CHAPTER II
REVIEW OF LITERATURE

Maize (*Zea mays* L.) is one of the most important fodder crop of the world. In India maize is traditionally grown during the *kharif* season with high temperature and low and excess rains, creating unfavorable condition for varying length of time during the crop growing season. The cultivation of maize during summer season is becoming a common practice among the farmers where irrigation facilities are available. Agricultural residues have tremendous value for soil and water conservation purposes, plant nutrient cycling and it is a valuable nutrient source for crop production, if it is properly managed. Also maize is better respondent to chemical fertilizer and it is essential for achieving higher productivity and profitability. However, meager information is available on agronomic requirements of fodder maize pertaining to residue management and fertilizer levels in India in general and Gujarat in particular. Efforts are, therefore made to present a brief summary of studies carried out at various places related to the investigation in this chapter. The review has been highlighted under the following broad topics.

2.1 Effect of residue management on growth parameters and yield of fodder maize
2.2 Effect of fertilizer levels on growth parameters and yield of fodder maize
2.3 Effect of residue management and fertilizer levels on quality parameters of fodder maize
2.4 Effect of residue management and fertilizer levels on nutrient content and uptake by fodder maize and soil fertility
2.5 Effect of residue management and fertilizer levels on soil microbial activity
2.6 Interaction effect of wheat residue management and fertilizer levels on fodder maize
2.7 Economics

2.1 Effect of residue management

Crop residues are an essential source and have tremendous value for soil and water conservation purposes, water infiltration, reduced evaporation, increased soil organic matter, soil microbial population, improved soil structure and plant nutrient cycling, decreased erosion, and reduction of some weed population, so sustainability point of view, there must be a judicious application in crop production.
2.1.1 Growth parameters

A field experiment was conducted on wheat by Rajkhowa and Borah (2008) in clay loam soil at Jorhat, Assam. The result revealed that incorporation of straw with cellulose decomposing organism and earthworm culture resulted in increased plant height and highest effective tillers m$^{-1}$.

Soleymani et al. (2016) conducted an experiment on clay loam soil at Iran and result revealed that incorporation of barley residue significantly increases final plant height, stem diameter, LAI, total fresh yield, leaf dry weight, ear dry weight and total dry weight of forage maize.

2.1.2 Yield

Shafi et al. (2007) carried out an experiment on silty clay loam soil at Pakistan and concluded that post harvest incorporation of rice residues significantly increased grain yield and straw yield of maize.

Incorporation of straw with cellulose decomposing organism and earthworm culture resulted in increased grain yield and straw yield of wheat on clay loam soil at Jorhat, Assam, reported by Rajkhowa and Borah (2008)

Mbah and Nneji (2011) conducted field experiment on typic haplustult at Nigeria concluded that maize grain yield was higher in residue treated plot relative to control.

Application of crop residues in sandy loam soil gives higher stover yield over no residue incorporation in pearl millet showed by Amgain et al., (2013) at IARI, New Delhi.

An experiment was conducted on clay loam soil at Faisalabad, Pakistan during spring seasons of 2010 and 2011 by Javeed et al. (2013) and results showed that wheat and rice straw treatment increases grain yield of maize significantly.

Shah et al. (2014) carried out an experiment on clay loam soil at Peshawar Khyber Pakthunkhwa and result revealed that shallow incorporation of crop residues
showed good results in terms of total above ground biomass yield and grain yield of maize.

2.2 Effect of fertilizer levels

Nitrogen, phosphorus and potassium is an primary basic nutrient elements for growth and development, these requires for improving quality, protein content, higher yield and palatability of fodder at optimum proportion, so the research work done on different fertilizer levels on fodder maize has been limited whereas effort has been made to work out optimum fertilizer dose. Available research work was revived as given here.

2.2.1 Growth parameters

Mishra et al. (2001) studied the effect of chemical fertilizer on maize during winter season of 1994-95 on silty loam soil at Faizabad (Uttar Pradesh) and reported that plant height, leaf area index and dry matter accumulation significantly increased with application of 150-60-40 kg NPK ha$^{-1}$ over control.

A long term manurial trial initiated in 1983 at Ranchi (Jharkhand) on winter maize by Pathak et al. (2002). They found that plant height, leaf area index, dry matter accumulation and net assimilation rate significantly increased with application of 100% RDF (100-50-25 kg NPK ha$^{-1}$) over control.

An experiment at National Research Centre, Cairo (Egypt) during two successive seasons of 2002 and 2003 by El-Kholy et al. (2005) on maize and results revealed that application of 100% RDF (100-50-60 kg NPK ha$^{-1}$) though fertilizers were recorded significantly higher plant height (174 cm) in maize as compared to other treatments.

From the result of a field experiment was conducted during 2004-05 on sandy clay loam soil of University Research Farm, Kalyani (West Bengal) on baby corn and result revealed that, an application of 100% RDF (150-60-40 kg NPK ha$^{-1}$) recorded maximum plant height than 75% RDF. Saha and Mondal (2006).

Verma et al. (2006) initiated an experiment during kharif seasons of 2000-01 and 2001-02 at Instructional Farm, Rajasthan Agriculture College, Udaipur.
(Rajasthan). They found that plant height, leaf area index and dry matter accumulation of maize was significantly increased with an application of 135-45-22.5 kg NPK ha\(^{-1}\) over control.

An investigation was carried out at Main Agricultural Research Station Dharwad on vertisols by Arun Kumar et al. (2007). Results revealed that the growth parameters of sweet corn viz. leaf area index and total dry matter production were influenced favourably with increasing level of NPK application.

Kumar (2008) at New Delhi reported that an application of 120 kg N + 26.2 kg P + 41.5 kg K ha\(^{-1}\) (RDF) showed significantly higher leaf area index and test weight in maize over rest of the treatments in sandy loam soil.

A field experiment during pre \textit{rabi} seasons of 2001-02 to 2002-03 on maize at Umiam, ICAR Research Complex for NEH Region Meghalaya by Panwar (2008) and found that an application of 100% RDF gave higher plant height (190.42 cm) over control (91.42).

Onasanya et al. (2009) laid out an experiment to study the growth and yield response of maize to different rates of nitrogen and phosphorus fertilizers in Southern Nigeria during \textit{rabi} 2007. Results revealed that application of 120 kg N ha\(^{-1}\) + 20kg P\(_2\)O\(_5\) ha\(^{-1}\) significantly enhanced leaf area index and stem girth.

Results showed that significant improvement in plant height and leaf area index of baby corn with application of 180-38.7-74.7 kg NPK ha\(^{-1}\) during \textit{kharif} season of 2004-05 at Varanasi (Uttar Pradesh) Singh et al. (2011).

Khaliq \textit{et al.} (2012) planned an experiment during 2000-2002 at National Agricultural Research Centre, Islamabad (Pakistan). They observed higher plant height and number of leaves per plant of maize crop with an application of RDF (100-50-00 kg NPK ha\(^{-1}\)).

Vandana \textit{et al.} (2012) conducted an experiment at Hisar, Haryana showed that application of 125% RDF in sandy loam soil to pearl millet gives significantly highest total number of tillers plant\(^{-1}\), leaf area plant\(^{-1}\) and leaf area duration (days) over rest of the treatments.
An experiment was conducted on maize during kharif 2010 at Udaipur (Rajasthan), by Joshi et al. (2013). The result revealed that an application of 100% RDF (120-60-30 kg NPK ha\(^{-1}\)) recorded maximum plant height (208.5 cm), dry matter accumulation (81.0 g per plant) and leaf area index (2.6) than control.

A field study was carried out at Manakkadavu, Pollachi, (Tamil Nadu) during rabi seasons of 2012 and 2013 on maize by Kannan et al. (2013). They found that application of RDF (120:60:50 kg NPK ha\(^{-1}\)) significantly increased plant height and leaf area index compared to control.

Maqsood and Shehzad (2013) at Faisalabad, Pakistan reported that an application of 150 kg N ha\(^{-1}\) resulted in significant increase in plant height, stem diameter, leaf area plant\(^{-1}\) of maize over rest of the treatments.

A field experiment was conducted by Meena et al. (2013) in sandy loam soil at IARI, New Delhi. Results revealed that an application of RDF (N\(_{120}\)P\(_{25}\)K\(_{35}\) kg ha\(^{-1}\)) recorded significantly highest plant height and leaf area index of maize over the control.

Khan et al. (2014) reported that an application of 180:120 kg NP ha\(^{-1}\) showed significantly more no. of plants per m\(^2\), plant height, no. of leaves plant\(^{-1}\) and leaf area plant\(^{-1}\) of fodder maize at Agricultural Research Farm, Peshawar, Pakistan.

Baral et al. (2015) carried out an experiment on sandy loam soils of Chitwan, Nepal. The result revealed that application of 240:90:60 kg NPK ha\(^{-1}\) gives maximum plant height, ear height, dry matter accumulation and ear length of maize over rest of the combinations.

Application of 90-60-40 kg NPK ha\(^{-1}\) gives significantly highest plant height, leaf area index and dry matter production in rainfed maize, reported by Gul et al., (2015) at Srinagar

### 2.2.2 Yield

Paradkar and Sharma (1994) while working at Chhindawara (Madhya Pradesh) during 1989-90 and 1990-91 on clay loam soil to find out the response of winter maize to different fertilizer levels and noted that grain yield of maize
significantly increased with 150-75-60 kg NPK ha\(^{-1}\) during both the years of the experimentation as compared to control.

A field trial was conducted on winter maize by Pathak et al. (2002) during 1983 at Ranchi (Jharkhand) and found that grain and fodder yield was significantly increased with application of 100 % RDF (100-50-25 kg NPK ha\(^{-1}\)) over control.

Verma et al. (2003) carried out a field experiment during two kharif seasons of 2000 and 2001 on maize at Kanpur (Uttar Pradesh). They concluded that application of 100% RDF (120-60-40 kg NPK ha\(^{-1}\)) recorded significantly maximum grain yield (36.13 q ha\(^{-1}\)) and straw yield (54.57 q ha\(^{-1}\)).

Application of 100% RDF (100-50-60 kg NPK ha\(^{-1}\)) recorded significantly higher grain and straw yields of maize as compared other treatments during two successive seasons of 2002 and 2003 at National Research Centre, Cairo (Egypt) by El-Kholy et al., (2005).

A field experiment was conducted by Iqbal et al. (2006) at Faisalabad, Pakistan on clay loam soil. The result revealed that maize crop (forage) supplied with 150-100-100 kg NPK ha\(^{-1}\) produced significantly the highest forage yield of 58.62 t ha\(^{-1}\) over rest of the treatments.

Jaliya et al. (2008) carried out an experiment on maize at Nigeria. And results revealed that application of 150:26:50 kg NPK ha\(^{-1}\) gave significantly higher cob yield ha\(^{-1}\) and grain yield ha\(^{-1}\) of quality protein maize over control.

Panwar (2008) designed an experiment during 2001-02 and 2002-03 at ICAR Research Complex for NEH Region, Umiam (Meghalaya). He found that application of 100% RDF through fertilizer in pre-winter season maize recorded significantly higher grain yield over control.

While working at Indian Institute of Soil Science, Bhopal (Madhya Pradesh) during rainy seasons of 2005-06 and 2006-07, Ramesh et al. (2008) reported that fertilizing with 100-50-30 kg NPK ha\(^{-1}\) recorded significantly higher grain yield of maize (5122 kg ha\(^{-1}\)) over control.
Onasanya et al. (2009) conducted a field experiment at Southern Nigeria during *kharif* season of 2007 on maize. They revealed that application of 120 kg N ha\(^{-1}\) - 40kg P\(_2\)O\(_5\) ha\(^{-1}\) significantly enhanced grain yield.

Lingaraju et al. (2010) conducted a field experiment at Main Agricultural Research Station, Dharwad (Karnataka) during 2005-06 and 2006-07 and concluded that application of 100 % RDF (100-50-25 kg NPK ha\(^{-1}\)) produced significantly higher maize yield (5578 kg ha\(^{-1}\)) as compared to other treatments.

A field experiment initiated during July- October of 2006-07 and 2007-08 at Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) by Paramasivan et al. (2011) on maize and found that highest grain and straw yields were obtained from the treatment with 250-60-25-10 kg NPK and Zn ha\(^{-1}\) over rest of all.

A field experiment conducted on clay loam soil at Okara, Pakistan; by Rashid and Iqbal (2012). They showed that an application of 55 kg phosphorus ha\(^{-1}\) gives maximum fodder yield of maize (42.18 t ha\(^{-1}\)) over rest of the levels.

Khaliq et al. (2012) designed an experiment during 2000-2002 at National Agricultural Research Centre, Islamabad (Pakistan). They recorded higher straw yield (18349.1 kg ha\(^{-1}\)) produced by maize crop with application of recommended dose of fertilizer (100-50-00 kg NPK ha\(^{-1}\)).

Joshi et al. (2013) laid out an experiment during *kharif* 2010 at Udaipur (Rajasthan) on maize and revealed that an application of 100% RDF (120-60-30 kg NPK ha\(^{-1}\)) recorded maximum values for grain and straw yields than control.

A field study was carried out at Manakkadavu Pollachi, (Tamil Nadu) during *rabi* seasons of 2012 and 2013 by Kannan et al. (2013) on maize. They found that application of RDF significantly increased grain yield (2868 kg ha\(^{-1}\)) over control.

Mahamed and Shirdon (2013) conducted a field experiment on clay soil at Ethiopia; showed that application of 100 kg N ha\(^{-1}\) significantly increased grain and straw yields of maize compared to other treatments.
Meena et al. (2013) was carried out a field experiment on sandy loam soil at IARI, New Delhi, showed that application of RDF (N$_{120}$P$_{25}$K$_{35}$ kg ha$^{-1}$) in maize recorded maximum grain yield and stover yield.

Significantly higher fodder yield of maize was recorded with application of 180:120 kg NP ha$^{-1}$ at Agricultural Research Farm, Peshawar, Pakistan coined by Khan et al. (2014).

A field experiment was laid out at Udaipur, Rajasthan on sandy clay loam soil by Sharma and Jain (2014). They concluded that application of 100% N, P, K, S and Zn significantly improved grain and stover yields of maize over rest of the treatments.

Gul et al. (2015) at Srinagar reported that application of 90-60-40 kg NPK ha$^{-1}$ recorded significantly the highest grain yield and stover yield over control in rainfed maize.

Maximum green fodder yield of maize was obtained with application of 160-50 kg NPK ha$^{-1}$ over control at Latur, Maharashtra reported by Kandhuri et al., (2016).

2.3 Effect of residue management and fertilizer levels on quality parameters of fodder maize

Kamalakumari and Singram (1996) carried out an experiment during 1972 at Coimbatore (Tamil Nadu) on maize and observed that reducing sugar, total sugar, crude protein and total carbohydrates significantly improved with an application of 100 % RDF (135-67.5-35 kg NPK ha$^{-1}$) over control.

Mishra et al. (2001) laid out an experiment during winter season of 1994-95 at Faizabad (Uttar Pradesh). The result revealed that protein content and carbohydrates of maize significantly increased with 100 % RDF (150-60-40 kg NPK ha$^{-1}$) as compared to control.

From the result of a field experiment conducted during 2004-05 on sandy clay loam soil of University Research Farm, Kalyani (West Bengal) by Saha and Mondal (2006) reported that higher protein (1.88 g per 100 g edible portion) in baby corn was recorded under 100% RDF (150-60-40 kg NPK ha$^{-1}$) as compared to 75% RDF.
Ramesh et al. (2008) planned a field experiment during rainy seasons of 2005-06 and 2006-07 at Indian Institute of Soil Science, Bhopal (Madhya Pradesh) and reported that an application of 100% RDF (100-50-30 kg NPK ha$^{-1}$) resulted in significantly higher protein content in maize (9.94 %) as compared to control (8.58 %).

Treatment receiving 200:60:40 kg NPK ha$^{-1}$ recorded significantly the highest protein content (8%) and the lowest soluble carbohydrates (12.80%) and fibre content (31.90%) of corn reported by Almodares et al., (2009) at Isfahan, Iran.

Singh et al. (2011) laid out an experiment on baby corn in kharif season of 2004-05 at Varanasi (Uttar Pradesh). They reported that significantly higher starch, non reducing sugar and sugar content with application of 180-38.7-74.7 kg NPK ha$^{-1}$ compared to other.

Rashid and Iqbal (2012) conducted a field experiment on clay loam soil at Okara, Pakistan, concluded that application of 57 kg P ha$^{-1}$ gave maximum crude protein content, crude fiber content and ash content in fodder maize over rest of the levels.

Among the nitrogen input rates, 150 kg N ha$^{-1}$ responsible for highest crude fat (%), crude protein (%) and crude fiber (%) content of fodder maize compared to other nitrogen treatments at Pakistan, Maqsood and Shehzad (2013).

A study was conducted at experimental area of the Field Crop Department of Cukurova University Turkey in 2010 and 2011 on clay loam soil by Nazali et.al. (2014). They concluded that the highest values of dry matter and crude protein yields (18.3 t ha$^{-1}$ and 1652 kg ha$^{-1}$, respectively) obtained in treatment receiving 100% RDF over rest of the levels.

Suthar et al., (2014) laid out an experiment on clay loam soil at Udaipur, Rajasthan. They observed that application of 90 kg N + 40 kg P$_2$O$_5$ ha$^{-1}$ significantly increased total soluble solid (TSS) content of green grain and protein content and total digestible nutrient content (TDN) of green fodder maize.

Kandhuri et al. (2016) conducted an experiment at Latur, Maharashtra on quality protein maize and results revealed that application of 160-50 kg NP ha$^{-1}$
showed maximum crude protein, crude fibre, ether extract and total ash content over control.

A study conducted in clay loam soils of Iran on forage maize, it was revealed that highest protein percentage was achieved in residue retention as compared to residue burning or removed (Soleymani et al., 2016)

2.4 Effect of residue management and fertilizer levels on nutrient content and uptake by fodder maize and soil fertility

A field experiment planned during 1997-99 in rainy and winter seasons at Ranchi (Jharkhand) by Singh and Sarkar (2001). They investigated that total NPK uptake by maize was significantly higher with application of (210-90-150 kg NPK ha$^{-1}$) over rest of all the fertilizer levels.

Kumar et al. (2003) while working at IARI, New Delhi on maize during 1999-2000 in rainy season and observed that an application of 100% RDF (120-60-00 kg NPK ha$^{-1}$) significantly increased N and P uptake by maize which was markedly reduced with reduction in fertilizer dose.

Recycling of crop residue by incorporation increased organic carbon, total nitrogen content and soil available potassium, also decreases soil bulk density in sandy clay loam soils of Andhra Pradesh reported by Surekha et al., (2003).

An experiment was conducted by Edem et al. (2004) on sandy loam soil at Nigeria showed that residue burning was found to increases bulk density and significantly reduction in total nitrogen content.

Rice residue incorporation and rice residue retention showed significantly lower bulk density and higher organic matter content over rice residue removed on silty loam soil of Faizabad, Uttar Pradesh, Singh and Yadav (2006).

Sahoo and Mahapatra (2007) laid out a field experiment during winter seasons of 2002-03 and 2003-04 at Jashipur (Odisha). They reported that application with 120-26.2-50 kg NPK ha$^{-1}$ recorded significantly highest N (76.9 kg ha$^{-1}$), P (32 kg ha$^{-1}$) and K (127.6) uptake by sweet corn maize over control.
Post harvest incorporation of crop residues in silty clay loam soil gives maximum nitrogen uptake of maize grain and stover, reported by Shafi et al., (2007) at Pakistan.

A field investigation was started during 2001-02 and 2002-03 in pre rabi seasons on maize by Panwar (2008) at ICAR Research Complex for NEH Region, Umiam (Meghalaya) and found that treatment with 100% NPK through fertilizer gave significantly higher available N, P and K over initial status.

Incorporation of rice straw with dual inoculation of cellulose decomposing microorganism and earthworm showed significantly increased uptake of nitrogen, phosphorus and potassium by wheat over the control, reported by Rajkhowa and Borah (2008) at Jorhat Assam.

Ramesh et al. (2008) evaluated a field experiment at Bhopal (Madhya Pradesh) during 2005-06 and 2006-07. They reported that application of chemical fertilizer (100-50-30 kg NPK ha\(^{-1}\)) recorded significantly higher uptake of N (332.2 kg ha\(^{-1}\)), P (90.33 kg ha\(^{-1}\)) and K (343.6 kg ha\(^{-1}\)) by maize as compared to control.

Residue retention on soil improves the organic carbon, total N, moisture; aggregate stability reduces the mechanical resistance and maintains the pH and EC of soil reported by Fuentes et al., (2009) on thermic cumulic halplustoll soils of Mexico.

Singh and Nepalia (2009) conducted an experiment at Rajasthan College of Agriculture, Udaipur (Rajasthan) during rainy season of 2004-05. They reported that application of 100% RDF favorably improved organic carbon content, N and P status of soil over control.

*Trichoderma* inoculation with trash mulch in sugarcane increased soil organic carbon and phosphorus content over their initial content, Yadav et al. (2009) at IISR, Lucknow. Also showed increased uptake of N, P and K content over uninoculated and trash burning treatments.

Fallah and Tadayyon (2010) at Iran showed that increasing the nitrogen dose resulted in a significant higher leaf, stalk, grain and whole plant N uptake in forage maize.
Application of 120-39.3-100 kg NPK ha\(^{-1}\) in maize gives significantly highest N, P and K uptake over rest of the treatments in clay loam soil of Bhubaneswar, Orissa coined by Nadunchezhiyan (2010).

Paramasivan et al. (2010) carried out an experiment on *typic* Haplusteps, at Tamil nadu on hybrid maize and they reported that treatment receiving 250:64:48:4.8 kg N, P, K and Zn ha\(^{-1}\) resulted highest total N, P and K uptake over control.

Application of high rate of mineral fertilizers (N\(_{160}\),P\(_{80}\)) in maize significantly increased soil organic carbon content compared to the unfertilized control in cambic chernozem soil of Iasi (Alliancai et al., 2011).

Mbah and Nneji (2011) studied the effect of different crop residue management techniques on selected soil properties in *typic* hapluatult soil at Abakaliki, Nigeria. Result revealed that in all the treatments, soil pH, organic matter, cation exchange capacity (CEC), available phosphorus and exchangeable bases improved significantly relative to the control.

An experiment was conducted at abakaliki, Nigeria by Ogbodo (2011) on ultisols during 2006-07 and results showed that burning of crop residues significantly reduced pH, organic carbon, cation exchange capacity, total nitrogen content and exchangeable Ca and Mg of the soil.

Singh et al. (2011) was laid out a field experiment at Varanasi (Uttar Pradesh) during *kharif* season 2004-05 on baby corn. They recorded maximum NPK uptake at 180-38.7-74.7 kg NPK ha\(^{-1}\).

Straw retention or incorporation in soil showed optimum values for electrical conductivity, pH and lower sodium concentration. In case of physical parameters, it showed higher mean weight diameter and lower penetration resistance in hyposodic vertisols of Mexico reported by Verhulst et al., (2011).

Vandana et al. (2012) carried out an experiment on sandy loam soil at Hisar, Haryana, concluded that application of 125% RDF gives maximum uptake and content of N, P and K by pearl millet.
Enujeke (2013) conducted an experiment at Nigeria from 2008 to 2010 on maize and reported that plant received nutrition through inorganic fertilizer in the ratio of 20:10:10 @ 450 kg ha\(^{-1}\) had the highest values of (1.74% N, 1.71% P and 0.49% K) content in plant on dry weight basis.

A field experiment was conducted on sandy loam soil at IARI, New Delhi on maize crop during 2010 to 2012 by Sepat and Rana (2013) they revealed that incorporation of crop residues in soil showed lower bulk density in the 0-10 cm soil layer over the control.

Residue burning showed reduction in the available N content, adverse effect on soil structure and labile carbon content on vertisols of Bhopal, Madhya Pradesh, reported by Lenka \textit{et al.}, (2014).

Sharma and Jain (2014) carried out an experiment on sandy loam soil at Udaipur, Rajasthan, showed that an application of 100% N, P, K, S and Zn significantly improved soil status of NPK (kg ha\(^{-1}\)) after harvest of maize.

Crop residue retention increased N uptake in grain by 1.32 times and in straw by 1.62 times in wheat compared with the treatments where residue was removed, reported by Pandiaraj \textit{et al.}, (2015) at GBPUAT Pantnagar.

\subsection*{2.5 Effect of residue management and fertilizer levels on soil microbial activity}

A field experiment was carried out at Ranchi, Bihar on acid soils by Lal \textit{et al.} (2000) concluded that incorporation of the residues of \textit{Lantana camara} tops, \textit{Ipomea cornea} tops, water hycianth, \textit{Karanj} leaves, subabul leaves, lentil straw, maize stover and rice straw significantly increased the populations of aerobic non symbiotic nitrogen fixing, phosphate solublizing and sulphur oxidizing microorganisms.

Belay \textit{et al.} (2002) conducted an experiment at South Africa and concluded that supply of nutrients (NPK) to maize through inorganic fertilizer showed higher bacterial, fungal and Actinomycetes count over control.
Incorporation of crop residues significantly increased microbial population over no residue incorporation on clay loam soil of Jammu and Kashmir (Kachroo and Dixit 2005).

Application of mineral fertilizer to soil gives maximum bacterial \((\text{cfu} \times 10^5)\), fungal \((\text{cfu} \times 10^3)\) and \textit{Azotobacter} \((\text{cfu} \times 10^3)\) count in silty loam soil of Himachal Pradesh given by Mahajan \textit{et al.}, (2007).

An experiment proved that residue retention induced higher population count of total bacteria, fluorescent \textit{pseudomonas} and actinomycetes compared to residue removal conducted by Goverts \textit{et al.}, (2008) on thermic Cumulic Haplustoll at CIMMYT Mexico.

Yadav \textit{et al.} (2009) conducted a field experiment at IISR Lucknow on sandy loam soil. The results revealed that soil microbial biomass increased in the treatment receiving trash with \textit{trichoderma} inoculation over uninoculated and burning of trash.

Incorporation of crop residues in soil showed significantly increased soil microbial biomass, C and B-glucosidase activity over control treatment on silt loam soil of Canada reported by Soon and Lupwayi (2012).

Wang \textit{et al.} (2012) carried out an experiment on fulvo – aquic soil at China revealed that incorporation of crop residues in soil increased count of total microbes, arbuscular mycorrhiza fungi, actinomycetes and \(G^+/G^-\) bacteria ratio.

Okore \textit{et al.} (2014) carried out an experiment at Nigeria, Africa. They concluded that application of fertilizer in the ratio of 20:10:10 showed highest viable bacteria count \((4.5 \times 10^5)\) similar trend was also observed in the viable fungal count \((2.2 \times 10^5)\).

### 2.6 Interaction effect of wheat residue management and fertilizer levels on fodder maize

Magare \textit{et al.} (2009) carried out an experiment in clay loam soil at PDKV, Akola and reported that highest uptake of NPK was observed after three years of experimentation in treatment receiving sunflower straw @ 4 t ha\(^{-1}\) combined with recommended dose of fertilizer in sunflower.
Application of 40 kg N + 10 kg P + 50 kg K ha\(^{-1}\) combined with cowpea residue gives significantly higher grain yield per plant (g), dry matter yield (t ha\(^{-1}\)) and grain yield (t ha\(^{-1}\)) of maize at Tanzania coined by Habonayo et al., (2010).

An experiment was conducted on sandy clay loam soil at Patna, Bihar by Singh et al. (2010) and they concluded that residue incorporation with NPK fertilizer resulted in the highest wheat yield, nutrient uptake, improved residual soil fertility and soil microorganism status.

Javadianfar and Saidat (2013) conducted an experiment in silty clay loam soils at north of Khuzestan province climatic conditions in 2012. Result showed that residue management and fertilizer levels had high significant effect on no. of plants/m\(^2\), grain yield, leaf area and biological yield.

### 2.7 Economics

A field experiment was carried out by Paradkar and Sharma (1994) at Chhindawara (Madhya Pradesh) during 1990-91 recorded significantly maximum net returns (₹13596 ha\(^{-1}\)) with 150-75-60 kg NPK ha\(^{-1}\) as compared to control.

A trial on integrated nutrient management in maize was conducted by Pathak et al. (2002) during winter season of 1983 at Ranchi (Jharkhand) and obtained higher benefit: cost ratio with 100 % NPK fertilizer (100-50-25 kg NPK ha\(^{-1}\)) as compared to control.

Verma et al. (2003) studied the effect of fertilizer on yield and economics of maize during kharif seasons 2000-01 and 2001-02 at Kanpur (Uttar Pradesh). They concluded that application of 100% RDF (120-60-40 kg NPK ha\(^{-1}\)) proved the most beneficial in terms of momentary return and benefit: cost ratio.

A field experiment was conducted during winter seasons of 2002-03 and 2003-04 at Jashipur (Odisha) in sweet corn by Sahoo and Mahapatra (2007) and revealed that application of 120-26.2-50 kg NPK ha\(^{-1}\) recorded significantly higher net profit range of ₹44215- 45952 ha\(^{-1}\) over control.

Application of RDF resulted in the highest net returns and benefit: cost ratio from maize at New Delhi in maize – wheat cropping system (Kumar 2008).
Panwar (2008) carried out a field experiment during 2001-02 and 2002-03 in pre *rabi* maize at ICAR Research Complex for NEH Region, Umiam (Meghalaya). He recorded maximum net profit of 12375 ha\(^{-1}\) and benefit: cost ratio of (1.35) with 100% RDF as compared to control.

An experiment was conducted by Singh *et al.* (2010) at Patna; Bihar the result revealed that incorporation of residues with RDF showed significantly highest net returns and benefit: cost ratio.

Lingaraju *et al.* (2010) planned a field experiment at Main Agricultural Research Station, Dharwad (Karnataka) during *kharif* season 2005-06 and 2006-07. They concluded that application of 100 % RDF (100-50-25 kg NPK ha\(^{-1}\)) noted significantly higher gross returns (₹ 52838 ha\(^{-1}\)), net returns (₹ 39188 ha\(^{-1}\)) and benefit: cost ratio (3.87) as compared to other treatments.

Nadunchezhiyan (2010) at Bhubaneswar, Orissa revealed that application of 120-39.3-100 kg NPK ha\(^{-1}\) in maize gives higher total productivity, productivity efficiency, net return and benefit: cost ratio.

A field experiment was conducted on baby corn at Varanasi (Uttar Pradesh) by Singh *et al.* (2011). They recorded maximum net return and benefit: cost ratio (₹123989 ha\(^{-1}\) and 3.97 respectively) with 180-38.7-74.7 kg NPK ha\(^{-1}\) which was at par with 120-25.8-49.8 kg NPK ha\(^{-1}\).

Joshi *et al.* (2013) carried out an experiment during 2010 in *kharif* maize at Udaipur (Rajasthan). They revealed that application of 100% RDF (120-60-30 kg NPK ha\(^{-1}\)) recorded significantly higher net return (₹ 26600 ha\(^{-1}\)) and benefit: cost ratio (1.84) than control.

Highest net return and benefit: cost ratio was recorded in wheat with application of rice residue mulch treatment which was followed by rice residue incorporation treatment at Varanasi, Uttar Pradesh, reported by Meena and Singh (2013).

From the results of a field experiment conducted at Pulse Research Station, Model Farm, Anand Agricultural University, Vadodara, (Gujarat) during *rabi* season
of the year 2009-10 by Raskar et al. (2013). The results revealed that highest benefit: cost ratio (2.21) was found under application of 160 kg nitrogen ha\(^{-1}\) and 80 kg phosphorus ha\(^{-1}\) in maize over other treatments.

Highest net return and benefit cost ratio was obtained from treatment receiving 300:150:130 kg NPK ha\(^{-1}\) over rest of the treatments, coined by Rehan et al., (2014) at Faisalabad, Pakistan.

Suthar et al. (2014) conducted an experiment in sweet corn at Udaipur, Rajasthan. They showed that the crop fertilized with 90 kg N + 40 kg P\(_2\)O\(_5\) ha\(^{-1}\) recorded significantly higher net returns and B: C ratio over remaining treatments.