CHAPTER V
DISCUSSION

The present experiment was carried out during summer seasons of 2015 and 2016 and reported with the results on the comparison of different residue management treatments along with varying fertility levels. The main aim of experiment was to develop a sound strategy for wheat residue management and nutrient management through different fertilizer levels for fodder maize. The experimental findings have already been reported in the previous chapter and their discussion in related to the reasoning and justification along with available supporting work done in past on the subject is given here under different appropriate headings as under.

5.1 Effect of weather on crop
5.2 Effect of residue management
5.3 Effect of fertilizer levels
5.4 Interaction effect
5.5 economics

5.1 Effect of weather on crop

The crop growth and development is largely influenced by soil and weather parameters. The data presented in Table 3.3 revealed that the soil of experimental site was clayey in texture, moderately high in organic carbon, low in available nitrogen and phosphorus and medium in potassium, alkaline in reaction with pH 7.3. So, the soil was found suitable for satisfactory growth and development of the fodder maize.

The meteorological data furnished in Table 3.1 and 3.2 revealed that all the meteorological parameters such as temperature, relative humidity, bright sun shine, rainfall and evaporation were quite congenial for satisfactory growth and development of fodder maize during the summer 2015 and 2016. The initial and final plant stand (Table 4.1 and 4.2) were not significantly influenced by the various treatments imposed. Further all the observations are recorded timely without any failure to get the fine results. Thus, whatever variations observed in the investigation are likely attributed to different treatments excised in the experiment.
5.2 Effect of residue management

5.2.1 Growth parameters

The plant height, leaf chlorophyll content, leaf area index, dry matter plant\(^{-1}\) at 30, 45 DAS and at harvest, stem diameter, no. of internodes plant\(^{-1}\), no. of leaves plant\(^{-1}\) at 45 DAS and at harvest and CGR between 30-45 DAS and 45 DAS- harvest were remarkably increased by adopting wheat harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\).

The results revealed that harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\) had favorable effect on growth and biomass production of fodder maize over residue burning. All the growth parameters viz., plant height at 30, 45 DAS and at harvest (Table 4.3, 4.4 and 4.5), no. of leaves plant\(^{-1}\) at 45 DAS and at harvest (Table 4.7 and 4.8), leaf area index at 30, 45 and at harvest (Table 4.9, 4.10 and 4.12), leaf chlorophyll content at 30, 45 DAS and at harvest (Table 4.13, 4.14 and 4.15), stem diameter at 45 DAS and at harvest (Table 4.17 and 4.18), no. of internodes plant\(^{-1}\) at 45 DAS and at harvest (Table 4.20 and 4.21), dry matter plant\(^{-1}\) at 30, 45 DAS and at harvest (Table 4.22, 4.23 and 4.24) and CGR at 30-45 DAS and 45- harvest (Table 4.26 and 4.27) were significantly influenced by wheat harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\) but remained at par with harvesting through combine harvester and straw incorporation in soil + 5 kg \textit{T. viride} + 25 kg N ha\(^{-1}\).

It is the fact that microbial culture along with N might have increased decomposition of residue during that they releases growth factors which plays role in cell division, cell elongation and progressive initiation of tissues and organ differentiation and expansion of component cell thereby enhanced growth parameters like plant height, no. of leaves plant\(^{-1}\), leaf area index and no. of internodes plant\(^{-1}\). These findings are in conformity with those reported by Meena and Singh (2013) and Soleymani \textit{et al.} (2016).

Incorporation of crop residues along with microorganism and supplemental nitrogen dose favours improved soil environment, fertility level and increased nutrient availability which is well reflected by increased stem diameter. These findings are similar to the findings of work done by Rajkhowa and Borah (2008).

Significantly maximum leaf chlorophyll content were recorded with harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam
+ 25 kg N ha\(^{-1}\) (Table 4.13, 4.14 and 4.15). This might be due to fact that microbial species helps to increase in the uptake of nutrient like Zn, Mn, Fe etc from soil. These nutrients play important role in increasing chlorophyll content, also nitrogen increases greenness in plant. It is worth mentioning that, these parameters are closely related to the photosynthesis process in plant. From this background, it is logical to appreciate its contribution in improving chlorophyll content. Similar finding were also reported by Canmak (2008).

Harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\) had significant improvement in dry matter plant\(^{-1}\) at different stages of fodder maize seems to an account of decomposed residues improves soil physical, chemical and biological properties and provides congenial environment for growth of crop in terms of plant height, number of leaves plant\(^{-1}\). Moreover higher leaf area index, resulting higher dry matter production and also CGR. Similar findings were reported by Gul \textit{et al.} (2015).

### 5.2.2 Yield

The results presented (Table 4.30) in preceding chapter showed that wheat harvesting through combine harvester along with madhyam and supplemental nitrogen dose appreciably increased fodder yield of maize.

A close perusal of data on green fodder yield (Table 4.30) indicated that harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\) (R\(_5\)) produced significantly higher fodder yield and it remained at par with treatment R\(_4\) (Harvesting through combine harvester and straw incorporation in soil + 5 kg \textit{T. viride} + 25 kg N ha\(^{-1}\)). Since, yield of crop is a function of several yield components which are dependent on complimentary interaction between vegetative and reproductive growth of crop. A significant increase in green fodder yield under these treatments because, straw incorporation with microbial inoculants leads to faster decomposition of straw, improved the status of soil organic matter, leading to higher uptake of available nutrients from soil and ultimately increased the growth and yield components. The present findings are in close agreement with the results obtained by Singh and Yadav (2006), Shafi \textit{et al.} (2007) and Rajkhowa and Borah (2008).
5.2.3 Quality parameters

Quality parameters like crude fiber content of fodder didn’t influenced perceptibly due to residue management treatments (Table 4.35).

The significant increase in protein content in fodder (Table 4.32) and protein yield (Table 4.33) under harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\) over straw burning has been observed in present investigation. Increased N content in fodder which might be the results of increased availability of nitrogen to plant. Another reason for higher nitrogen content might be due to increased activity of nitrate reductase enzyme. Higher nitrogen content is directly responsible for higher protein because it is a primary component of amino acid which constitutes the basis of protein. Soleymani et al. (2016) also observed similar findings. Whereas protein yield was also found highest because it is directly correlated with fodder yield and protein content and both the parameters showed highest values for that treatment.

5.2.4 Soil moisture content

Soil moisture content before each irrigation (Table 4.36, 4.37, 4.38, 4.39 and 4.40) was maximum under residue incorporated treatments as compared to residue burning and residue removal. This might be due to fact that residue incorporation increased the soil aggregation, increased aggregate distribution and stability, improved infiltration and maximize the profile recharge during irrigation events which directly reflected towards increased moisture content. Similar findings were reported by Govaerts et al. (2008), Fuentes et al. (2009) and Verhulest et al. (2011).

5.2.5 Nutrient content and uptake

The data related to content and uptake of the nitrogen, phosphorus and potassium by fodder maize were remarkably influenced by different residue management treatments. Significantly higher values of N, P and K content in fodder (Table 4.41, 4.42 and 4.43) and N, P and K uptake by fodder (Table 4.44, 4.46, and 4.48) were recorded under harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha\(^{-1}\), which remained at par with with harvesting through combine harvester and straw incorporation in soil + 5 kg T. viride + 25 kg N ha\(^{-1}\). Significantly lower content and uptake of N, P and K in fodder under harvesting through combine harvester and burning the straw.
Residue incorporation can improve physical, chemical and biological conditions of the soil by increasing soil organic matter and available nutrients. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts.

The nutrient uptake is a function of yield and nutrient concentration in plant. Thus significant improvement in uptake of NPK might be attributed to their concentration in fodder and associated with higher fodder yield. This might also attributed to decomposition of straw inoculated with microorganism may release soluble nutrients chelating compounds, which may improve nutrient uptake. The results of present investigation are in close agreements with the findings of Kachroo and Dixit (2005), Yadav et al. (2009) and Pandiaraj et al. (2015).

5.2.6 Effect on soil physical and chemical properties

The concerned data revealed that different residue management treatments significantly influenced to soil bulk density (Table 4.50). Lower bulk density was recorded under the treatment R₄ (Harvesting through combine harvester and straw incorporation in soil + 5 kg T. viride + 25 kg N ha⁻¹), followed by the treatment R₅ (Harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha⁻¹) and R₃ (Harvesting through combine harvester and straw incorporation in soil) which might due to more organic matter from residue decomposition and better root proliferations lead to increased soil porosity. Conversely, the treatment R₂ (Burning of wheat residues) recorded higher soil BD, which can be ascribed to the fact that burning can cause loss of organic matter which in turn decreased soil porosity. The findings are in conformity with those of Surekha et al. (2003), Kachroo and Dixit (2005), Verhulst et al. (2011) and Soon and Lupwayi (2013).

An appraisal of data revealed that residue management treatments caused significant influence on soil organic carbon (Table 4.53). It can be attributed to decomposition of residues by microorganism resulted in formation of organic matter in soil. While, the treatment R₂ (Burning of wheat residues) recorded lower SOC as burning lead to loss of organic matter from soil. The analogous findings are reported by Surekha et al. (2003), Yadav et al. (2009) and Ogbodo et al. (2011).

An evaluation of data revealed that residue management treatments caused perceptible influence on soil available nitrogen, phosphorus and potash (Table 4.54,
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4.55 and 4.56). This might be due to fact that the microbial strains could have decomposed wheat residues and mineralised nutrients. Further it might have solubilised unavailable forms of nutrients into available forms leading to increased status of N and P₂O₅ in soil. Likewise, lower N and P₂O₅ status noticed under the treatment R₂ (Burning of wheat residues) was probably due to residue burning might have reduced nutrient transformation by microorganisms. However, numerically higher soil K₂O was recorded under the treatment R₂ (harvesting through combine harvester and burning the straw). It might be due to residue burning left ash which contain large amount of potassium. The findings are in conformity with those of Lal et al. (2000), Kachroo and Dixit (2005), Singh and Yadav (2006) and Sharma and Jain (2014).

5.2.7 Soil microbial population

An examination of data indicated that fungal colony count (Table 4.57) was significantly influenced by residue management treatments. Significantly the higher count of fungal colonies was observed under the treatment R₅ (Harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha⁻¹) and followed by R₄ (Harvesting through combine harvester and straw incorporation in soil + 5 kg T. viride + 25 kg N ha⁻¹).

Bacterial colony count (Table 4.58) was significantly influenced by residue management treatments, which shows same trend of colony count seen in fungal count. Addition of organic matter owing to residue decomposition by microbial culture like madhyam, T. viride might have favoured proliferation of bacteria and fungi in soil. On the other hand, burning of residues leads to loss of organic matter which reduced population of microorganisms in soil. The findings are comparable with those of Kachroo and Dixit (2005), Govaerts et al. (2008) and Soon and Lupwayi (2012).

5.3 Effect of fertilizer levels

5.3.1 Growth parameters

Growth parameters viz., plant height at 30, 45 DAS and at harvest (Table 4.3, 4.4 and 4.5), No. of leaves plant⁻¹ at 45 DAS and at harvest (Table 4.7 and 4.8), leaf area index at 30, 45 and 60 DAS (Table 4.9, 4.10 and 4.12), leaf chlorophyll content at 30, 45 DAS and at harvest (Table 4.13, 4.14 and 4.15), stem diameter at 45 DAS
and at harvest (Table 4.17 and 4.18), no. of internodes plant\(^{-1}\) at 45 DAS and at harvest (Table 4.20 and 4.21), Dry matter plant\(^{-1}\) at 30, 45 DAS and at harvest (Table 4.22, 4.23 and 4.24) and crop growth rate between 30-45 DAS and 45 DAS- harvest (Table 4.26 and 4.27) were remarkably influenced by fertilizer levels. Significantly highest values of these parameters were observed with the application of 100% RDF. While, significantly the lower growth parameters were recorded under without application of fertilizer.

The improvement in growth parameters with application of 100% RDF might have resulted in better and timely availability of primary nutrients for their utilization by plant. Profound influence of fertilizer on crop growth seems to be due to maintaining congenial nutritional environment on account of their greater availability from soil media. The significant improvement of nutrient status of plant parts might have resulted in greater synthesis of growth promoting substance, which seems to have enhanced the meristmatic activity and increased cell division and their elongation. Further increase in chlorophyll content accompanied with more leaves and leaf area under the application of 100% RDF might have increased interception, absorption and utilization of radiant energy, which in turns increased photosynthesis and their by plant height, stem diameter, no. of internodes, CGR and no. of leaves plant\(^{-1}\). These findings are similar with reported by Khot and Umran (1992), Oad et al. (2004), Arun Kumar et al. (2007), Asghar et al. (2010), Khan et al. (2014) and Baral et al. (2015).

The increase in leaf area index is attributed to increase in leaf area with increasing fertilizer levels might be due to increased amount of cellular constituents, mainly protoplasm (Sheshagiri, 1998) and also due to influence of phytochromes in promotion of cell division and cell multiplication resulting in consistent increase in leaf area per plant and leaf area index. The similar results were obtained by Rao and Padmaraja (1994).

Highest dry matter plant\(^{-1}\) in 100% RDF treatments attributed to vigorous growth of crop in terms of gaining in plant height, higher number of leaves per plant. Moreover higher leaf area index resulting higher dry matter production. Another probable reason, increased dry matter production with fertilizer application was due to role of NPK in determining the use efficiency of sunshine by the increased biomass and if any inadequacy of fertilizer reduces the sunshine use efficiency or ability to
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photosynthesize. Similar results had been reported by Arun Kumar *et al.* (2007), Khan *et al.* (2014) and Gul *et al.* (2015).

### 5.3.2 Yield

The fodder yield (Table 4.30) was appreciably influenced by different fertilizer levels. Fertilizing the crop with 100% RDF significantly turned out higher fodder yield of maize, which was 74.56 per cent higher over without application of fertilizer.

Fertilizing the fodder maize with 100% RDF produced remarkably higher fodder yield. This may probably attributed to NPK being part of the essential nutrients required for the promotion of the meristematic and physiological activities such as plant height, no. of leaves, root development, plant dry matter production leading to an efficient absorption and translocation of water and nutrients, interception of solar radiation and assimilation of carbon dioxide. These activities promote higher photosynthetic activities leading to the production of enough assimilates for subsequent translocation towards sink and hence the production of higher yield. These findings closely associated with those of Jalia *et al.* (2008), Maqsood and Shehzad (2013), Khan *et al.* (2014), Baral *et al.* (2015), Kanduri *et al.* (2016) and Nirmal *et al.* (2016).

### 5.3.3 Quality parameters

Quality parameter like crude fiber content in fodder was not significantly influenced by fertilizer levels (Table 4.35). Protein content and protein yield of fodder maize (Table 4.32 and 4.33) was significantly influenced by fertilizer levels. Application of 100% RDF recorded significantly the highest protein content and protein yield. Significantly lowest protein content and protein yield registered in control. The higher protein content in fodder under 100% RDF as compared to control is due to its dependence on nitrogen content. In the present investigation, higher N content in fodder and subsequently higher N uptake by fodder that supports to enhance protein content under the effect. This could also be explained on the basis of increase in crude protein content was due to fact that P is an important structural component of DNA and RNA. The phosphate group in nucleic acid bridges the RNA or DNA. DNA is the carrier of genetic information and RNAs functions in protein synthesis. Protein yield was also found significantly highest in 100% RDF; might be due to increase protein content and fodder yield. The results of present investigation
are in close agreement with the findings of Almodares et al. (2009), Rashid and Iqbal (2012) and Kanduri et al. (2016).

5.3.4 Nutrient content and uptake

The content and uptake of the nitrogen, phosphorus and potassium by fodder were significantly influenced by different fertilizer levels. Significantly highest values of N, P and K content (Table 4.41, 4.42 and 4.43) and N, P and K uptake (Table 4.44, 4.46 and 4.48) by fodder were exerted with application of 100% RDF. No application of fertilizer to fodder maize reported remarkably lowest N, P and K content and uptake by fodder maize.

Higher photosynthetic activity in plant as evident from increase in biomass accumulation at successive duration and plant height reveals higher availability of metabolites from shoot to root. This might have promoted growth of root as well as their functional activity resulting in higher extraction of nutrients from soil environment to aerial parts.

The uptakes of N, P and K by fodder of maize were increased significantly due to 100% RDF ($F_3$) over control ($F_1$). The nutrient uptake is a function of fodder yield and nutrient concentration in plant. Thus, significant improvement in uptake of N, P and K might be attributed to their respective higher concentration in fodder and associated with higher fodder yield. This might also be attributed to better availability of nutrient in the soil under these treatments. The results of present investigation are in close agreements with the findings of Paramasivan et al. (2010), Rashid and Iqbal (2012), Enjueke (2013) and Kanduri et al. (2016).

5.3.5 Effect on soil physical and chemical properties

The data revealed that different fertilizer levels treatments did not significantly influenced soil bulk density (Table 4.50). Whereas, available N, P$_2$O$_5$ and K$_2$O (Table 4.54, 4.55 and 4.56) were significantly influenced by treatment 100% RDF.

Optimum supply of nutrient through RDF provides congenial environment for crop growth resulted in higher shoot and root biomass production, which may be increases available N, P$_2$O$_5$ and K$_2$O in soil under 100% RDF significantly improved over control. The significant built up of available N and P$_2$O$_5$ status to meet the crop demand. The increment in status of K$_2$O might be due to enhanced mineralization owing to better root growth under this fertility level. The result of present
investigation strongly supports the findings of Panwar, (2008), Singh and Nepalia (2009) and Alliancai et al. (2011).

5.3.6 Soil microbial activity

Total fungal (Table 4.57) and bacterial (Table 4.58) count were observed significantly higher under 100% RDF (F3) as compared to control (F1). This is because application of inorganic fertilizer increased soil organic matter content, resulting in more microbial proliferation, whereas in control no fertilizer application degraded the soil quality and produced a deleterious effect on biological soil environment and ultimately on soil microbial population. The similar results were also earlier reported by Belay et al. (2002), Mahajan et al. (2007) and Okore et al. (2014).

5.4 Interaction effect

The interaction effect of residue management and fertilizer levels was found significant on growth attributes such as leaf area index at 45 DAS (Table 4.11) and dry matter plant$^{-1}$ (Table 4.25) in pooled results and fodder yield kg ha$^{-1}$ (Table 4.31) in both the individual years and pooled results.

Residue incorporation in soil with microbial inoculants and supplemental nitrogen dose along with 100% RDF (R5F3) recorded maximum leaf area index during pooled results. This was due to the fact that combined application of crop residues along with RDF, creates favorable environment for crop growth and increase the availability of nutrients near the active root zone, also applied microbes releases growth chemicals which helps in plant development and vigorous plant growth resulted in increase leaf area index. The similar results were also reported by Vandana et al. (2012).

The interaction effect of harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha$^{-1}$ along with 100% RDF (R5F3) registered maximum dry matter plant$^{-1}$ and fodder yield as compared to harvesting through combine harvester and burning the straw with control (R2F1). The maximum dry matter and fodder yield obtained in residue incorporation with 100% RDF might be due to integration of crop residue inoculated with microbial culture along with RDF accelerated the decomposition of crop residues, which improves organic matter status of the soil, soil health and release the nutrient throughout crop growth period. Similar findings were observed by Singh et al., (2010) and Vandana et al. (2012). On other hand residue burning with no fertilizer application leads to loss of organic
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matter from soil and reduced availability of nutrient for crop uptake resulting lower dry matter and fodder yield.

A data regarding protein yield (Table 4.34) in pooled results found to be significant in treatment receiving harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha$^{-1}$ along with 100% RDF (R$_5$F$_3$). The probable reason behind that, residue incorporation along with microbial culture and inorganic fertilizer increase the availability and uptake of nitrogen which synthesizes the amino acid and it’s a main constituent of protein and also it had synergistic effect on crop yield, which may be increased protein yield.

Residue incorporation and application of RDF to R$_5$F$_3$ recorded significantly higher nitrogen, phosphorus and potassium uptake (Table 4.45, 4.47 and 4.49) by fodder maize as compared to residue burning and no fertilizer (R$_2$F$_1$). This might be due to fact that residue incorporation and fertilizer nutrient application resulted in higher soil nutrient status which the crop utilized efficiently and produced higher yield that leads to higher N, P and K uptake.

Another reason to increase the uptake is attributed to combined application of residues and fertilizer might have enhanced decomposing process residues, thereby releasing the nutrient in quicker time on one hand and reduced immobilization of nutrients. Similar findings were observed by Nedunchezhiyan (2010), Singh et al. (2010) and Vandana et al. (2012).

5.5 Economics

The examination of data (Table 4.59 and 4.60) revealed that maximum gross returns (₹ 65228, 64510 and 64869), net realization (₹ 45556, 44501 and 45029) and B:C ratio, (3.32, 3.22 and 3.27) were obtained in treatment R$_5$ (harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N ha$^{-1}$), followed by the treatment R$_4$ (harvesting through combine harvester and straw incorporation in soil + 5 kg *T. viride* + 25 kg N ha$^{-1}$). The higher gross, net returns and B:C ratio under these treatments are obviously due to higher fodder yield of maize. Whereas, the treatment R$_2$ (Harvesting through combine harvester and burning the straw) has given lower B:C ratio, (2.29, 2.57 and 2.43). This might be due to fact that lowest fodder yield recorded in this treatment reflected directly towards lower B:C ratio. These findings are in vicinity with those reported by Rajkhowa and Borah (2008), Singh et al. (2010), Meena and Singh (2013) and Sepat and Rana (2013).
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The data for gross realization, net realization and B:C ratio (Table 4.59 and 4.60) clearly indicated that treatment F_3 (100% RDF) recorded highest (₹ 63295, 63137 and 63216) gross realization, (₹ 43268, 42774 and 43021) net realization and highest B:C ratio (3.16, 3.10 and 3.13). This might be on account of higher forage yield registered under this treatment. Whereas, lowest gross realization (₹ 46539, 49145 and 47842), net realization (₹ 29701, 31970 and 30836) and B:C ratio (2.76, 2.86 and 2.81) registered under treatment F_1 (control). The reason is self explanatory that lowest fodder yield. Kumar (2008), Rehan et al. (2014), Suthar et al. (2014) and Baral et al. (2015) also reported alike results.