SUMMARY AND CONCLUSIONS

The field investigation entitled "Forage yield and quality of *Pennisetum pedicellatum* varieties in relation to fertilizer nitrogen and intercrops" was conducted at Central Research Farm of Indian Grassland and Fodder Research Institute, Jhansi (UP) during Kharif season of 1989 and 1990. The experiment included three *Pennisetum pedicellatum* varieties (Bundel-1, Bundel-2 and IGFRI-3808), three crop stands (*Pennisetum pedicellatum* pure, *Pennisetum pedicellatum* + cowpea, *Pennisetum pedicellatum* + clusterbean) and three levels of nitrogen (30, 60 and 90 kg N/ha). These treatments were evaluated in $3^3$ partial confounding design replicated twice with 6 blocks each of nine plots. The experimental findings have been summarised in the following sections.

Crop Growth, Forage Yield and Quality Traits in Relation to Weather Conditions:

The rainfall during crop period was 487.5 mm in 15 rainy days in 1989 and 844.1 mm in 31 rainy days in 1990. Thus, the uniform distribution of rainfall accompanied with higher humidity influenced the crop growth favourably in 1990. Contrary to this, the year 1989 experienced critical dry spells beginning from standard week No. 30 for a period of two weeks immediately
after sowing which affected the germination and establishment of component crops. Again, the second long dry spell occurred from standard week No. 36 from 3rd September till the harvest. This coincided with active grand growth period of crops resulting in low green and dry matter yields. The maximum and minimum temperatures as well as evaporation beyond standard week No. 35 also remained higher in 1989 as compared to 1990. All these caused soil moisture stress coinciding with establishment and grand growth period in 1989 which affected most of the growth characters viz., number of functional leaves, length and breadth of leaf, leaf area index, leaf:stem ratio and relative leaf turgidity of grass component. In turn this culminated in lower green forage (334.8 q/ha) and dry matter (73.3 q/ha) yields in 1989 as compared to 1990 (455.2 q/ha green forage and 87.4 q/ha dry matter). Moreover, dry year, 1989 produced forage with relatively higher dry matter content both of grass and legume components. The congenial weather conditions for component crops in 1990 also resulted in higher green forage (5.4 q/ha/day) and dry matter (1.0 q/ha/day) productivity as compared to 1989 (4.2 q/ha/day green forage and 0.9 q/ha/day dry matter).

The crude protein content of Dinanath grass was higher (7.1%) in 1990 as compared to 1989 (6.5%). Consequently, the crops caused greater uptake of nitrogen (126.2 kg/ha) in 1990 than in 1989 (97.8 kg/ha). The water soluble carbohydrates content, however, remained higher (4.8%) in 1989 as compared to 1990.
The oxalate content in corresponding years was 2.8 and 3.2 per cent.

Among fibre fractions, plants contained relatively higher percentage of ADF, cellulose and lignin in 1990 whereas, the reverse was the trend with respect to NDF and hemicellulose. However, the differences were marginal. Acid insoluble ash (plant silica) content in grass was higher in 1990 (4.0 %) than in 1989 (2.6 %).

Growth Characters and Forage Yield in Relation to Treatment Variables:

Pennisetum pedicellatum varieties: Pennisetum pedicellatum variety Bundel-1 registered highest relative leaf turgidity percentage in dry year of 1989. Forage legume intercropped with this variety exhibited more number of functional leaves and root nodules in both the years. Variety Bundel-1 also accommodated greater number of plants with higher dry matter content of intercropped legume plants in 1989. On the basis of pooled data, variety Bundel-1 produced highest total green forage (405.6 q/ha) as well as resulted in maximum productivity (4.9 q/ha/day). This was followed by Bundel-2 with corresponding production levels of 396.5 q/ha and 4.8 q/ha/day. On an average, grass and legume contributed 56.4 and 43.6 per cent to the total herbage yield with this variety.

Variety Bundel-2 produced significantly higher total dry matter yield (87.6 q/ha) as compared to IGFRI-3808 (78.5 q/ha).
and Bundel-1 (75.0 q/ha) which, in turn, did not differ statistically from each other. The dry matter productivity of Bundel-2 was also higher (1.1 q/ha/day) as compared to remaining varieties (0.9 q/ha/day). In intercropping system, variety Bundel-2 and associated legume accounted for 68.5 and 31.5 % to the total dry matter accumulation. However, variety Bundel-2 resulted in greater number of functional leaves and higher dry matter content in both the years. This variety maintained greater leaf:stem ratio in 1989 and higher relative water content in 1990. Legume in association with this variety maintained higher leaf:stem ratio in 1989 and produced taller plants with greater dry matter accumulation in 1990.

On the other hand, Pennisetum pedicellatum variety IGFRI-3808 excelled other varieties in number of tillers, plant height and leaf area index in both the years. This variety also proved superior over others for root mass in 1989 and for leaf:stem ratio in 1990. Forage legume intercropped with Pennisetum pedicellatum variety IGFRI-3808 produced taller plants in 1989, higher leaf:stem ratio in 1990 and greater leaf turgidity in both the years.

Crop stands: Pure stand of Pennisetum pedicellatum produced taller plants in 1989, higher dry matter content in 1990 and more number of tillers with greater leaf:stem ratio in both the years. Dinanath grass in association with cowpea produced more number of
leaves, accumulated higher dry matter content and maintained higher leaf turgidity in 1989. On the other hand, in 1990, grass in association with clusterbean produced taller plants, higher relative leaf turgidity and greater leaf area index in both the years. Among intercrops, cowpea produced taller plants, greater number of leaves, higher leaf:stem ratio, increased relative leaf turgidity and greater number of root nodules. However, clusterbean accommodated more plants per running meter and accumulated higher dry matter content in both the years. On an average, pure Dinanath grass produced significantly highest total green forage (447.4 q/ha) as compared to grass + clusterbean (377.0 q/ha) and grass + cowpea (360.7 q/ha) which, in turn, did not differ significantly between themselves. In terms of dry matter yield, the crop stands differed significantly and the corresponding yield levels were 93.0, 79.2 and 69.0 q/ha. Similar trend was observed with respect to green and dry matter productivity per day.

Nitrogen levels: Application of 60 kg N/ha resulted in higher leaf area index in 1989, greater number of leaves with higher dry matter content in 1990 and more number of tillers with greater plant height as compared to 30 kg N/ha in both the years. Nitrogen at 60 kg N/ha also produced greater number of functional leaves and more number of root nodules in
intercropped forage legume in both the years. Further, increase in nitrogen levels to 90 kg N/ha, however, produced greater number of functional leaves, accumulated higher dry matter in 1989 and resulted in greater leaf area index in 1990. In so far as the legume component was concerned, 90 kg N/ha accumulated higher dry matter content in 1989 and produced taller plants with high leaf turgidity in 1990.

Pooled data revealed that application of 90 kg N/ha significantly increased the green forage (430.1 q/ha) and dry matter (87.4 q/ha) yields as compared to 60 kg N/ha. The highest per day productivity in terms of green forage (5.2 q/ha/day) and dry matter (1.1 q/ha/day) was also obtained at 90 kg N/ha.

Quality Traits in Relation to Treatment Variables:

Crude protein: On an average the crude protein content both of grass (7.5 %) and legume (17.1 %) components remained highest with Pennisetum pedicellatum variety Bundel-1. This in turn, registered the highest outturn of crude protein (752.5 kg/ha) for the mixed sward. Intercropping of grass + cowpea not only recorded the highest crude protein content for individual component but also the total crude protein yield of the system.

The highest crude protein content was obtained at 60 kg N/ha for grass (6.8 %) and at 30 kg N/ha for legume (16.4 %) in dry year of 1989. In wet year of 1990, however, highest crude protein
content for both the component crops (7.9% for grass and 17.4% for legume) occurred at 90 kg N/ha. Increasing doses of nitrogen from 30 to 90 kg N/ha increased the total outturn of crude protein both in pure and mixed stands. Intercropping system of *Pennisetum pedicellatum* + cowpea and *Pennisetum pedicellatum* + clusterbean receiving 60 kg N/ha gave additional crude protein of 129.2 and 49.5 kg/ha, respectively over *Pennisetum pedicellatum* pure fertilized with 90 kg N/ha. This, therefore, indicated a saving of fertilizer nitrogen equivalent to 30 kg N/ha, besides providing protein rich nutritious herbage.

Water soluble carbohydrates (WSC): Variety IGFRI-3808 exhibited the highest WSC content of 5.1% in 1989 whereas in 1990, variety Bundel-1 showed higher WSC content of 3.9 per cent. Forage legume intercropped with IGFRI-3808 consistently registered higher WSC content (3.6%) than in association with other varieties. The grass grown in association with cowpea accumulated greater WSC content in both the years. Among intercrops, cowpea in 1989 (4.9%) and clusterbean in 1990 (2.6%) showed higher WSC content. On an average, the accumulation of WSC content was highest at 90 kg N/ha in grass (4.4%) and at 30 kg N/ha in legume (3.5%).

Oxalate content: Variety Bundel-2 accumulated the lowest oxalate content (2.8%). The association of forage legume in reducing the oxalate content of Dinanath grass was observed in relatively dry year (1989) but not in wet year (1990) and more so, the effect
was pronounced in association with cowpea. In general, the application of 30, 60 and 90 kg N/ha gave an oxalate content of 3.2, 3.0 and 2.9 %, respectively indicating that nitrogen nutrition exercised favourable effect in reducing oxalate content of Dinanath grass.

Fibre fractions: *Pennisetum pedicellatum* variety Bundel-1 exhibited lowest percentage of NDF, ADF, cellulose and lignin suggesting that this variety possesses desirable quality characteristics of higher intake and digestibility. However, Bundel-2 and IGFRI-3808 contained minimum plant silica and hemicellulose. Forage legume associated with Bundel-1 also gave lowest lignin content. Lower content of NDF, hemicellulose and plant silica occurred when legume was grown in association with Bundel-2. Grass contained minimum lignin in pure stand, plant silica with cowpea and NDF with clusterbean. No definite trend was observed with respect to remaining fibre fractions. Among intercrops, clusterbean exhibited lower content of NDF, hemicellulose, lignin and plant silica whereas cowpea gave low cellulose content.

The effect of nitrogen nutrition in modifying the fibre fractions of grass was variable. It follows that 90 kg N/ha reduced the content of NDF and hemicellulose whereas, the decrease in lignin content was observed at 30 kg N/ha. Acid
detergent fibre, cellulose and plant silica, however, remained unaltered due to nitrogen nutrition. In case of legume, lower contents of NDF, ADF, hemicellulose, cellulose and plant silica were observed at 30 kg N/ha whereas, minimum content of lignin occurred at 90 kg N/ha.

Response to Fertilizer Nitrogen:

On an average, Pennisetum pedicellatum variety Bundel-1 showed greater uptake of nitrogen (120.3 kg/ha) than remaining varieties. Among crop stands, Pennisetum pedicellatum + cowpea in 1989 and Pennisetum pedicellatum + clusterbean in 1990 registered significantly higher nitrogen uptake as compared to pure grass stand. Nitrogen uptake of the sward increased from 93.5 kg/ha with 30 kg N/ha to 126.4 kg/ha at 90 kg N/ha.

All the three Pennisetum pedicellatum varieties showed linear response to per kg of applied nitrogen both in pure as well as in mixed stands. However, variety Bundel-2 registered the highest degree of response to each kg of applied N and more so in dry matter production. The degree of response, however, decreased with increasing doses of fertilizer nitrogen with the result that average response to each kg of fertilizer N at 30, 60 and 90 kg N/ha worked out to be 11.8, 6.7 and 4.8 q/ha in terms of green forage. The corresponding responses in terms of dry matter yields were 2.4, 1.4 and 1.0 q/ha.
Conclusions:

1. *Pennisetum pedicellatum* variety Bundel-1 proved superior in green forage production, crude protein outturn and associability with forage legumes. Variety Bundel-2 produced the highest dry matter yield with the lowest oxalate content and ranked second in green forage as well as crude protein production.

2. All the *Pennisetum pedicellatum* varieties responded linearly to fertilizer nitrogen both in pure and mixed stands ranging from 30 to 90 kg N/ha. The maximum response to each kg of applied N occurred with Bundel-1 for green forage production and with Bundel-2 for dry matter accumulation.

3. Nitrogen nutrition had a distinct positive effect on increasing crude protein and water soluble carbohydrates and reducing oxalate in *Pennisetum pedicellatum*.

4. Intercropping of *Pennisetum pedicellatum* with forage legume showed superiority over its pure stand in terms of crude protein content and its outturn in the sward along with reduction in the fibre fractions of grass component. Moreover, intercropping of Dinanath grass + cowpea resulted in nitrogen economy equivalent to 30 kg fertilizer N/ha.

Recommendations:

*Pennisetum pedicellatum* variety Bundel-1 + cowpea with 60 kg N/ha and/or Bundel-2 + clusterbean with 90 kg N/ha may be recommended for achieving optimum forage yield, better quality traits and greater nutrient outturn.
Future Line of Research Work:

1. There is need to identify appropriate *Pennisetum pedicellatum* variety capable of maintaining quality even after boot stage with minimum or no risk of oxalate toxicity. The forage legume should be compatible with matching physiology to harness the positive associative effects. This will ensure ideal combination to optimise yield and quality in intercropping system.

2. Studies are required to develop nitrogen management techniques to activate \( N_2 \) fixation by forage legume in initial stage and to meet the increased nitrogen demand of grass during peak vegetative growth period.

3. Since, in intercropping system grass is able to extract potassium much more readily causing K starvation to legume, especially on K deficient soils, appropriate cutting-cum-potassium fertilizer schedules need to be worked out to supply enough K to legume without causing luxury consumption by the grass.

4. There is need to generate basic information on selectivity and availability of forms of nitrogen and fractions of phosphorus to grass and legume components, respectively in mixed stand.

5. The grass and legume components in combination cropping vary in species aggressivity, botanical composition and forage productivity. This causes considerable variation in chemical composition and mineral balances of the produce. Thus, there is need to find out appropriate grass-legume proportion to achieve the desired N:S, Ca:P and K:Mg ratios in mixed herbage in relation to animal requirement.