CHAPTER - III

Effect of chemical fertilizers on fodder yields from five crops

Green plants requires at least 16 nutrient elements for various metabolic processes, growth, development and differentiation (Vaidya and Sahastrabuddhe, 1979). These elements are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, iron, manganese, zinc, copper, molybdenum, boron and chlorides. The first three elements namely carbon, hydrogen and oxygen are supplied by water and atmospheric carbon dioxide. The remaining 13 elements are taken up by plants from the soil, out of which nitrogen (N), phosphorus (P) and potassium (K) are used in large quantities and hence known as primary elements. In agriculture, these three elements are supplied through fertilizer application and thus these are known as fertilizer elements (Motsara and Singh, 1981). As most of the agricultural lands are deficient in either N, P or K, the land is made productive by adding fertilizers.

Most of the agricultural lands in Marathwada region are deficient in nitrogen, limiting in phosphorous and adequate in potassium. Under such situation it is imperative to supply large amount of nitrogen along with phosphorous to increase the productivity of crop plant (Venkateshwarulu, 1981).
Among the three fertilizer elements nitrogen (N) is viewed as a central element, because of its role in protein and nucleic acid metabolism which is responsible for the formation of living material. Nitrogen alone governs the yield of crop in agriculture (Cooke, 1967). It affects the productivity of plants through enhancement in biochemical, physiological and morphological processes. Adequate supply of nitrogen increase plant photosynthesis which support greater assimilation of other element resulting into increased yield (Novoa and Loomis, 1981). It makes plant dark green and succulent, promotes vegetative growth and increase absorption of other nutrients like phosphorous (P), potassium (K) and calcium (Ca).

The organic nitrogen (N) constitutes 1.5 to 5 % of the plant dry weight and in higher plants; 80 to 90 % of it is in protein. Extensive literature has accumulated on the effect of fertilizer nitrogen (N) on yields of dry matter and crude protein from various fodder species cultivated at different locations. Research in this laboratory have shown that large yields of dry matter and protein could be obtained from non-leguminous crops, particularly in tropics due to the application of fertilizer nitrogen (Deshmukh et al., 1974; Gore et al., 1974, Mungikar et al., 1976, Dakore and Mungikar, 1985, Dakore et al., 1985, Reddy and Mungikar, 1985-86, Dakore and Mungikar, 1991, Patil and Mungikar, 1991, 1992, Bhuktar and Mungikar, 1998, Mungikar, 1999). All these studies were undertaken with large decreasing of nitrogen fertilizer on the yield of popular fodder crops of Marathwada region.
During present research project attempts were made to study the effect of nitrogen (N) fertilizer application on growth and fodder productivity of maize and *Sorghum* and that of phosphorus (P) on *Phaseolus* and *Dolichos*. In addition, the effect of N and P along with potassium (K) on wheat was also studied for investigations on growth. The experiments were undertaken in the pots, while for yield measurements field experiments were conducted.

**EXPERIMENTAL**

During pot experiment several pots of 25 cm diameter were filled with the soil collected from University Botanical Garden. Fifteen pots were employed for each experiments comprising of 5 treatments and 3 replicates. The given experiment was simultaneously repeated by adding Farm Yard Manure (FYM) to each pot at a rate of 250 gm per pot. For the first two experiments maize and *Sorghum* were selected to observe the effect at the rate of 0, 150, 300, 450 and 600 mg N/pot applied through urea. For another experiment, either *Dolichos* or *Phaseolus* were selected to investigate the effect of P\(_2\)O\(_5\) at a rate of 0, 150, 300, 450 and 600 mg/pot. In one of the experiments, 20 pots filled with only soil (without FYM) were employed to investigate the effect of five fertilizer treatments replicated 4 times. The five fertilizer treatments were N (300 mg/pot), P (300 mg P\(_2\)O\(_5\)/pot), NP (150 mg N and 150 mg P\(_2\)O\(_5\)/pot) and NPK (150 mg N, 150 mg P\(_2\)O\(_5\) and 75 mg K\(_2\)O/pot).
Table 1 gives details of sowing and harvesting dates along with information on fertilizer application. The sowing was done by dibbling and after emergence extra seedlings were removed to maintain uniform plant population of 5 plants/pot in case of maize, Sorghum, Phaseolus, Dolichos, while 10 in case of wheat. The fertilizers were applied in three equal split doses, and the plants were raised under irrigation in glass house located in the University Botanical Garden.

Data on height of the plants and number of leaves were recorded before harvesting. The Dolichos and Phaseolus plants were carefully separated from the soil, washed with water and number of nodules per plant were measured. The above ground biomass or the shoot portion comprising of the stem and leaves was separated and its yield per pot was recorded for each crop. The plants were dried in oven at 95°C till constant weight for determination of per cent dry matter (DM). On the basis of the yield of foliage per pot and per cent dry matter in the foliage, the dry matter (DM) yield per pot was calculated.

The dry samples obtained from each pot were ground to a fine powder and employed for the estimation of nitrogen (N) by microKjeldahl method. Using data on the yield of dry matter per pot and N % of DM, the accumulation of nitrogen (N) per pot was calculated.

**Agronomy and field techniques**

The crops were cultivated on the research farm of Dr. Babasaheb Ambedkar Marathwada University, Botanical Garden. A piece of land was
prepared by ploughings and cross ploughings. For each crop the land was divided into 12 equal plots measuring 9.30 m$^2$ of land area. The five crops viz., Maize (*Zea mays* L. var. African tall), *Sorghum* (*Sorghum tricolour* (L) Moench var. Maldandi), Wheat (*Triticum aestivum* L. var. 2189), *Dolichos* (*Lablab niger* Medicus syn. *Dolichos lablab*) and *Phaseolus* (*Phaseolus* L.) were cultivated during present study. The sowing was done 30.5 cm apart in rows. Details of the cultivation practices are given in Table 2 which gives data on duration of the crops and amount of fertilizer applied. The seed rate used was slightly higher than that recommended for grain production, as the crops were cultivated for the production of foliage.

All crops received fertilizer treatment through urea, single super phosphate and Saphala (18 : 18 : 10). Each treatment was replicated three times in randomised block design (RBD). The four fertilizer nitrogen treatment received by maize and *Sorghum* were 0, 20, 40 and 60 kg N/ha, while *Phaseolus* and *Dolichos* received 0, 15, 30 or 45 Kg P$_2$O$_5$/ha. Wheat received 36 kg/ha N or P$_2$O$_5$, 15 kg N/ha + 15 kg P$_2$O$_5$/ha, or 15 kg N, 15 kg P$_2$O$_5$ and 10 kg K$_2$O/ha. The fertilizers were applied in three equal split doses. All crops received first dose 15 days after sowing while the remaining doses were given after every 15 days.

The crops were cultivated under irrigation and the use of insecticides and pesticides were avoided. The weeds were irradiated twice by hand weeding.
Sampling

The crops were harvested for green fodder on the dates given in table 2. Net size of the plot harvested was 8.25 m$^2$. The harvesting was done with steel cutter early in the morning and the yield of green fodder was recorded. A sample of fresh green produce was brought into the laboratory for estimation of dry matter (DM) and crude protein (CP).

Analysis

The sample of green foliage was chopped into 2-3 cm pieces and allowed to dry to a constant weight at 90 ± 5$^o$C for the determination of dry matter (DM). The dried samples were ground to a fine powder and used for the estimation of nitrogen. The nitrogen (N) content was determined by microKjeldahl method which involves digestion of the material with H$_2$SO$_4$ in presence of catalyst (9 K$_2$O$_4$ + 1 CuSO$_4$ + 0.025SeO$_2$) and distillation followed by titration of the liberated ammonia with acid (Bailey, 1967). The crude protein was expressed as N x 6.25.

Calculations:

The yield of green fodder, Dry matter and crude protein were calculated as Kg/ha with the help of net size of plot harvested, yield of green foliage / plot and dry matter (DM) and crude protein (CP) content in the foliage.

The data were analysed by standard statistical methods, following Panse and Sukhatme (1978) and Mungikar (1997, 2003) and the values for critical difference (CD) and ‘F’ were calculated. The data was also
processes to calculate correlation coefficient (r), between fertilizer nitrogen or phosphorus applied (X) and the yield received (Y). In addition, the data were fitted in a quadratic function using fertilizer applied as parameter X and the yield as parameter Y. The equation was in the form of:

\[ Y = a + bX + cX^2 \]

Where a, b and c are the constant values while Y indicated the yield and X the amount of N added. The equation was computed by solving following set of simultaneous equation:

\[
\begin{align*}
\sum Y &= na + \sum Xb + \sum X^2C \\
\sum XY &= \sum Xa + \sum X^2b + \sum X^3C \\
\sum X^2Y &= \sum X^2a + \sum X^3b + \sum X^4C
\end{align*}
\]

The optimum dose of nitrogen was worked out by the following equation (Mungikar, 1974), since the economic dose depends on the cost / price ratio of input and output.

\[
N_{opt} = \frac{b(p-q)}{2cp}
\]

Where

i) q is the cost of unit N fertilizer, which was worked out as Rs. 12.10 per kg of fertilizer N,

ii) P is the price per quintal of fresh vegetation, which was considered as Rs.153/-, Rs.345 / per quintal of green fodder obtained from maize, Sorghum respectively and

iii) b and c are constants.
RESULTS AND DISCUSSION

Crop: maize

From 1-8-2003 to 24-9-2003

The African tall variety of maize which was selected for cultivation during present investigation showed favourable growth. The results obtained during pot experiment are presented in Table 3 and Fig. 1 in the form of histogram. During this experiment Nitrogen fertilizer was applied to the crop in the pots along with or without FYM. In untreated pots the height of the plant was 38.9 cm which gradually increased to 70.1 cm due to the application of nitrogen at the rate of 60 mg/pot. When FYM was added to the soil the height of maize plant was 79.2 cm without fertilizer application which increased to 105.6 cm with 450 mg of nitrogen added per pot. On an average application of FYM along with nitrogen fertilizer significantly increase height of plant.

The number of leaves per plant raised from 5.2 to 5.8 in the pots which received only fertilizer nitrogen while fluctuated between 5.8 and 6.8 due to the application of FYM along with fertilizer nitrogen. Thus FYM was also responsible for increasing number of leaves / plant. The fresh weight per plant increased from 11.6 to 35.5 gm due to the application of 450 mg N / pot. Application of FYM significantly increased the fresh weight of the plant from 15.5 to 48.8 gm, when the pots received 600 gm nitrogen. It was interesting to note that when 600 mg of nitrogen was used, the fresh weight of the plant increased from 24.9 to 48.8 gm due to the use
of FYM. Similar trend was observed when dry weight per plant was considered as a growth parameter. The effect of FYM was found to be more pronounced under the influence of fertilizer nitrogen.

Nitrogen content in the dry matter of leaf marginally increased from 1.25 to 1.33 % due to the application of fertilizer nitrogen alone, while it increased from 1.33 to 1.66 % of dry matter in the presence of FYM. Thus application of FYM not only increased height and biomass of the plant but also improved nitrogen content in leaf. Table 3 also gives an account on the amount of nitrogen accumulated by maize which indicated that application of FYM along with urea is more beneficial. The results indicated improvement in efficiency of using nitrogen when the plants were cultivated with FYM.

Table 4 gives an account on yields of maize. Application of fertilizer nitrogen increased dry matter content of the plant with little variation in nitrogen content of the leaf when nitrogen was applied at a rate of 40 kg N/ha. Application of 60 kg N/ha slightly decreased dry matter content with an increase in nitrogen percent of dry matter. The data on dry matter and nitrogen content clearly indicated that application of fertilizer nitrogen at a rate of 60 kg N/ha was effective. The yields of green fodder, dry matter, crude protein were 14705, 1253 and 120 kg / ha, when the plots did not received any fertilizer nitrogen. Application of nitrogen gradually increased the yields to 31204, 3131 and 340 kg / ha which was statistical significant. The yields of maize recorded during present investigation where higher than
those recorded by Bhuktar and Mungikar (1998), while lower than these recorded by Patil and Mungikar (1991). Bajwal et al. (2002) also noticed that fertilizer amendment increase the yield of maize. Oad et al., (2004) reported that almost all growth character of maize are affected significantly due to the application of FYM and nitrogen in respect of tall plants, green leaves and higher fodder yields. The results are illustrated in Fig. 2 in the form of histogram while in Fig. 3 in the form of growth curve. The optimum dose of nitrogen for maximum fodder productivity was calculated as 119.8 kg N/ha. Nehra et al. (1981) worked it as 103 Kg/ha, Patil (1999) as 97 kg/ha, while Bhuktar (1995) as 73 kg /ha. The higher optimum dose recorded during present investigation might be due to higher price of green fodder as well as low fertility status of the soil at the experimental site.

The efficiency of fertilizer nitrogen of maize was calculated and given in table 5. the crop used fertilizer or nitrogen more efficiently (79.5%) at lower dose of nitrogen. The efficiency decreased with increase fertilizer nitrogen application and it was 58.6% with 60 kg N/ha. The results are in agreement with a those recorded by Mungikar (1974), Bande (1989), Dakore (1985) and Patil (1999). The regression equations obtained for various yield parameters are given in table 6 along with correlation coefficients (r), which indicates significant positive correlation between the application fertilizer nitrogen and yields of green fodder, dry matter and crude protein. Table 6 also gives observed and expected yields, which are in agreement with each other. The over all results presented in table 3 – 6 and
Figs. 1 - 3 indicates that maize is highly productive fodder crop, the yields of which increases with the application of fertilizer nitrogen. The pot experiments indicated the use of FYM along with nitrogen for higher productivity of green fodder. The results suggested a need for field experiments with FYM to confirm finding reported during pot experiments.

**Crop : Sorghum**

**From 1-8-2003 to 2-10-2003**

The results obtained during pot experiment are presented in Table 7. The height of Sorghum plant was 39.6 and 54.8 cm when the pots did not received any chemical fertilizer. The difference in the height was mainly due to the amendment of FYM. Application of fertilizer nitrogen significantly increased height of plant to 67.00 cm without FYM, while 78.2 cm with FYM. On an average the effect of FYM on height of Sorghum plants was not as satisfactory as was found with maize. Though, fertilizer nitrogen application increased the number of leaves per plant, application of FYM showed very little influence on the number of leaves per plant. The fresh weight of the Sorghum plant significantly increased with the application of fertilizer nitrogen and the increase was more pronounced due to the application FYM in combination with fertilizer nitrogen. The same was true with a dry weight per plant. Both fertilizer nitrogen and FYM contributed to N% of dry matter which increased from 1.69 to 1.74% due to fertilizer application. Sorghum plant accumulated high proportion of nitrogen in the plant due to increased dry matter rather than N% of dry
matter. Data presented in Table 7 is also illustrated in Fig. 4 in the form of histogram. The overall results obtained with Sorghum showed slightly different trend than that observed with maize. Maize responded better in the presence of FYM while fertilizer nitrogen played significant role in case of Sorghum for favourable growth.

The results obtained on the yields of green fodder, dry matter and crude protein are presented in Table 8 and Fig. 5 in the form of histogram. Application of fertilizer nitrogen did not effect dry matter content of the leaf, which fluctuated between 15 to 16%. The N% of dry matter however, increased from 1.38 to 1.74 due to the application of fertilizer nitrogen. A significant increase in the yield from 7890 to 14346 kg/ha dry mater and 103 to 223 kg/ha for crude protein was recorded due to the application 40 kg N/ha. Application of nitrogen above this dose reduced the yields under investigation. Thus the application of fertilizer nitrogen above 40 kg/ha was not found beneficial. The data presented in Table 9 is also illustrated in Figure 6 in the form curve. The optimum economical dose for Sorghum was calculated as 30.5 kg/ha which was lower than recorded by earlier workers. The efficiency of nitrogen fertilizer use for fodder production in Sorghum decreased 88.9 % with 20 kg N/ha to 30.2 % with 60 kg N/ha. Sorghum thus used fertilizer nitrogen more efficiently when applied at lower level probably due to its drought resistant nature. Under such situation application of FYM may prove useful for which filed trials are necessary. Table 10 gives the regression equations for various fields parameters of
Sorghum. As the values of ‘r’ where not significant for all yields parameters, the response of nitrogen to Sorghum in absence of FYM was same or low. The overall results obtained of Sorghum does not indicated its suitability as a fodder crop, the fertilizer management should be carefully planned for higher and economically fodder production.

Crop: Phaseolous (Mung)

From 16-9-2003 to 30-11-2003

Phaseolus or mung is an important pulse crop of this region which is mainly cultivated for tender pods and grains. Its cultivation for fodder has also been recommended particularly under rainfed condition (Rahudkar, 1965). The fresh foliage is nutritious and palatable feed to the livestock. The crop was selected to evaluate the effect of graded levels of P$_2$O$_5$ on the fodder yield from this crop plant.

The results obtained during pot experiment are given in Table 11 wherein 5 plants of Phaseolus were cultivated in each pot comparing of soil alone or along with FYM, to which P$_2$O$_5$ was added through single supper phosphate. The height of plant was 18.6 cm in the pots which did not received P$_2$O$_5$. It significantly increased within the range of 24 to 26 cm due to the application P$_2$O$_5$. The pots containing FYM along with the soil supported growth of the plant which were 19.3 cm tall. An increase in the height within the range of 20.5 to 25.0 cm was observed. On an average FYM had no influence on height of the plant, which decreased from 24.0 to 21.8 cm. The number of leaves per plant increased due to the application of
P₂O₅ at the rate of 150 mg per pot from 8.9 to 13.0. However, increase in the amount of phosphorous fertilization led to decrease in the number of leaves to 9.0. Application of P₂O₅ along with FYM showed almost negligible effect and on such pots the number of leaves fluctuated between 9.00 and 10.4. On an average the FYM treated plants showed reduced number of leaves. The root length remained almost stable due to the application of P₂O₅ particularly in the presence of FYM. The FYM thus had no effect on root length of the plant. Though application of P₂O₅ increased the number of nodules per plant, it was not so when the soil was amended with FYM. On an average there were 32.8 nodules per plant which decreased to 20.0 in presence of FYM. The decreased nodulation in the presence of FYM was due to the available nitrogen content in the manure which was sufficient for growth of the plant. The fresh weight increased from 2.5 to 4.4 gm per plant due to the application of 300 mg P₂O₅ per pot, while from 3.1 to 5.0 when FYM was used. The overall results showed very little effect of FYM on fresh weight of plant. Somewhat similar trend was observed with dry matter per plant under the influence of FYM and P₂O₅. The nitrogen content in the plant increased due to the application of P₂O₅ which was more pronounced in the presence of FYM. The yield of nitrogen per plant was higher in the plant treated with P₂O₅ as well as FYM with a maximum value of 59.4 mg N/plant when the pots received 300 mg P₂O₅ along with FYM. Data presented in Table 11 is also illustrated in Fig. 7 in the form of histogram.
The overall results indicated that the plant requires moderate amount of P$_2$O$_5$ for its better growth. The data further revealed that application of FYM was not beneficial for growth of plant, though it increased the productivity of the plant to some extent.

The results obtained during field trail supported the findings reported while the experiments undertaken in pots. Application of P$_2$O$_5$ did not alter dry matter (DM) content of the crop which raised from 20 - 21 per cent. The application of P$_2$O$_5$ however, increased nitrogen content in leaf from 2.66 - 3.52 percent of dry matter. Though marginal increase in the yields of green fodder, dry matter and crude protein was observed at lower doses, the yields decreased with subsequent increase in the amount of P$_2$O$_5$ added. The effect of P$_2$O$_5$ on productivity on *Phaseolus* was statistically non significant. The overall results indicated that application of P$_2$O$_5$ was not beneficial. The data presented in Table 12 is also illustrated in Fig. 8 in the form of histogram. In addition FYM, either alone or with P$_2$O$_5$ also failed to give favourable results when the experiment was done in pots. It is felt that the response of P$_2$O$_5$ on the plant growth and yield was due to alkaline nature of the soil and that of FYM also. The introduction of VAM in the form of various fungi may be useful to the crop for favourable up take of P$_2$O$_5$.

Table 13 gives an account of regression equation computed for yields of green fodder, dry matter and crude protein along with observed and expected values. The correlation between the yields and amount of P$_2$O$_5$ added was however statistically nonsignificant.
Crop: *Dolichos*

**From 16-9-2003 to 13-12-2003**

*Dolichos* also known as dhorwal is cultivated in this region in and around the fields of sugarcane for edible pods, fodder or green manuring. In 1972 it was cultivated by Deshmukh (1972) when it yielded 70 quintal of green foliage / ha with more than 20 % protein in the foliage.

During present investigation the crop was cultivated in pots as well as in the field to assess its growth and productivity under the influence of P$_2$O$_5$ as sources of phosphorus. During pot experiment the crop was raised using soil, alone or mixed with FYM. The data presented in Table 14 is also illustrated in Fig. 9 in the form of histogram. The height of plant was 33.6 cm which gradually increased to 58.0 cm due to the application of P$_2$O$_5$ (600 mg / pot). When the FYM was mixed with soil for cultivating *Dolichos* the height of the plant was 48.1 cm, which increased to 57.4 cm due to the application of 600 mg P$_2$O$_5$ / pot. The results indicated that either FYM alone or P$_2$O$_5$ in absence of FYM significantly increased the yield, effect of P$_2$O$_5$ in presence of FYM was non significant.

There was little increase in the number of leaves / plant (22.2 - 27.4 and 25.8 - 31.2 in the pots without and with FYM respectively). Both FYM as well as P$_2$O$_5$ also showed little influence on root length of the plant as well as number of root nodules. However slight improvement in the number of nodules per plant was observed due to the application of FYM. Though fresh and dry weights of the plant marginally increased due to the
application of P$_2$O$_5$ the weight were low under the influence of FYM. The nitrogen content in the leaves increased due to the application of P$_2$O$_5$ which was more pronounced in the presence of FYM. The accumulation of the nitrogen in the plant was improved due to P$_2$O$_5$, while FYM was not influential at higher doses of phosphorous.

The over all results obtained with *Dolichos* were slightly different than those obtained with *Phaseolus*. An increase in height of the plant, number of leaves per plant, root length and number of nodules improved due to the application of P$_2$O$_5$ with very little effect of FYM. Though amendment with P$_2$O$_5$ increased dry matter and nitrogen accumulation of the plant, the FYM had very little influence in contributing these two components. However the use of P$_2$O$_5$ along with FYM was found to be beneficial as well as sustainable.

The Table 15 and Fig. 10 gives an account on the yields of green fodder, dry matter and crude protein obtained from *Dolichos* under the influence of application of P$_2$O$_5$ as a source of phosphorous. Application of P$_2$O$_5$ had no effect on either percent dry matter or nitrogen content in dry matter of the foliage. These two parameters fluctuated between 20.16 - 20.66 and 3.24 - 3.36 respectively. The yield of green fodder increased from 4268 kg/ha - 5308 kg/ha due to the application of 45 kg P$_2$O$_5$/ha which was statistically significant. Similarly though the yields of dry matter and crude protein increased from 879 - 1074 and 184 - 222 kg / ha respectively, the increase in the yield was statistically non-significant. The results thus
indicate that application of $P_2O_5$ upto 45 kg/ha was not beneficial in increasing the productivity of fodder from *Dolichos*.

The regression equation for the yields of green fodder, dry matter and crude protein are given in Table 16 along with observed and expected values. A positive significant correlation was observed between phosphorous fertilization and the yield of green fodder. However, the observed and expected values fluctuated to some extent. The results obtained with *Dolichos* suggested that it is suitable fodder crop which can be cultivated with higher doses of $P_2O_5$ for maximum productivity. The data obtained during the pots experiments suggested very poor response of phosphorous in the presence of FYM and it is felt that either FYM or $P_2O_5$ added to the soil for increasing the productivity of *Dolichos*.

**Crop: Wheat**

**From 4-1-2004 to 8-3-2004**

Wheat is an important staple food grain crop cultivated in Marathwada region. The crop is mainly cultivated for harvesting the grains and very rarely it is cultivated for fodder purpose. On this farm it was cultivated for harvesting green foliage to prepare leaf protein concentrate (LPC) by Batra (1974). The results obtained during the field trials indicated that the crop responded favourably to the application of nitrogen resulting in higher productivity of green foliage (Mungikar *et al.*, 1976). During present investigation attempts were made to study the effect of N, P and K on growth of wheat as well as its foliage and grain productivity.
Table 17 and Fig. 11 illustrated in the form of histogram gives an account on the effect of various fertilizer elements on different growth characters of wheat. When the experiment was undertaken in pots the height of wheat plant was 40.4 cm which increased to 45.0 cm due to the application of nitrogen, 45.2 cm due to the application of N + P and 48.0 cm with NPK. Thus application of NPK significantly increased height of plant. Application of either N, P and K alone or in combination did not altered the number of leaves per plant which fluctuated between 5.5 to 5.7.

The fresh weight per plant of wheat increased from 2.4 - 2.6 gm due to the application either nitrogen or phosphorus and further increased to 3.4 under the influence of N, P and K. Almost similar trend was observed with the yield of dry matter / plant wherein, it increased from 0.61 - 0.85 gm / plant due to the application of N, P and K. It can thus be assumed that application of N, P and K significantly increased the accumulation of dry matter in the plant. Improvement in nitrogen (N) content of dry matter in the foliage from 1.4-1.92 % was observed due to the application of either nitrogen or phosphorous, which further increased to 2.0 % and 2.16 % due to the application of N + P and NPK respectively. As the result of increased nitrogen content in foliage, the accumulation of nitrogen in the plant also improved from 8.66 - 18.36 mg N / plant due to the application of all three fertilizer elements. The results obtained from the pot experiment thus indicated need of all the three fertilizer elements i.e. N, P and K for
desirable growth and increased dry matter and nitrogen accumulation in the plant.

The results obtained during the field trials are given in Table 18 and Fig. 12 illustrated in the form of histogram. Application of fertilizer elements had very little effect on percent dry matter of the foliage which ranged from 23.31 - 23.65%. A marked increase in nitrogen (% of DM) was observed due to the application of nitrogen alone, followed by its application with P$_2$O$_5$ and K$_2$O. The yield of green fodder, dry matter and crude protein was 4035, 943 and 82 kg/ha on unfertilized plots. A significant increase in the yields of all these three parameters was observed due to the application of nitrogen along with phosphorus and potassium. The maximum yield of 5272, 1234 and 173 kg/ha was recorded with N + P + K fertilization. The results indicate the need of P$_2$O$_5$ as well as K along with N for higher yields of foliage with high crude protein content.

The information on grain yield of wheat obtained at the time of harvesting is given in Table 19. The plots which received no fertilizer had 603636 cobs/ha which increased with application N, P and K and reached to 1058784 cobs/ha. On an average length of cob were 5.9, when fertilizers were not used; it increased within the range of 6.0 and 6.6 due to fertilizer application. Similarly there was increase in number of grains per cob from 18.2 on unfertilized plots to 22.3 when the plots received N, P and K. The effect of nitrogen was found to be more pronounced in the development of cobs. Application of nitrogen increased the grain yield from 15.49 q/ha to
16.78 q/ha, which further increased to 18.07 q/ha due to the application of P and K along with N. Application of fertilizer also increased bulk density of the wheat grains. The weight of 100 grains was 3.1 gm, which increased within the range of 3.6 - 3.9 gm due to fertilizer application. The results obtained on field experiment clearly indicate that application fertilizer N, P and K.

The importance of nitrogen as a fertilizer element in increasing the yield of cereals and that of phosphorous in case of pulses in well known. When the crop is cultivated solely for the purpose for green fodder application of nitrogen is sufficient in case of non-leguminous fodder crops. However when the crop is cultivated for grains, with an intention to use remaining portion for animal nutrition, use of P and K along with N has been recommended.

The chemical fertilizer, which supply N, P and K play an important role in agriculture and productivity of crop plants. The efficiency of utilization of each fertilizer element varies under different conditions. Most of the nitrogen is lost by leaching, only 15 - 20 % of applied $\text{P}_2\text{O}_5$ is utilized by the crop and around 30 - 40 % $\text{K}$ was used by the crop. Thus the efficiency of using fertilizer by the crop plants was much less and it can be increased by using these fertilizer in a proper way taking into consideration the status of the soil, the crop plant to be cultivated, time of planting, season, water fertilizer management and the desired product. During present investigation attempts were made to evaluate the effect of nitrogen on the
productivity of maize and *Sorghum*, phosphorous on *Phaseolus* and *Dolichos*, while N, P and K on wheat.

Maize is an important fodder crop which can be grown around the year for fodder production. It is quick growing, high yielding palatable and nutritious (Whyte 1964; Relwani, 1979; Tanjera *et al.*, 1984). The crop is leafy (Desai and Devre, 1983) having the potential to yield from 160 - 600 q/ha green fodder (Naryannan and Dahadghao, 1972; Mungikar, 1974; Relwani, 1979; Hunshal *et al.*, 1989). It is suitable for making hay and saliage (Chatterjee and Maiti, 1981). African tall variety of maize was employed during present investigation.

*Sorghum* is another important fodder crop having an ability to grow under various climatic conditions (Rahudkar, 1965) for fodder purpose. It is harvested at the time of flowering, when it is suitable for feeding to animals as well as making hay or silage. The crop has a potential to yield up to 850 q/ha green fodder (Relwani, 1979).

*Phaseolus* is a leguminous fodder crop which can yield from 200 - 250 q/ha green fodder (Patil, 1990; Reddy, 1986). *Dolichos* is a twiner which gives dark green cover over the land. It is nutritiously superior with potential to yield about 60 - 80 q/ha green fodder under rainfed condition (Deshmukh, 1972). Wheat is well known cereal crop mainly cultivated for grains rather than foliage, and it has a potential to yield from 18 - 20 q/ha grains.
Extensive work has been reported on the effect of fertilizer on the productivity of fodder crop. Recent studies indicated that maize gives higher yields due to the application of nitrogen (Dakore et. al., 1990). Thakur and Shing, (1990) observed that better fertilizer management along with weed control can give better yields of maize foliage. Bajwal et. al., (2002) reported higher yields of maize due to application of FYM. Similarly Sonwane and Jain (2004) reported that the use of fertilizer for fodder production reduced the cost of nutrient production for use in animal nutrition. Raja and Reddy (1990) gave emphasis on intercropping and mulching in addition to fertilizer application for higher fodder productivity. Sharma and Gupta (1996) suggested on conservation of succulent green fodder obtained due to fertilizer application in the form of silage.

The overall results reported during four glass house and five field experiments with maize, Sorghum, Phaseolus, Dolichos and wheat indicate that the crops can be employed for fodder production, wherein the productivity of green foliage can be increased with the application of chemical fertilizer in the form of N, P and K. The use of farm yard manure (FYM) should also be employed to reduce the use of chemical fertilizers.

**SUMMARY**

Fodder production is an important aspects of mixed farming which is most common in India. Several fodder crops are suitable for animal nutrition and have been recommended for cultivation to obtain green fodder. The productivity of green fodder and its nutritive value can be
increased by cultivating them under the influence of chemical fertilizers (Dakore and Mungikar, 1986). Since the initiation of green revolution more emphasis has been given on the use of high yielding varieties of crop plants and use of chemical fertilizers for their higher productivity. The finding reported during present investigation with five crop plants confirmed with earlier reports that application of N, P and K increases the growth of plants along with productivity per unit land area. Though it helps in catering the need of animal nutrition, consistent use of nitrogen and other fertilizer elements may degrade the soil structure as well as nutrient status of the foliage through the accumulation of nitrates and oxalates in the foliage (Mungikar, 1974).

This situation calls for reduced use of chemical fertilizer and replacement of a part of it by organic or biofertilizers, or manures. In view of this, attempts have been made to use biofertilizer and observe their effects on fodder crops under investigation. An account of the use of biofertilizers in agriculture is presented in subsequent chapter.