in accordance with the results obtained in the present investigation on wheat growth of Badawy *et al.* (2011), (field experiments 1, 2, and 3), other investigators reported that the conjunctive use of Sulphar with organic manures has been found beneficial in increasing productivity of many crops (Attia and El-Dosuky, 1996, Awad *et. al.*, 2002). Statistical analysis of the data revealed that results were significantly affected by the treatments for average weight of spike in FYM and PL plots.

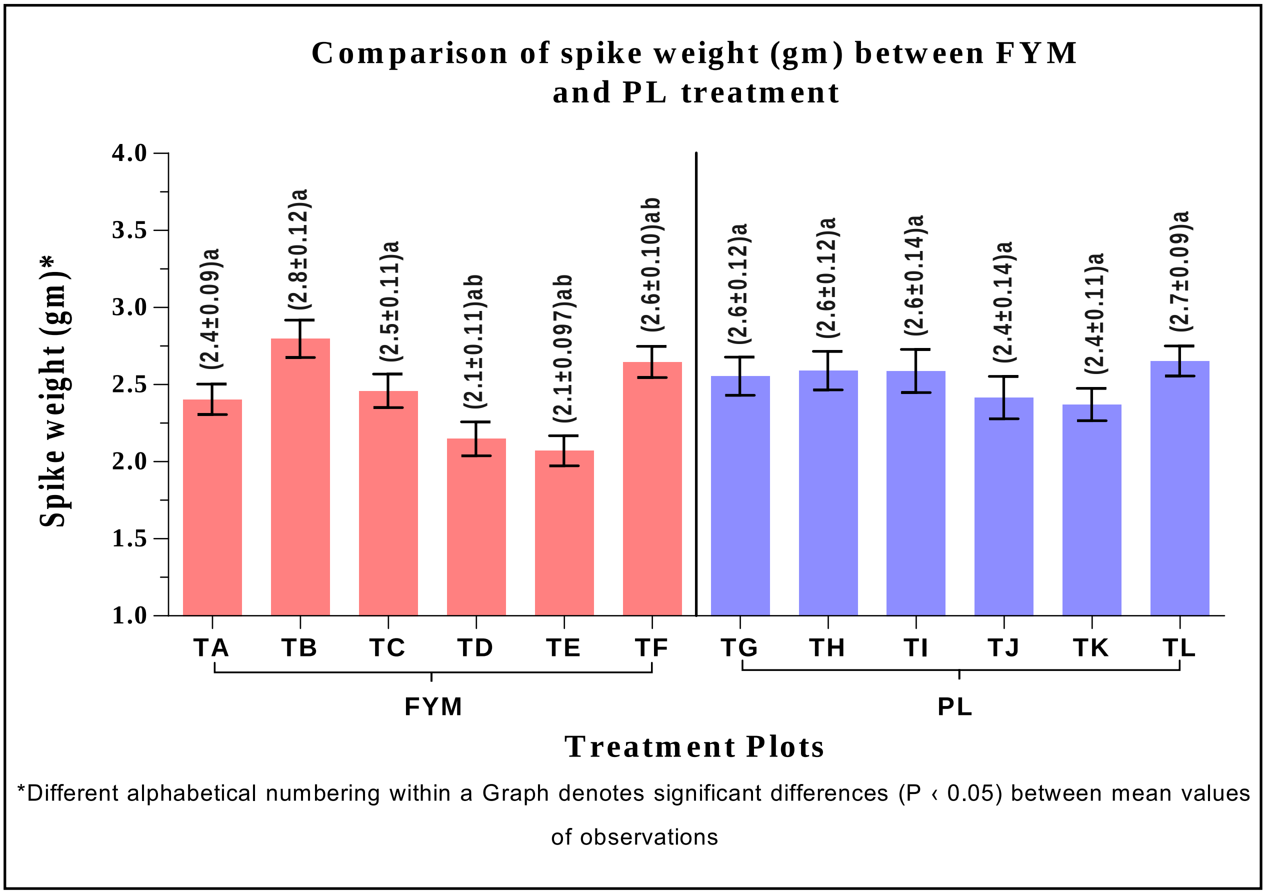


Fig: 4.9. Effect of treatments on spike weight (gm)

4.7. Effect of treatments on grains per spike

The results obtained from the experimental findings showed that different organic matters of FYM and PL had an effect on number of grains per spike. It was found that maximum and minimum grains per spike of FYM (TE, 39±1.8 and TC, 26±0.099) treatments and PL treatment were found (TH, 36±1.5 and TI, 29±0.1.3), respectively (**Fig: 4.10**). In other study, Jan and Noor, (2007) found lower number of grains per spike from combinations of FYM in compared to our current study. Same as, Ahmad *et al.* (2013) recorded that grain per spike was lower than PL in our present study.

Moreover, Abbas *et al.* (2012) showed that grains per spike gave the best result from FYM in comparison to different combinations of poultry manure during the experiment. Moreover, Hammad *et al.* (2011) recorded of higher grains per spike in PL than our average grains per spike. Statistical analysis of the data revealed that treatment was significantly affected and showed significant variation on grains per spike between FYM and PL plots.

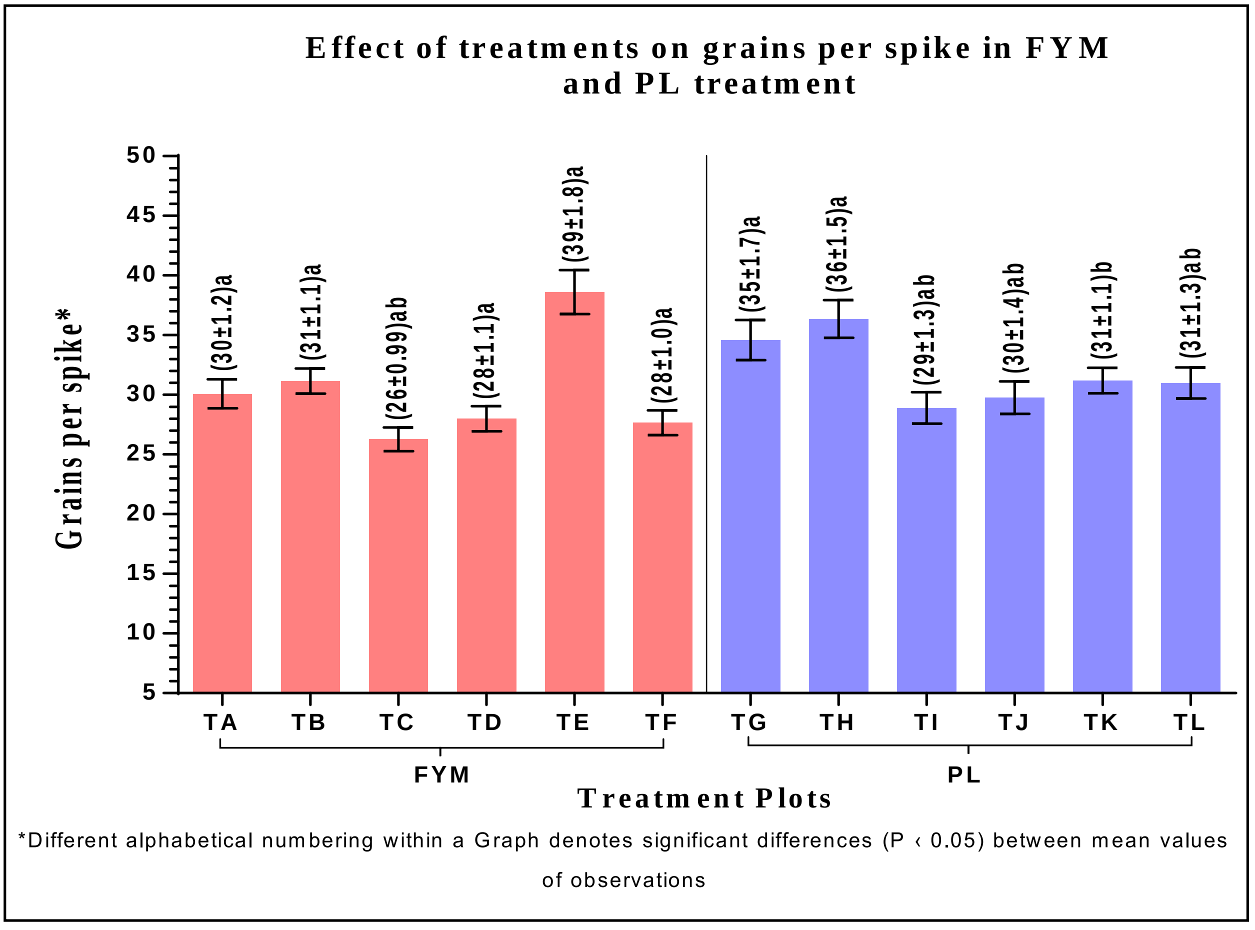


Fig: 4.10. Effect of treatments on grains per spike

4.8. Effect of treatments on spikelets per spike

Spikelets per spike were significantly influenced by different organic matters of FYM and PL. Maximum and minimum spikelets per spike were found in FYM (TE, 22±0.45 and TD, 15±0.580, resepctively) and for treatments of PL, the spikelets per spike for different treatments were TH, 31±0.24 and TL, 16±0.36, respectively (**Fig: 4.11**). Previous experiment, Muhammed *et al.* (2013) found that the application of FYM were measured that various number of spikelets spike were significant. His results indicated that it was excellent performance, but our present investigations were found the number of spikelet's per spike was better than Muhammed *et al.* (2013).

In other view, Jamali *et al.* (2008) experiment was statistically showed significant variation, and lower number of spikelet's recorded compare with our present treatments. Statistical analysis of the data revealed that treatment was significantly affected and showed significant variation on spikelets per spike between FYM and PL plots. Because, ear and stem growth coincides in wheat, genetic reductions in height reduce stem growth, and thereby reducing competition for assimilate between the elongating stem and developing ear (Youssefian *et al.* 1992).

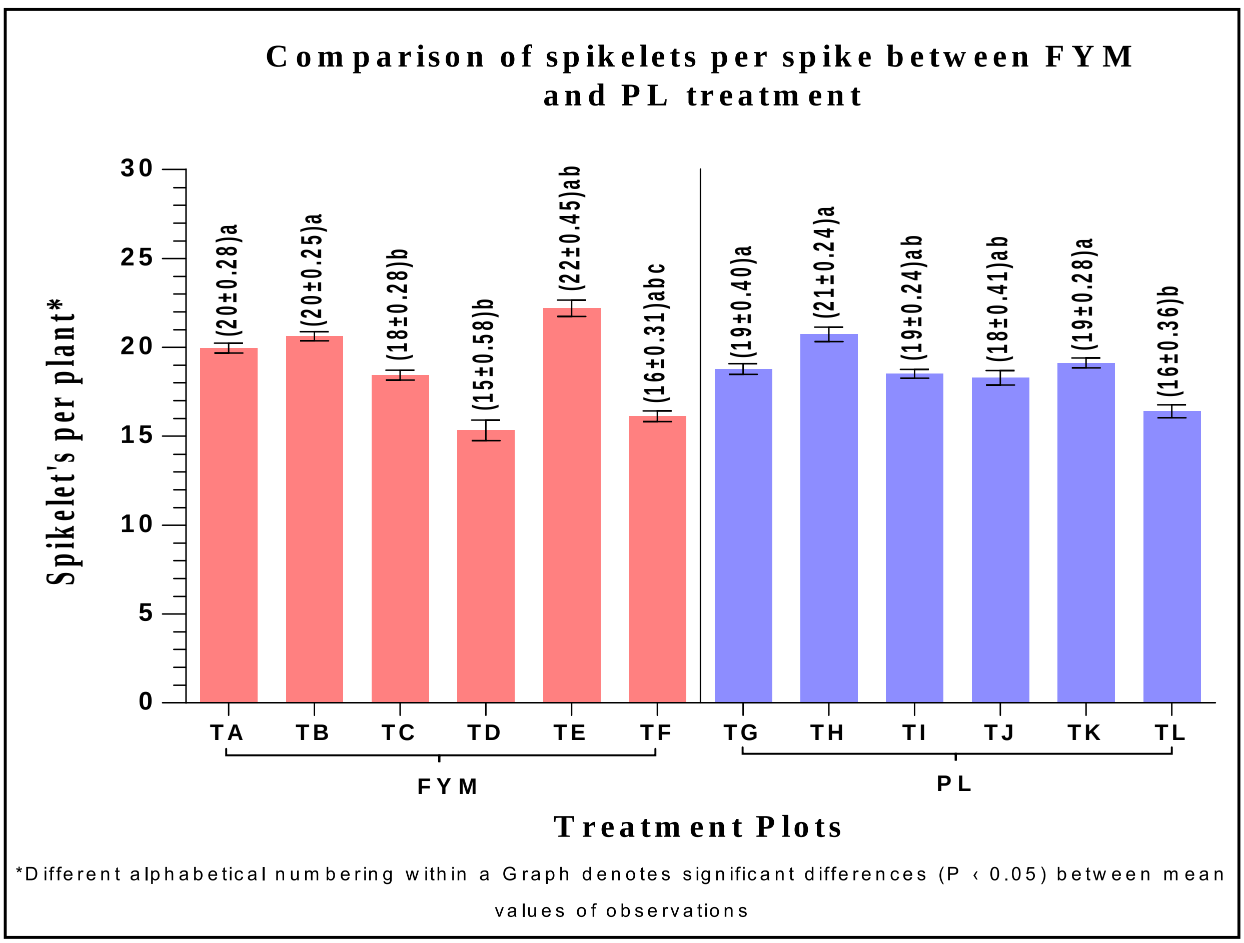


Fig: 4.11. Effect of treatments on spikelets per spike

4.9. Effect of treatments on spike per m²

The results obtained from the experimental findings showed that level of FYM and PL had an effect on spike per m². It was found that, max and min number of spikes in FYM (TC, 295 and TE, 187) treatment and in PL (TL, 237 and TG & TI, 195) (**Fig: 4.12**). Our result was confirmatory of the finding of Hammad *et al*. (2010); and Channabasanagowda *et al.* (2008). In other experiment Rehman *et al.* (2008) was found that spike per m² was significantly affected. Levels of FYM also significantly increased spike per m². Maximum spikes which received the highest level, but our present treatments were found significant difference among the different levels of FYM and PL. The favorable effect of organic and inorganic fertilizers on spike per m² was reported by Metho *et al.* (1997) and Badaruddin *et al.* (1999). Their results showed significant increase in spike per m² of wheat. They concluded that the increase in spike per m² was due to increased soil fertility under combination of organic and inorganic fertilizer. Significant increase in spike per m² with the application of different levels of N, NP and NPK combinations was also reported by Mossedaq and Smith (1994), Ayoub *et al.* (1994), Frederick and Camberato (1995) and Lloveras *et al.* (2001) and Iqtidar *et al.* (2006).

In other views, Zahoor (2014) observed that the spikes per unit area are the most vital determinants of the yield which are affected by factors including balanced nutrition. Our current trail showed, application of FYM had positive effects on spike per m².

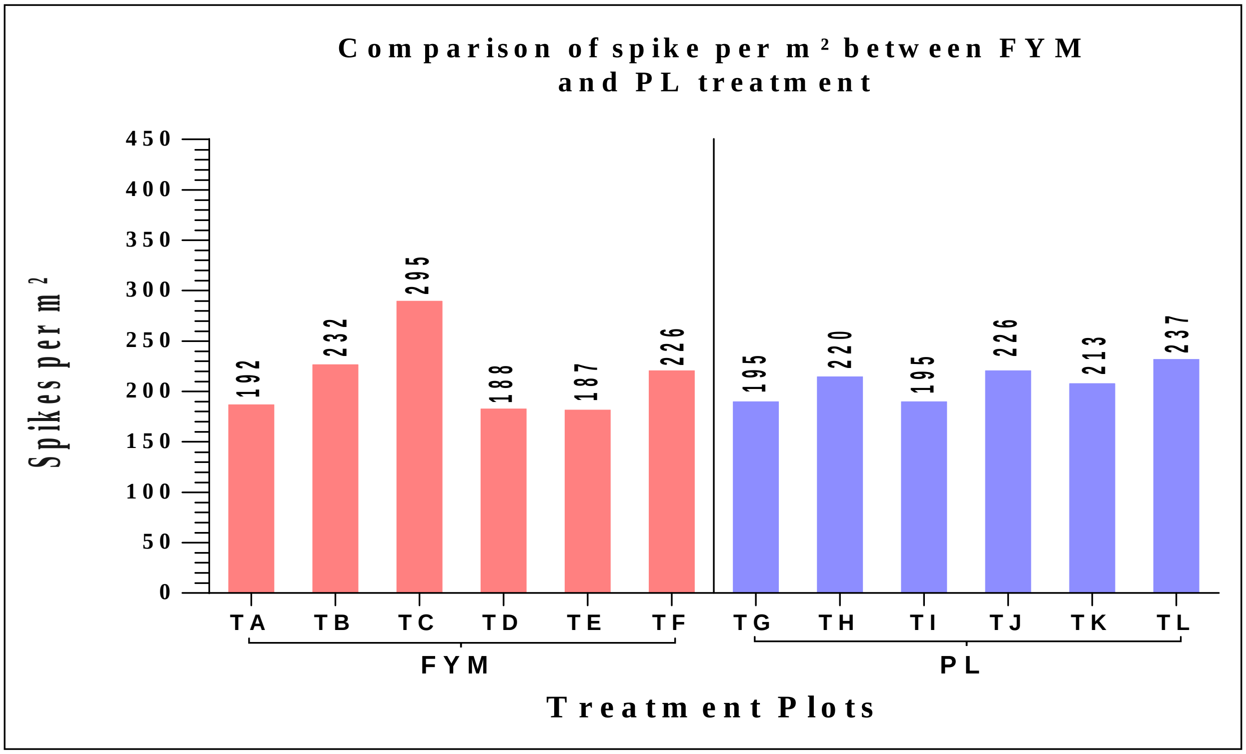


Fig: 4.12. Effect of treatments on spike per m²

4.10. Effect of treatments on weight of 1000 grains

Thousand grain weight (1000 grain weight), as it is called the test weight of the desired output, is referred to be considered as one of the most significant agronomic parameters ever trusted that contributes in having a reconnaissance over the possible production of a lot (grain yield) from the (**Fig: 4.15**). It was found that maximum and minimum weight of 1000 grain was (TB, 62.97gm and TC, 53.73gm) for the treatment FYM and for treatments of PL were found (TL, 55.86gm and TJ, 47.06gm.), respectively. In contrast, Akhtar *et al*. (2011) has found significant differences among the treatments and maximum 1000-grain was observed in FYM meanwhile which was lower than our present investigation of both FYM and PL treatments. Shah *et al.* (2013) has observed a maximum 1000 grain weight obtained in the treatment and similar results have been reported by Zeidan and Kramany (2001) who revealed higher 1000 grain weight with the use of organic manure and mineral N. Highest 1000 grain weight may be due to large accumulation of proteins and other reserved food in the seed because of high availability of nitrogen and other soil nutrients from organic manures and mineral source. Better utilization of readily available fertilizer nitrogen from treatment having organic and inorganic combination of 50:50 may have made plants more efficient in photosynthetic activity, which led to higher 1000-grain weights. Grains become a dominant sink at their maturity stage and the entire photo-assimilate deposited in the grains has resulted in an increase in 1000-grain weight.

These results are supported by Alam *et al.* (2005) who reported increased in 1000-grain weight of wheat through integrated use of organic and chemical fertilizer. Our present treatments were found significantly greater than PL treatments. Statistical analysis of the data revealed that was significantly affected by the treatments showed significant variation on weight of 1000 grains for FYM and PL plots.

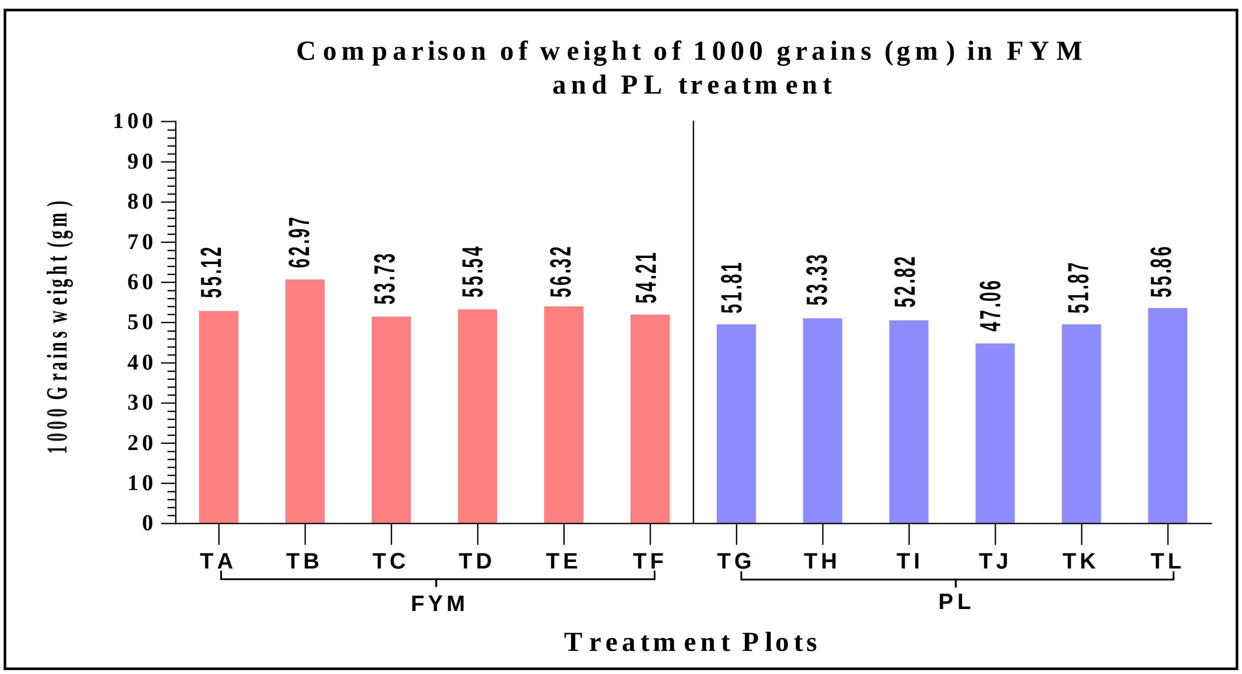


Fig: 4.15. Effect of treatments on weight of 1000 grains (gm)

Fig: 4.16. Effect of treatments on weight of 1000 grains (FYM)

Fig: 4.17. Effect of treatments on weight of 1000 grains (PL)

4.12. Effect of treatment on straw yield

Application of organic fertilizers can implicitly improve yields and quality traits by increasing the organic matter, alkaline nitrogen, available phosphorus and potassium and reduce soil bulk density and improve field moisture capacity (Jiang *et al*., 2006; Zhao and Zhou, 2011) and accelerate the accumulation of soil organic carbon and nitrogen content (Ndayegamiye and Cote, 1988; Zhengchao *et al.* 2013). In our case, the data of straw yield, biological yield harvest index and 1000 grain weight for different treatments are presented in (**Table 1.3**). FYM and PL treatment has a significant effect on straw yield. The highest and lowest yield was found in TD, 5.16 and TC, 3.69 (t/ha) for the treatments of FYM and the yield were TH, 5.97 and TJ, 3.29 (t/ha) for the treatments of PL, respectively (**Fig: 4.18**). From other studies, Hlisnikovský and Kunzová., (2014) found that the application of NPK with organic matters and straw resulted in highest with combined NPK, but our present treatments were found better.

In others case, these findings are consistent with those from Jiang *et al.* (2006), who recorded the highest yields with organic fertilizers combined with NPK and almost 1.0 t/ha higher yields when compared to NPK without organic compounds. The positive response of winter wheat on applied organic fertilizers was also published by Barzegar *et al.* (2002), who experimented with wheat straw, composted sugarcane bagasse residues and with farmyard manure and are also in agreement with the findings of Ailincăi *et al.* (2007), who obtained higher grain yields with NPK incorporated with farmyard manure in comparison with NPK alone. Highest biological yield might be due to efficient use of available resources for plant and roots because of continued supply of nutrients as well as more water absorption as reported by Jagadeeswari and Kumaraswamy (2000), Swarup and Yaduvanshi (2000).At the same time, table 4.2 shows that highest 1000 grains weight (62.97gm and 55.86gm) was found for TB, TL in FYM and PL, respectively. Among the treatments the lowest value (53.73gm and 47.06gm) was found for TC, TJ of FYM and PL treatments receptively.

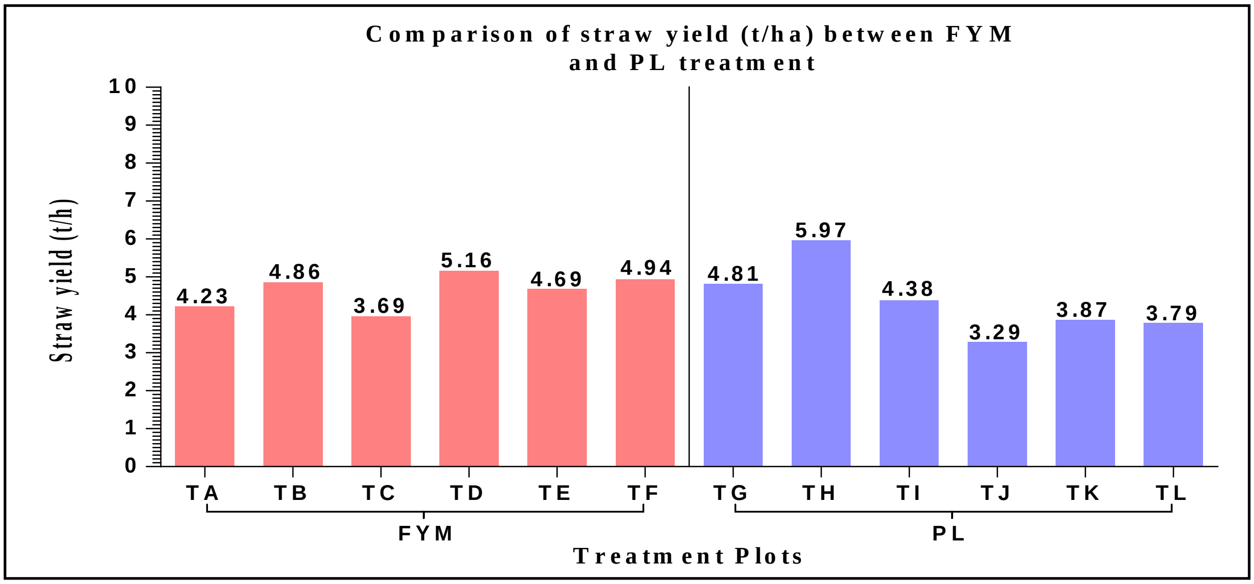


Fig: 4.18. Effect of treatment on straw yield (t/ha)

Table 4.3. Straw yield, Biological yield, 1000 Grains weight and Harvest index for different treatment combinations

Treatment		Straw Yield (t/h)	Biological yield (t/h)	Harvest index (%)	1000 grains weight (g)
FYM	TA	4.23	8.13	47.97	55.12
	TB	4.86	8.96	45.75	62.97
	TC	3.96	8.36	52.63	53.73
	TD	5.16	8.96	42.41	55.54
	TE	4.69	8.39	44.10	56.32
	TF	4.94	8.94	44.74	54.21
PL	TG	4.81	8.61	44.13	51.81
	TH	5.97	9.97	40.12	53.33
	TI	4.38	8.78	50.11	52.82
	TJ	3.29	6.09	45.97	47.06
	TK	3.87	7.77	50.19	51.87
	TL	3.79	7.89	51.96	55.86

4.13. Effect of FYM and PL treatments on biological yield

Sum of grain yield and straw yield are termed as the biological yield of a crop. Biological yield is the total biomass produced by the plant by utilizing available resources. Data indicated significant increase in biological yield per hectare of wheat as a result of application of different organic manures and their combinations by Hammad *et al.* (2010). Our present treatments were found that FYM and PL treatments have a significant effect on biological yield. The biological yield of wheat was measured for each plot and expressed in t/ha. Maximum and minimum biological yield was TB, TD, 8.96 (t/ha) and TH, 8.13 (t/ha) for the treatment FYM and TH, 9.97 and TJ, 6.09 (t/ha) for treatments PL (**Fig: 4.19**), respectively.

Present maximum biological yield was higher than Hammad *et al.* (2010) recommended dose of NPK was applied. These results are corroborating with those of Akhtar *et al.* (1990). Grain yield per hectare is the outcome of collectively contribution of various yield components, which is affected by different growing conditions and crop management practices. Statistical analysis of the data showed that different treatments had significant influence on grain yield of the wheat crop due to different concentrations of NPK in the organic manures.

For example, Result of Youssef *et al.* (2013) as has been explained the results also showed that mineral, organic and bio-fertilizer applications improved the biological wheat yield. These results are in agreement with those obtained by Amin (2003), Sidrak (2003), Khalil *et al*. (2006) and EL-Sayed (2007) they also reported that the amount of irrigation water applied was closely related to the biological yield due to the increases in the plant height, number of grains/spike, single grain weight, grain yield and straw yield which were greatly affected by the soil moisture condition. Regarding the interaction, the maximum and minimum values were better than our present treatments. Analysis of the data revealed that the treatments showed variation on biological yield for FYM and PL plots.

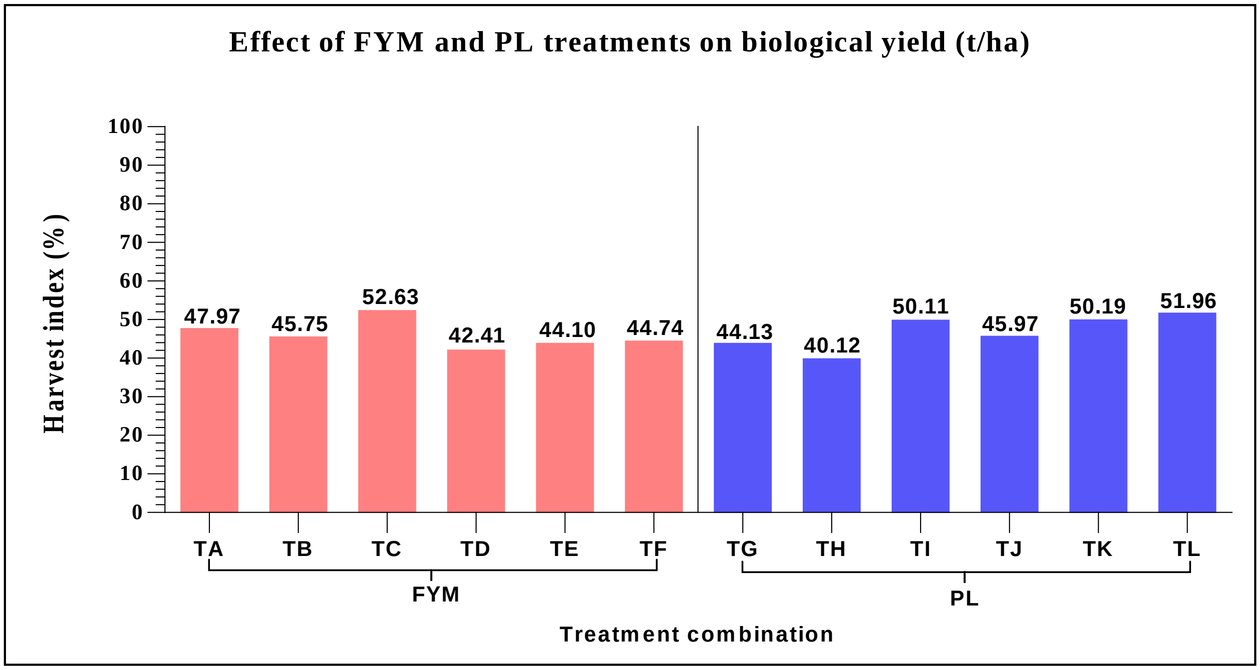


Fig: 4.19. Effect of FYM and PL treatments on biological yield (t/ha)

4.14. Effect of treatments on spike per plant

Spike per plant has no significant variation and were not influenced by different organic matters of FYM and PL with half recommended dose of chemical fertilizers. Maximum spike per plant were found 7.0±0.43 (FYM, TC) and minimum spike per plant were found 6.0±0.29 (FYM, TD). In treatments of PL, spike per plant were found maximum 6.9±0.39 and minimum 6.28±0.33 in TJ and TH, respectively. **Fig: 4.20** represent the spike per plant for different treatment. Statistical analysis of the data revealed that was same as affected by the treatments showed on spike per plant for FYM between PL treatments.

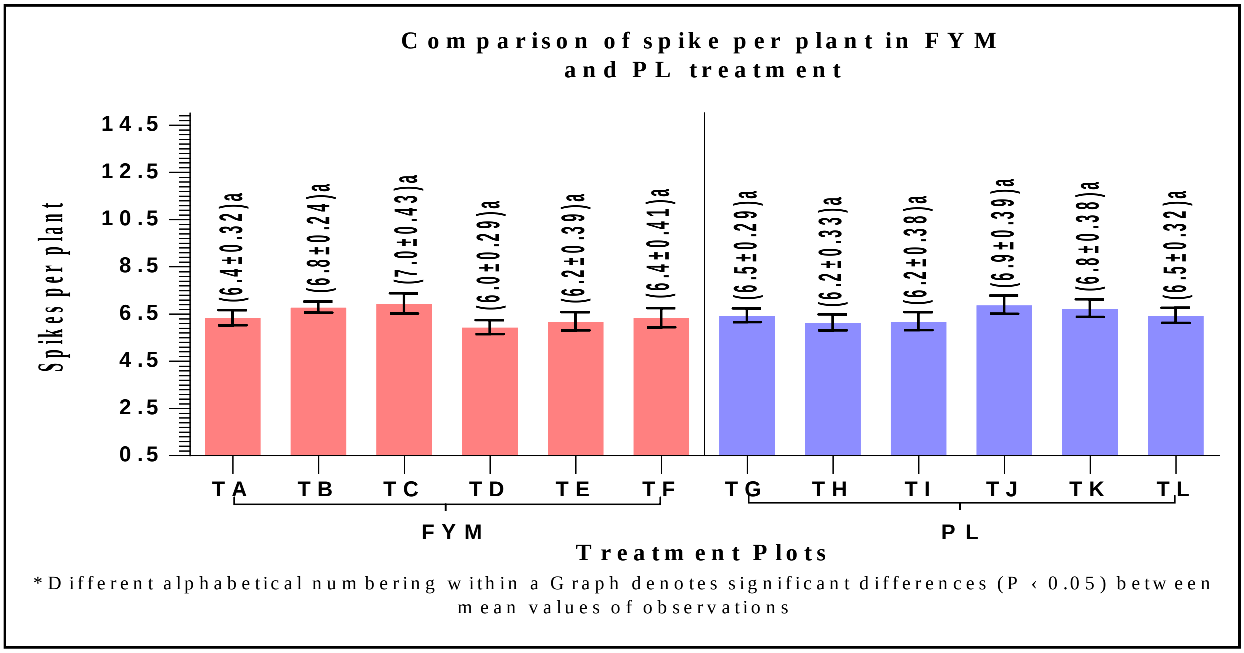


Fig: 4.20. Effect of FYM and PL treatments on spike per plant

4.15. Effect of treatments on weight per spike

The results obtained from the experimental findings showed that different organic matters of FYM and PL with half recommended dose of chemical fertilizers had an effect on weight per spike. It was found that highest and lowest length of FYM (TB, 2.8±0.12gm and TE, 2.1±0.097gm); treatments PL were found (TL, 2.7±0.09gm and TK, 2.4±0.14gm) (**Fig: 4.21**) represent the weight per spike for different treatment. Statistical analysis of the data revealed that the treatments has significantly affected on weight per spike for FYM and PL.

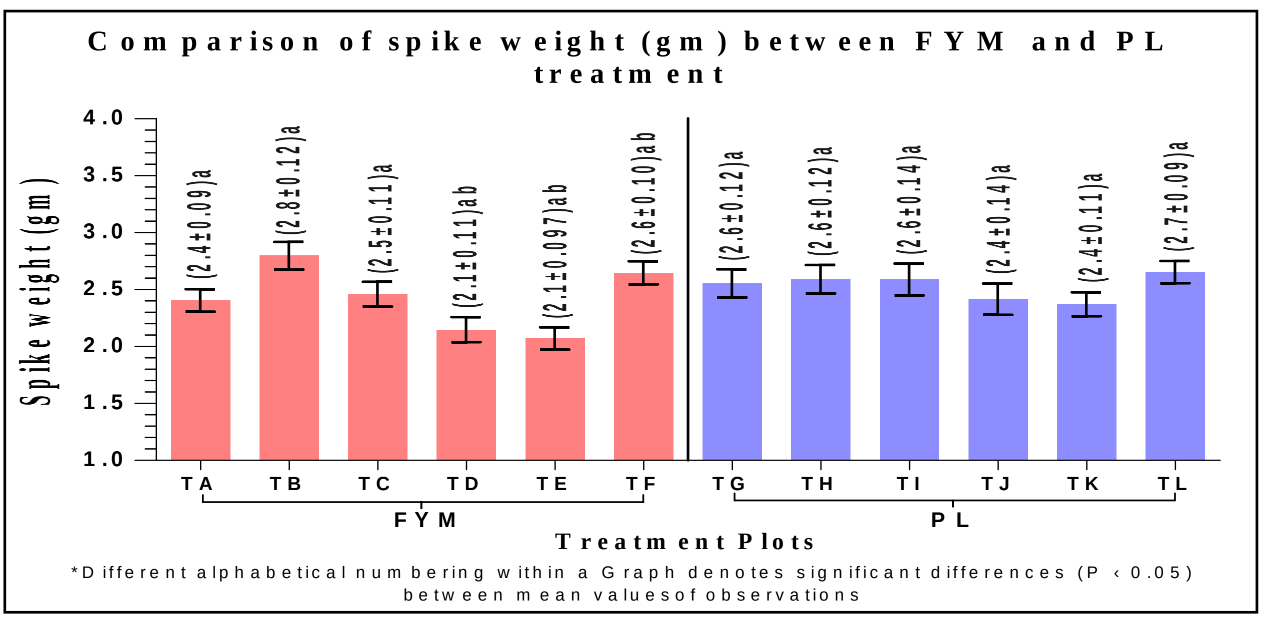


Fig: 4.21. Effect of treatments on spike weight (gm)

4.16. Effect of treatments on gloom size

The results obtained from the experimental findings showed that different organic matters of FYM and PL half recommended dose of chemical fertilizers had an effect on gloom size. It was found that maximum and minimum size of gloom was in FYM (TF, 9.0±0.25cm and TD, 5.5±0.038cm) and in PL (TI, 8.6±0.15cm and TG, 7.0±0.22cm). **Fig: 4.22** represent the gloom size for different treatment. Statistical analysis of the data revealed that it was significantly affected by the treatments showed on gloom size for FYM and PL.

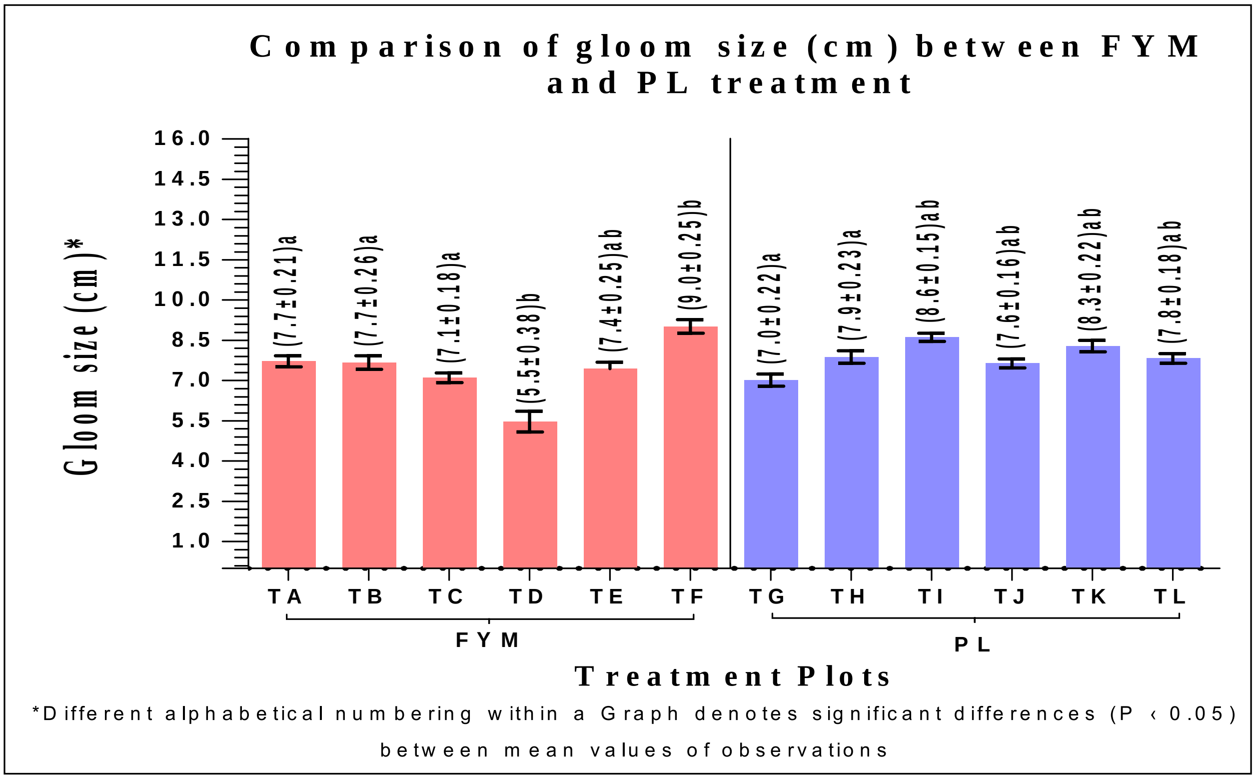


Fig: 4.22. Effect of treatments on gloom size (cm)

4.17. Effect of treatments on grains weight per spike

The results obtained from the experimental findings showed that different organic matters of FYM and PL half recommended dose of chemical fertilizers had an effect on grains weight per plant. It was found that maximum and minimum grains weight per plant of FYM (TB, 2.1±0.10gm and TE, 1.6±0.073gm), treatments PL were found (TL, 2.0±0.82gm and TJ, 1.6±1.1gm). **Fig: 4.23** represent the grains per spike for different treatments. Statistical analysis of the data revealed that it was significantly affected by the treatments within FYM but no significant variation was obtained among PL in our present investigation.

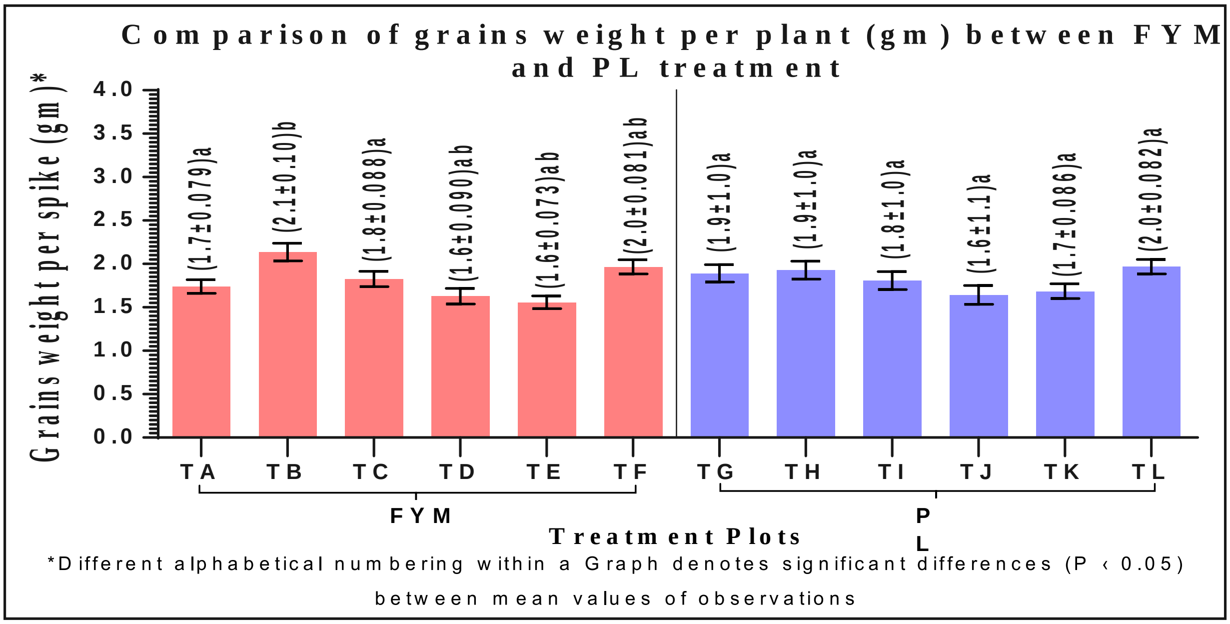


Fig: 4.23. Effect of treatments on grains weight per plant (gm)

4.18. Effect of treatments on husk weight per plant

The results obtained from the experimental findings showed that FYM and PL half recommended dose of chemical fertilizers had an effect on husk weight per plant. Maximum and minimum husk weights were found (TF, 0.68±0.031gm) and (TE, 0.51±0.027gm), respectively in FYM and in treatments of PL were found maximum (TI, 0.78±0.065gm) and minimum (TH, 0.66±0.027gm). **Fig: 4.24** represent the husk weight per plant for different treatments. Statistical analysis of the data revealed that the husk weight per plant for FYM was significantly varied whereas PL treatments were showed no significant variation in the current investigation.

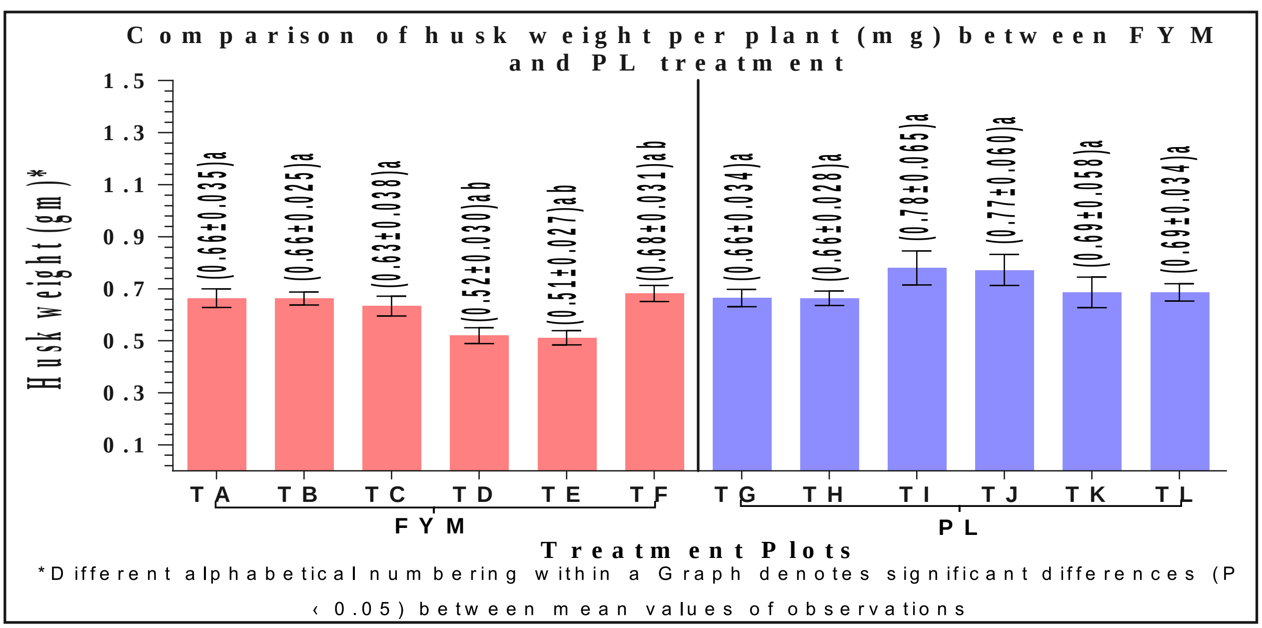


Fig: 4.24. Effect of treatments on husk weight per plant

4.19. Effect of treatments on spike weight m²

The results obtained from the experimental findings showed that level of FYM and PL with half recommended dose of chemical fertilizers had an effect on spike weight m². It was found that, highest and lowest weight of spike FYM (TC, 712gm and TD, 563gm, respectively) and in treatment of PL (TH, 825gm and TJ, 445gm, respectively) (**Fig: 4.25**). Analysis of the data revealed that the treatments showed variation on spike weight m² for FYM as well as for PL treatment in the present research.

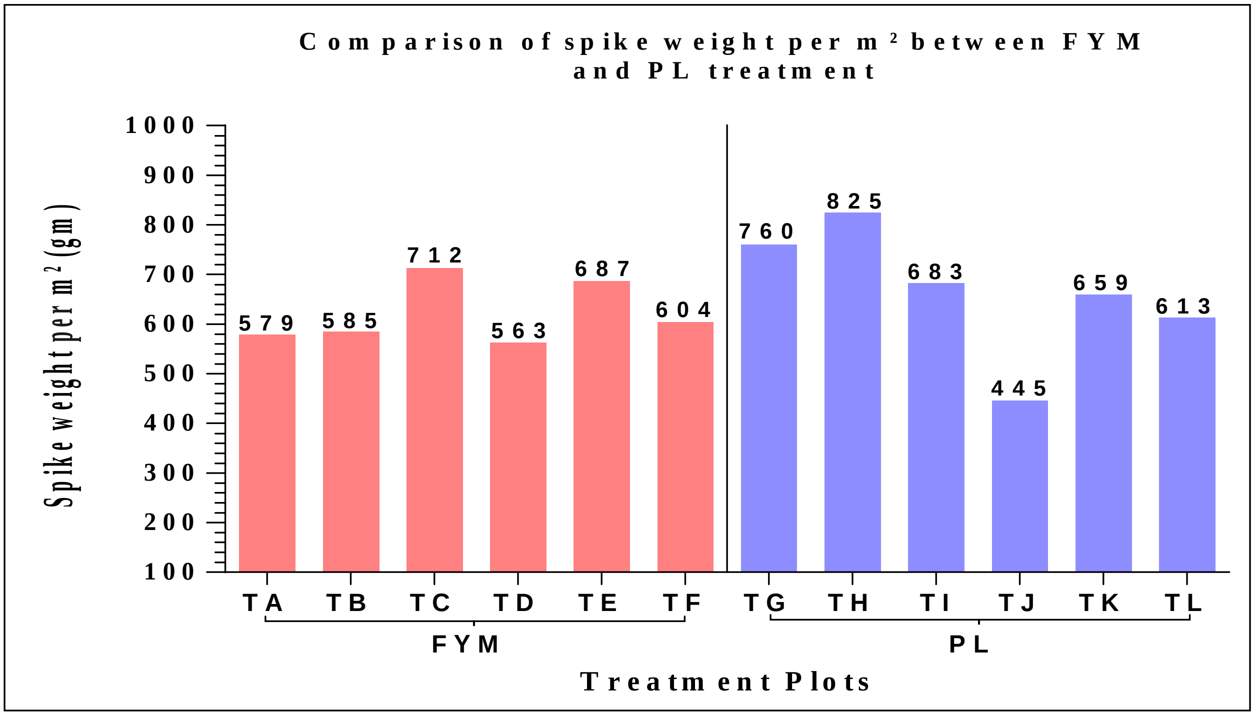


Fig: 4.25. Effect of treatments on spike weight per m²

4.20. Effect of treatments on grains weight m²

The results obtained from the experimental findings showed that level of FYM and PL half recommended dose of chemical fertilizers had an effect on grains weight. It was found that, highest and lowest grains weight m² FYM (TC, 447gm and TE, 377gm), treatment PL (TK, 466gm and TJ, 287gm) (**Fig: 4.26**). Analysis of the data revealed that it was affected by the treatments showed on grains weight m² for FYM and PL treatment in the present experiment.

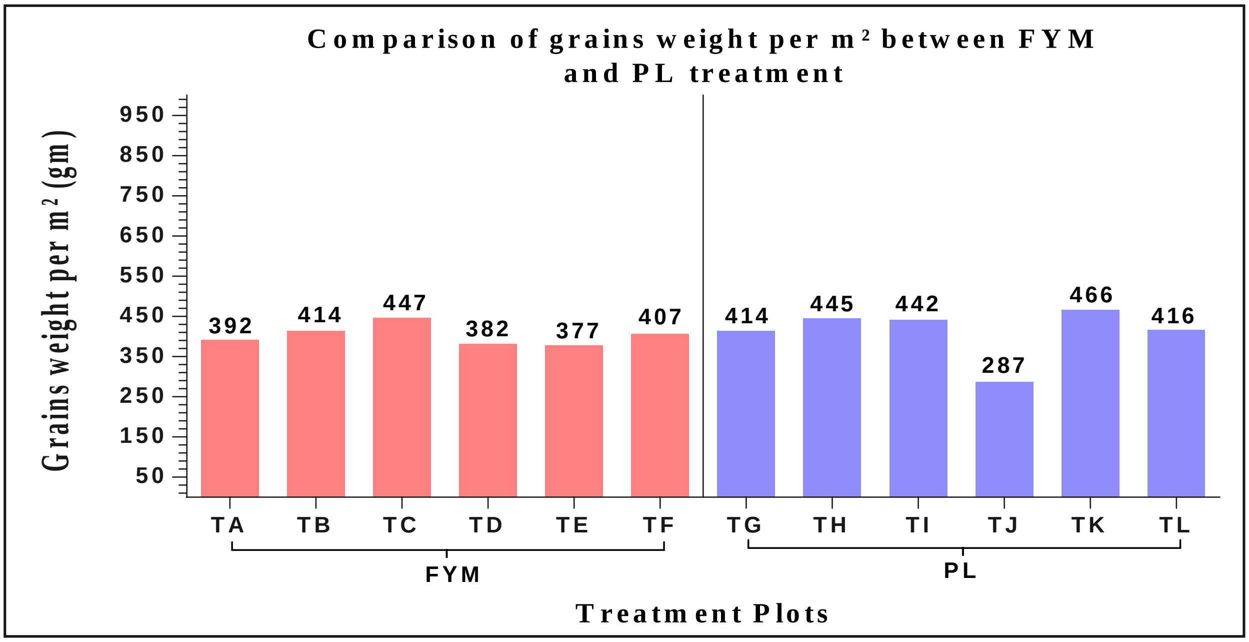


Fig: 4.26. Effect of treatments on grains weight per m²

4.21. Effect of treatments on grain yield of Wheat

Reduced plant productivity due to drought is a major concern for wheat grown in arid and semiarid areas. In these areas, most wheat is grown under rainfed conditions where drought may occur at any time. About 37% of the world wheat is grown in semiarid areas where moisture is the most serious production constraint (Osmanzai *et al.*, 1985). Different organic matters and water holding capacity have a strong effect on production of wheat. From the **Fig: 4.27**, it is shown that maximum yield interaction between FYM and PL treatment has no significant variation, except in PL (TJ, 2.8 t/ha). We found maximum and minimum yield of FYM and PL treatments which were TC, 4.4 t/ha, TE, 3.7 t/ha and TI, 4.4 t/ha, TJ 2.8 t/ha; respectively.

The stress factors especially drought negatively affects plant growth and development and causes a sharp decrease of plants productivity Pan *et al.* (2002). Blum and Pnuel (1990) reported that yield and yield components of wheat varieties were significantly decreased when they received minimum annual precipitation. The effect of drought stress on wheat grain yield may be analyzed yield components, some of which can assume more importance than others, depending upon the stress intensity and growth stage at which it develops Giuntaet *et al.* (1993).

In comparison of other studies, Tanveer *et al.* (2010) examined grain yield of wheat lower than our present treatment. Same as, Shah *et al.* (2006) found that maximum yield of wheat among the lower than our present treatments of FYM. In other view, Pandit *et al.* (2011) examined grain yield of wheat that the highest mean yield were statistically similar but the present treatment were found better than Pandit *et al.* (2011) in his treatment. Analysis of the data revealed that the treatments showed significant variation on grain yield for FYM and PL plots. The worldwide losses in crop yield from water stress exceed the losses from all other classes combined (Kramer, 1980). Even a temporary drought can cause a substantial loss in crop yields and sometimes can amount to many million dollars (Moseley, 1983). Singh and Agarwal (2001), Zeidan and Kramany (2001), Abbas *et al*. (2006), Negi and Mahajan (2000) also reported significant increases in wheat grain and straw yield with addition of organic and inorganic fertilizer.

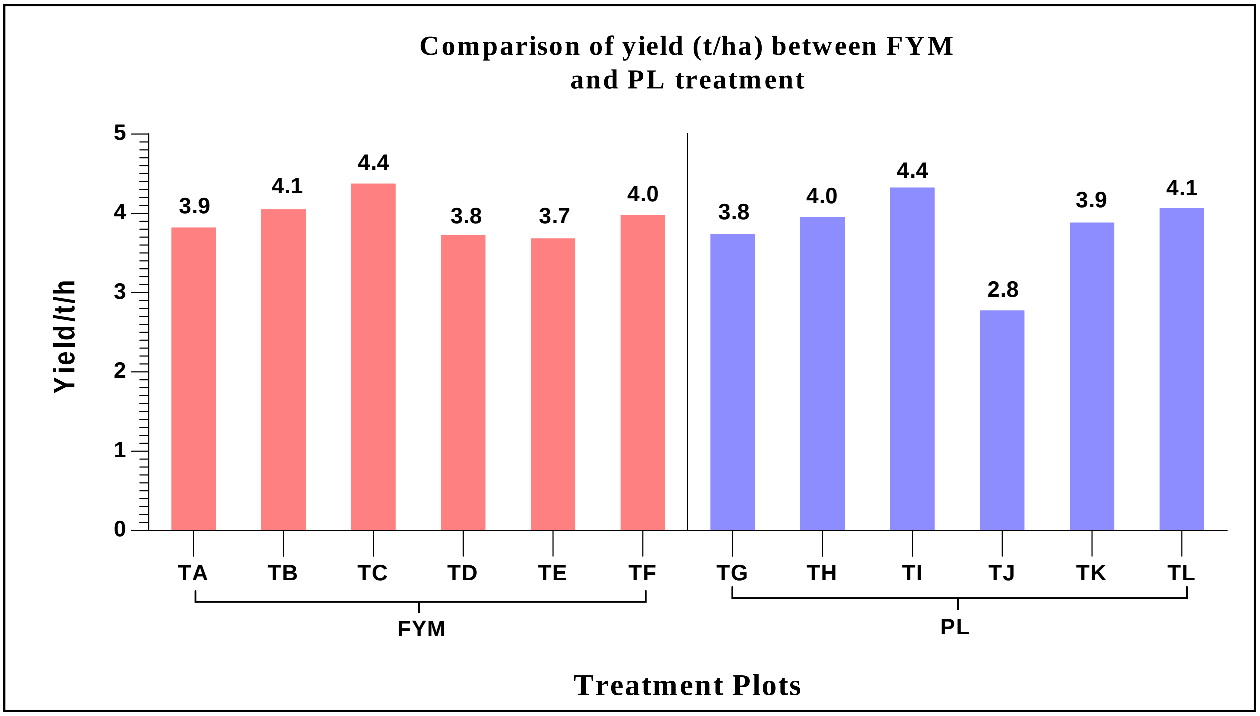


Fig: 4.27. Effect of treatments on grain yield of wheat (t/ha)

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of *"Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN)"* is a collaborative project lead by CARITAS Austria under the supervision of CARITAS Bangladesh, EC Project Number: DCI-FOOD 2010/230-309 at Boraigram, Natore, Rajshahi-6000 during the Rabi season (from 05 Nov 2014 to 15 March 2015) with a view to evaluating the effect of different organic matter (FYM and PL) with ½ recommend chemical fertilizers dose in soil of farmer`s field on wheat (cv. BARI GAM-24) growth, yield and yield attributes in rainfed area. The experiment was designed with two treatments. The experimental plots were laid out with local farmer's practices the three irrigation and tillage for FYM and PL treatments. There were two replications of combination of both the treatments. According to the farmer's practices, FYM and PL treatment was assigned in the mother plot and the two replications were assigned in the different area and different plots on the treatment. The plot size was $400m^2$ except mother plot ($200m^2$). The treatment combinations were T1, Farmyard Manure (FYM @ 3 ton/ha) and T2 Poultry litter (PL @ 3 ton/ha) with ½ recommended chemical fertilizers dose.

Nitrogen, phosphorus, potassium and sulphur were applied as Urea, TSP and MoP. Urea was applied in two equal splits. The first split was applied during final land preparation, the second split at active tillering stage of the crop. All organic manures were applied before final land preparation. A seed of wheat Prodip (BARI GAM-24) @ 120 kg/ha, were sown in the experimental plots on 5th December, 2014 and the crop was harvested at maturity on 15^{th} March, 2015. All the cultural practices were done in time. Twenty plants were randomly selected from each plot for data collection. The recorded data were plant height (cm), tillers per plant (no.), leaf area (cm^2), spikes per plant (no.), spike length (cm), spikelets per spike (no.), spike weight (gm), gloom size (cm), peduncle length (cm), grains/spike (no.), grains weight/spike (gm), spikes/m^2 (no.), grain weight/m^2 (gm), husk weight/spike (gm), weight of 1000 grains (gm), grain yield (t/ha), straw yield (t/ha), and biological yield (t/ha). All the data were statistically analyzed following the (ANOVA) and the mean comparisons were made by statistically insignificant difference ($P > 0.05$) level. The results of the experiment are summarized below:

Plant height, tillers per plant and number of spikelets of wheat (BARI GAM-24) responded significantly to the different treatment combinations of organic matter (FYM and PL) with ½ recommended dose of chemical fertilizers. The highest plant height (TF, 100cm and TI, 106cm) was obtained in FYM and PL treatment, which was significantly higher than all other same plots. The treatment FYM and PL treatment also caused a statistically multi-locational variation of plant height over the treatment plots. The lowest plant height (TD, 97cm) and (TH, 87cm) was observed in FYM and PL treatment. The plant height recorded in FYM and PL treatment was statistically identical. The tiller per plant of wheat (BARI GAM-24) varied between FYM (TC, 7.0 to TD, 6.0) and PL (TJ, 6.9 to TH and TI, 6.2). The highest tiller/plant was observed in FYM treatment. The data of tiller/plant was statistical analysed and showed no significant differences for FYM and PL plots. The number of spikelets per spike obtained was significantly influenced by different organic matters of FYM and PL with ½ recommended dose of chemical fertilizers. Maximum number of spikelets per spike in FYM and PL treatment (TE, 22 and TH, 21 per spike) and minimum number of spikelets per spike for treatments was (TD, 15 and TL, 16 per spike), respectively. The number of spikelets per spike recorded in FYM and PL treatment was statistically identical but we found multi-locational variation in experimental plots. The highest number of spike/m² (TF, 100cm and TI, 106cm) was obtained in FYM and PL treatment, which was significantly higher than all other plots. The results obtained from the experimental findings showed that level of FYM and PL had an effect on spike per m². It was found that, max and min number of spikes in FYM (TC, 295 and TE, 187) treatment and in PL (TL, 237 and TG & TI, 195) was observed in treatment. The number of spike/m^2 in FYM and PL treatment was affected by organic matter and had malti-locational variation on the treatments among the groups. The highest 1000- grains weight of (BARI GAM-24) was (TB, 72.97gm and TL, 55.86gm) observed in FYM and PL treatment. The 1000- grains weight of FYM treatment was statistically higher than PL treatments. The lowest 1000 grain weight yielded in TJ, (47.06gm) was obtained in PL treatment. Analysis of the data revealed that the treatments showed variation on 1000-grains weight for FYM as well as for PL treatment in the present research.

Grain and straw yields of wheat *Prodip* (BARI GAM-24) responded significantly to the different treatment combinations of organic matter (FYM and PL). The highest total grain yield (4.40 and 4.40 t/ha) was obtained in FYM and PL treatment respectively, which was significantly higher than all other sample plots. The treatment of FYM also caused an increased grain yield over the PL plots. The lowest grain yield (2.80 t/ha) was observed in PL treatment. The lowest grain yield (3.70 t/ha) was recorded in FYM treatment. The straw yield of wheat *Prodip* (BARI GAM-24) varied from FYM (3.69 to 5.16) t/ha and PL (3.29 to 5.97) t/ha. The highest straw yield (5.97 t/ha) was observed in PL treatment. The straw yield of FYM treatment was statistically higher than PL treatments. The lowest straw yield (3.29 t/ha) was obtained in PL treatment.

Thus, the results indicate that the grain yield and yield attributes were affected by the use of organic matter (FYM and PL) along with ½ recommended doses of chemical fertilizer in rainfed area. It can be concluded that the use of organic matter improves soil environment over the effect of climate change and it also affect the growth parameters positively which could help farmers to reduce the use of chemical fertilizer. Moreover, the use of organic fertilizer could play role to improve the soil condition in farmland and it will help to retain soil moisture to sustain the production in less water or irrigation in the dry season. It is necessary to investigate further in how this treatments effect in soil quality as well as soil ecology for long term vision.

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