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Enhancing Productivity and Quality of Annual Cereal Forages through INM: A Review

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A B S T R A C T

Supply of good quality and adequate quantities of fodder play an important role in improving the health and productivity of animals. Green and dry fodders are cheaper sources than concentrate feed, hence its inclusion would curtail the cost of feed purchase. Unfortunately, in our country there is acute scarcity of green and dry fodder mainly due to very less area available for its cultivation. In future also there are less chances to increase area under forage cultivation because of heavy pressure of burgeoning human and livestock population on meager land. Among various improved agro techniques Integrated Nutrient Management (INM) has been proved to be the best options to augment good quality forage production per unit area by sustaining soil fertility and its productivity under limited land resources available today.

Introduction

Livestock plays an important role in the national economy and in the socio-economic development of the country. It also plays a significant role in the rural economy as supplementing family incomes and generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and farm women's. The growth in the livestock sector is expected to contribute in the poverty alleviation as nearly 70 percent of livestock market in India is owned by 67 per cent of small and marginal farmers and by the land less poor peoples. The livestock sector contributed over 4.5 per cent to the total GDP during 2015-16 and it's estimated value of the output of Rs. 5,60,613 Crore which is about 25.77 per cent of the value of the total output of Rs.21,75,547Crorefrom agriculture &

allied Sector (National Accounts Statistics, 2016). With an estimated 165.4 million tons of annual milk production from 512.1 million livestock, India is the top-most milk producing country in the world and the per capita milk availability is about 355 grams per day as against the recommended requirement of 250 grams (DAHD & F, 2016).

Although India recorded substantial increase in milk production but the productivity (production per animal) in the country is far less as compared to those in developed dairy nations. There are many reasons but inadequate supply of good quality feed and fodder is the primary cause of lower productivity of milch animals in India (DARE, 2013). Deficiency in feed and fodder is identified as one of the major constraints in achieving desired level of livestock productivity. Further, availability and quality of feed and fodder is increasingly becoming a challenge due to rapidly shrinking land and natural resources and hardly 4.5% of the cropped area is utilized to grow fodder crops. At present, the country faces a net deficit of 35.6 % of green fodder, 10.95 % of dry crop residues and 44 % of concentrate feed ingredients (IGFRI VISION 2050). The performance of the animals depends on the quantity and quality as well as availability of green fodder at various times during the year (Hatam *et al.,* 2001).

Therefore, there is big challenge before the researchers, strategy makers and scientists to bridge the gap between fodder demand and fodder supply and overcome fodder deficit under declining land resources by adopting various improved agro techniques. Among the various improved agro techniques, Integrated Nutrient Management (INM) is one of the best options for enhancing the forage yield and quality of annual as well as perennial forage crops per unit area. After green revolution due to continuous use of chemical fertilizers we have witnessed detrimental effects on soil, crop, environment and health of human as well as animals. Therefore, judicious use of fertilizers which include chemical fertilizers, organic manures and bio-fertilizers together in forage production is becoming the need of the day to sustain the fodder production under limited land resources available in our country.

Integrated nutrient management (inm)

In almost all parts of the India annual cereal fodder crops such as sorghum, maize and pearl millet are mainly grown during *kharif* season and fodder crops like oat and barley grown during *rabi* season. Cereal forages are rich in carbohydrates but contain less protein as compare to legume fodders. It has been proved that productivity and quality of these annual cereal forages can be improved by adopting all the nutrient management methods available judiciously (Rasool *et al.,* 2015). Secondly, Integrated Nutrient Management of annual cereal forages has become more essential as these crops don't fix up atmospheric nitrogen like legume crops.

INM in sorghum (*Sorghum bicolor*)

In India, fodder sorghum is grown in 2.6 m ha mainly in western Uttar Pradesh, Haryana, Punjab, Rajasthan and Delhi and fulfills over two third of the fodder demand during *Kharif* season (Pandey and Roy, 2011).In a field experiment of integrated nutrient management it was observed that green and dry fodder yield of sorghum was significantly higher with the inoculation of *Azosprillum* however, it had no significant effect on crude protein and crude fibre content in fodder sorghum. Further, it was reported that green and dry fodder yield, crude protein and crude fibre content increased significantly with an increase in the dose of FYM and nitrogen application (Kumar and Sharma, 2002).Field

experiments conducted at IGFRI,Jhansi for consecutive three years revealed that application of 50 per cent recommended dose of NPK (40 : 20 : 0) + vermicompost 5 t ha^{-1} + FYM 5 t ha^{-1} gave significantly higher green fodder, dry matter and crude protein yields of sorghum than other treatments under investigation(Kumar *et al.,* 2004).At Hisar (Haryana) application of 25 per cent N through FYM along with 75 per cent RDF + *Azotobacter r*ecorded significantly higher green fodder and dry matter yield of sorghum over other treatment combinations of organic and inorganic fertilizers, whereas highest crude protein content was recorded with sole application of 15 t ha^{-1} FYM (Kumar *et al.,* 2008). At PAU, Ludhiana (Punjab) Tiwana and Chaudhary(2009) reported that 100 per cent RDF alone or along with Zn and INM treatments recorded significantly higher green fodder and dry matter yield of sorghum over control. Shekara *et al.,* (2009) at Mandya (Karnataka) reported that application of 50% recommended dose of nutrients (RDN) through inorganic fertilizer + 50% N through FYM recorded significantly higher green fodder yield and nutrient use efficiency in sorghum. Further, it was reported that 100% RDN through inorganic fertilizer + VAM produced highest dry matter yield, crude protein yield, net monetary returns and benefit : cost ratio followed by 50% RDN through inorganic fertilizer + 50% N through FYM treatment. Application of 75 kg N ha^{-1} through chemical fertilizer + 25 kg N ha^{-1} through FYM or castor cake along with the combined inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum* recorded significantly higher green forage yield and crude protein content of forage sorghum in sandy loam soils of Gujarat (Yadav *et al.,* 2010). At Udaipur (Rajasthan) application of recommended dose of fertilizers (80 kg N + 40 kg P_2O_5 ha^{-1}) through inorganic fertilizer along with 25 kg $ZnSO_4$ ha^{-1} recorded maximum green fodder and dry matter yields of sorghum, which remained at par with 75 % recommended dose of fertilizers along with 2.5 t vermicompost ha^{-1} + *Azotobacter* + PSB (Kumar *et al.,* 2010).Application of recommended dose of fertilizers through inorganic source along with bio-fertilizer recorded maximum green fodder and dry matter yields of sorghum at Udaipur, Rajasthan (Meena *et al.,* 2010).

INM in maize (*Zea mays)*

Maize is one of the most important fodder crops particularly for milch animals. The crop is grown in over 0.9 million ha in different parts of the country throughout the year (Pandey and Roy, 2011).Verma *et al.,* (2006) at Udaipur (Rajasthan) recorded significantly higher plant height, LAI at 60 DAS and grain as well as straw yield with application of 150% NPK which was statistically at par with 100% NPK + Azotobacter, 100% NPK + FYM @ 10 tha^{-1} and different rate of inorganic fertilizers alone or its combination with Zn and or S. At Anand (Gujarat) Patel *et al.,* (2007) reported that application of 100 percent Recommended dose of fertilizer + 10 t FYM ha^{-1} recorded significantly higher green forage, dry matter and crude protein yield; however, it was it par with 75 per cent recommended dose of fertilizer + 10 t FYM ha^{-1} for green forage yield.Rasool *et al.,* (2015) reported that application of 75 per cent (NPK) + FYM (4.5 t ha^{-1}) + bio-fertilizers (*Azotobacter*+ Phosphate solubilizing bacteria) recorded significantly higher cob yield, dry fodder yield and green biomass yield of maize as compared to other combinations including unfertilized control. At Shimoga (Karnataka)Shilpashree *et al.,* (2012) observed significantly higher straw and grain yields of maize with the application of 100% N through inorganic fertilizers + 7.5 tha^{-1} FYM which was at par with 150% N through inorganic fertilizers + 7.5 tha^{-1} FYM, 100% (50 % N through inorganic

fertilizers + 50% N through FYM/ vermicompost), 150% (75% N through inorganic fertilizers + 75% N through FYM/vermicompost). In a field experiment conducted at Malaprabha (Karnataka) for consecutive five years application of recommended dose of fertilizer + biofertilizer (*Azospirillum* + *PSB*) with one row of sunhemp between two rows of maize (sunhemp incorporated at 45 days after sowing) recorded significantly higher fodder yield and NPK uptake as compared to rest of the treatments. Further, application of 75% recommended dose of fertilizer + maize stalk incorporation with cellulolytic culture + biofertilizer (*Azospirillum*+ *PSB*) and one row of sunhemp between two rows of maize (sunhemp incorporated at 40 days after sowing) recorded at par values of green fodder yield and NPK uptake with 100 % recommended dose of fertilizers during fifth year of experiment (Gundlur *et al.,* 2015). Tetarwal *et al.,* (2011) from Jhalawad (Rajasthan) recorded significantly higher plant height, cobs/plant, grains/cob, grain and biological yield of maize with 150% RDF which was at par with RDF + 10 tha^{-1} FYM, however significantly higher dry matter at harvest was recorded with RDF + 10 tha^{-1}FYM which was at par with150% RDF.

In another experiment it was observed that combined application of 100 % recommended dose of fertilizer + *Azotobacter* + PSB performed better under agro climatic conditions of Gujarat by recording 58.23 and 52.63 per cent higher green forage and dry fodder yield over other treatments (Jadhav *et al.,* 2018). At Dharwad (Karnataka) significantly higher growth, yield attributes and yield of maize was recorded with sunnhemp + poultry manure @ $1tha^{-1}$ + 100% RDN which was at par with sunnhemp + poultry manure @ $1tha^{-1}$ + 75% RDN and cowpea + poultry manure @ $1tha^{-1}$ + 100% RDN in case of grain and straw yields (Sujatha *et al.,* 2008).

INM in pearl millet *(Pennisetum typhoides)*

It is an important forage crop of the arid and semi-arid regions of the country. It is fed to the cattle either as green or dry fodder. Bajra is highly drought tolerant and can grow well in the areas with low rainfall (Pandey and Roy, 2011).At Bichpuri (Agra) in a cropping sequence of pearl millet-wheat it was recorded that combined application of organic manures and fertilizers had significant and positive effects on productivity of the system. The results further indicated that the productivity of the wheat and pearl millet crop can be sustained by the application of balanced use of nutrients to the crops through integration of organic manures and fertilizers (Kumar *et al.,* 2014).

Application of farm yard manure in combination with bio-fertilizer (*Azospirillum* + PSB) to pearl millet showed significant increase in growth parameters such as plant height, number of leaves $plant^{-1}$ and number of tillers $plant^{-1}$ which in turn increased green fodder yield of 70.7 t ha^{-1} in hybrids and 87.2 t ha^{-1} in composites varieties as compared to control (Basanthi *et al.,* 2012).Golada *et al.,* (2012) reported that application of FYM 10 t ha^{-1}, nitrogen 100 kg ha^{-1} and inoculation with *Azospirillum* to fodder pearl millet recorded significantly higher green forage yield over treatments with their respective lower fertility levels. Further, it was revealed that among different treatment combinations, the treatment 10 t ha^{-1} FYM + 100 kg N ha^{-1} + *Azospirillum* inoculation recorded significantly higher green forage yield, net return and B:C ratio as compared to rest of treatment combinations. At Navsari, (Gujarat) it was observed that application of FYM @ 2.5 t ha^{-1} along with recommended dose of fertilizer and seed inoculation with

Azotobacter and phosphorus solubilizing bacteria (PSB) resulted in significantly higher growth characters like plant height and number of tillers plant^{-1} which produced higher dry fodder yield of 7492 kg ha^{-1} (Thumar *et al.,* 2016).An experiment of pearl millet –wheat cropping system conducted at CCS HAU, Hisar revealed that highest grain yield of pearl millet followed by wheat was recorded with the application of 100% recommended dose of NPK in both crops which was at par with 50% NPK + 50% N (farmyard manure) to pearl millet and 100% NPK to wheat and significantly superior over the rest of treatments (Kumar *et al.,* 2005).At Bichpuri (Agra) in a cropping sequence of pearl millet-wheat it was recorded that combined application of organic manures and fertilizers had significant and positive effects on productivity of the system. The results further indicated that the productivity of the wheat and pearl millet crop can be sustained by the application of balanced use of nutrients to the crops through integration of organic manures and fertilizers (Kumar *et al.,* 2014). Patil *et al.,* (2018) from Tirupati reported that application of 75 % RDF + Poultry Manure (PM) @ 2 t ha^{-1} + Azospirillum @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1} produced higher yield attributes (number of earheads m^{-2} , length of earhead, weight of grains earhead^{-1} , 1000 grain weight), yield (Grain yield, stover yield and harvest index) and quality parameters (protein, carbohydrate) in pearlmillet. However, it was comparable with application of 75 % RDF + FYM @ 5 t ha^{-1} + Azospirillum @ 5 kg ha^{-1} + PSB @ 5 kg ha^{-1}. Application of 50 % RDF + FYM @ 7.5 t ha^{-1}, registered the lowest values of yield attributes, yield and quality parameters.

INM in oat (*Avena sativa L.*)

Oat locally known as *jai*, is one of the most important dual purpose winter cereal crop grown for animal food and grain production under irrigated conditions of northern and north-western regions of India (Pandey and Roy, 2011). During the experiment at Assam it was found that application of 50 per cent recommended dose of fertilizers + 2.5 t ha^{-1}Vermicompost + 2.5 t ha^{-1}FYM gave the highest green forage yield, dry matter yield and net return per rupee invested (Sharma *et al.,* 2004).Application of 50 per cent recommended dose of fertilizers + vermicompost 5 t ha^{-1} + FYM 5 t ha^{-1} produced significantly higher green fodder and dry matter yield of oat than other treatments except 50 per cent recommended dose of fertilizers either with vermicompost or FYM @ 5 t ha^{-1} (Sheoran *et al.,* 2005).

Kumar and Shivadhar (2006) at Jhansi observed that application of 50 per cent recommended dose of NPK, vermicompost 5 t ha^{-1} and FYM 5 t ha^{-1}may be adopted for getting higher, sustainable and quality fodder from single cut oat under irrigated conditions. Godara *et al.,* (2012) reported that higher green herbage, dry matter yield and quality of oat could be obtained with integration of either vermicompost @ 5 t ha^{-1}or FYM @ 10 t ha^{-1}and *Azotobacter* with 75 per cent of recommended dose of fertilizer resulted in saving of 25 per cent chemical fertilizers. At Srinagar, Khanday *et al.,* (2009) reported that application of 20 t FYM ha^{-1} and 60 kg P_2O_5 ha^{-1} have marginal effect on seed yield and straw yield, than 15 t FYM ha^{-1} and 40 kg P_2O_5 ha^{-1}. However, the application of 15 t FYM ha^{-1} and 40 kg ha^{-1} were economically feasible. Application of 10 kg Zn ha^{-1} was better both with respect to productivity and economically than no zinc application. At West Bengal, Hembram and Kundu (2016) reported that higher green forage and dry matter yield of oat were recorded with the application of GM + 25% N FYM + 50% NPK inorganic. But higher crude protein was recorded with the application of GM + 25% N FYM + 50% Biofertilizer which is

statistically at par with GM + 25% N FYM + 50% NPK inorganic and GM + 50% N FYM + PSB + Biofertilizer. At Bichpuri (Agra) maximum values of growth, yield attributes, green foliage yield and dry matter yield were recorded with 75% NPK+5 t FYM +20 kg S ha^{-1} closely followed by 75% NPK+5t FYM +10 kg Mn ha^{-1}. Further, the uptake of N, P, K, S, Fe, Cu and Zn by oat crop was highest at 75% NPK+5 t FYM +20 kg S ha^{-1} and lowest in control. The amounts of available N, P and K in post-harvest soil were maximum with the application of 100 % NPK but organic carbon, sulphur and iron, were maximum with the 75% NPK+5 t FYM +20 kg S ha^{-1} and Cu and Zn with 75% NPK+5t FYM +10 kg Mn ha^{-1} . The minimum amounts of available nutrients in post-harvest soil were recorded under control treatment (Pandey, 2018).

INM in barley (*Hordeum vulgare*)

Barley is generally grown in areas where irrigation facilities are limited, as it can tolerate moisture and salt stress to a great extent (Yadav *et al.*, 2003).At Bichpuri, Agra maximum values of number of effective shoots/m, spike length, number of spikelets/spike, number of fertile spikelets/spike, number of grains/spike, weight of grains/spike, 1000-grain weight, grain yield and straw yield were recorded at 75 per cent NPK+5 t FYMha^{-1}+biofertilizer over lower levels of NPK and control (Singh and Chauhan, 2016). Tomar *et al.*, (2016) recorded significant improvement in ear length, grains ear^{-1}, effective ears m^{-1}, test weight, grain, straw and biological yields with the application of RDF + bio-fertilizer + FYM (5 t ha^{-1}) as compared to rest of the fertility levels. Dinka *et al.*, (2018) from Ethopia reported that integrated nutrient management significantly improved yield and yield components of barley. The phenological and growth parameter of barley were improved with application of integrated nutrient management. Higher biomass and grain yield of barley were obtained from application of 66.6:33.4% NPS: FYM. According to Bhakher *et al.,* (1997) application of FYM @ 10 t ha^{-1} significantly increased the protein content in barley grains and total nitrogen uptake by 3.6 and 28.9 per cent, respectively over control. At Bichpuri, Agra, the maximum values of plant height, dry matter accumulation, effective tillers m^{-1}, spike length, spikelets $spike^{-1}$, fertile spikelets $spike^{-1}$, grains $spike^{-1}$, test weight, grain and straw yield of barley were recorded at 75% NPK+5t FYM ha^{-1} + biofertilizer and minimum in control. However, the maximum protein contents in grain and straw were recorded with 100% NPK alone. Further, the integrated use of chemical fertilizers and FYM improved the starch content in grain and maximum value was recorded with 75% NPK + 5 t FYM ha^{-1} + biofertilizer.

The uptake of N, P and K by grain and straw of barley was found to be associated with production of grain and straw resulted by the addition of 75% NPK + 5 t FYM ha^{-1} + biofertilizer (Singh, 2017).Ram and Dahliwal (2012) reported that in the two years of experiment at PAU, Ludhiana (Punjab) the highest productivity of barley was recorded in 75 per cent RDF + FYM in first year and in 75 per cent RDF + FYM + biofertilizer in second year which was statistically at par with 75 per cent RDF + FYM + biofertilizer in first year and 75 per cent RDF + FYM treatments in second year but significantly higher than rest of the treatments. Tufa *et al.*, (2018) from Ethopia reported that significantly higher grain yield and biomass yield of barley were obtained with the application of sole recommended NP and the integrated use of 50 : 50% vermicompost and conventional compost with recommended NP. The economic analysis confirmed the profitability of the integrated use of 50 : 50% conventional

compost and vermicompost with recommended NP fertilizer for barley production. Kumawat (2003) recorded significantly higher N, P, K concentration in grain and straw and their uptake and protein content in barley due to application of organic manures. Vermicompost @ 4.5 t ha^{-1} was found to be superior to other treatments and recorded a protein content of 11.53 %.

Due to mounting pressure of burgeoning human and livestock population on limited land in future also there is least chance to bring more arable land under forage cultivation .Hence, for achieving fodder and nutritional security every piece of available land should be efficiently utilized and managed by adopting modern agro techniques like Integrated Nutrient Management. It could be concluded that productivity as well as quality of annual forage crops can be improved through judicious fertilizer management. This agronomic strategy will reduce the present wide gap between fodder demand and fodder supply at some extent by providing better forage yield and nutritious fodders per unit area per unit time and thereby help to improve health as well as productivity of our animals.

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