Review Article

Productivity and profitability of fodder oat (*Avena sativa* L.) as affected by integrated nutrient management – A Review

ABSTRACT

Fodder oat (*Avena sativa* L.) serve as a valuable feed resource for livestock, providing high-quality forage rich in nutrients essential for animal health and productivity. This review summarizes the key components and benefits of INM in fodder oats cultivation. Organic inputs such as farmyard manure, compost, and green manure enhance soil quality while inorganic fertilizers provide essential macro and micronutrients necessary for robust crop growth and yield.Various researchers found that higher green and dry fodder yields were obtained with application of FYM @ 5 t/ha + 50 percent of recommended dose of fertilizers (329.76- 518.32 q ha^{-1}) and 75% RDF along with 2 t Poultry manure ha^{-1} (77.57- 91.31 q ha^{-1}). While 75% recommended dose of fertilizer (RDF)+Zn + plant growth promoting rhizobacteria (PGPR)+residual farm yard manure (R-FYM) and 100%RDF + Zn + R-FYM significantly increased fodder quality traits- Crude protein (9.44-10.10%), ether extract (4.5-5%), total ash yield (33.8-34.6%), ADF and NDF. Uptake of N, K, P, S and Mn by oat crop was highest at 75% NPK+2.5t Vermicompost +10kg Mn+20kg S ha^{-1}. And higher net returns per ha were obtained by integrated nutrient management treatment of FYM @ 5 t/ha + 50 percent of recommended dose of fertilizers and the application of 75% RDF (60:40 NP) kg ha^{-1} along with 2 t poultry manure ha^{-1}.Thus Integrated nutrient sources increased yield and quality of fodder oat besides enhancing profitability

Keywords: INM, Nutritional quality, soil health, productivity, FYM, Green manure

INTRODUCTION

Oat is an important cereal mainly for fodder during rabi season. Oat provides a very nutritious fodder (protein 12- 17%) especially suited to milch animals. Protein, fat, vitamin B, and minerals like iron and phosphorus are all abundant in it. Oats have the benefit of providing a large quantity of extremely nutritious fodder for rations for sheep, cattle, chickens, and other animals. Oats may be given in any form, such as hay, silage, or fresh forage, which helps to

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cover certain times of the year when there are shortages (Mary*et al*., 2022). A consistent supply of high-quality feed in appropriate amounts is essential to the success of dairy production and animal husbandry.Unfortunately, there is a severe lack of both green and dry fodder, amounting to 35.6% and 11.0%, respectively, according to IGFRI Vision 2050. This is because there is a lower percentage of acreage dedicated to green fodder crops (4.9%) and a greater focus on the production of food grains, which has a significant negative impact on animal productivity when compared to other nations (Sumanth *et al*., 2021). Compared to other rabi fodder crops, oats have a somewhat greater nutritional need.Higher dosages of inorganic fertilizers are needed to fulfill this need, which makes it unfeasible to produce feed. In addition, the health of the soil may suffer from the ongoing usage of chemical fertilizers. Because of this, integrated nutrient management (INM) has a lot of potential to maintain soil health in addition to ensuring high productivity (Shiyal *et al*., 2021). In addition to providing critical nutrients (like-Nitrogen for early rapid growth), the integration of organic and synthetic sources of nutrients (INM) also has several beneficial interactions that boost nutrient usage efficiency, lower environmental dangers, and improve soil qualities (Singh and pallavi 2020). Its growth behavior is vegetative, and balanced forms of nitrogen treatment improve both the amount and quality of its green fodder in particular with integrated nutrition management (Sunita *et al*., 2023).In addition, INM practices help farmers determine the most cost-effective dose of integrated nutrient management to achieve a larger yield and better nutritional quality of oats while also reducing production costs and boosting farmer returns (Anjum *et al*., 2022).

RESULTS AND DISCUSSION

Effect on growth characters

Plant height (cm)

Bhilare and Joshi (2008) reported significant increase in the plant height (158.6 cm) with increase in levels of nitrogen from 0 to 160 kg/ha in fodder oat under Pantnagar conditions.

Pathan and Bhilare (2009) conducted a field experiment at Rahuri and observed significant increase in plant height (129.70 cm) of fodder oat with increase in nitrogen levels up to 120 kg N/ha.

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Ahmad *et al*. (2011) while conducting an experiment at Faisalabad, Pakistan put forth that significantly highest plant height (146.3 cm) was observed in those treatments where150 kg N: 60 kg P_2O_5 /ha was applied followed by 112 kg N: 45 kg P_2O_5+750 kg poultry manure /ha (141.7cm) and 112 kg N: 45 kg P_2O_5+1000 kg FYM/ha (140 cm).

Godara *et al*. (2012) conducted a field experiment at Ajmer, Rajasthan and revealed that significantly highest plant height of fodder oat was observed in RDF +5t vermi-compost (111.8 cm) which was statistically at par with RDF +10t FYM (107.2cm) and 75 per cent RDF +10t FYM (105.7 cm) seed inoculation with azotobacter whereas, significantly lowest plant height was recorded in treatment 100 per cent RDF.

Roshan *et al*. (2012) reported from Madhya Pradesh that increasing nitrogen levels up to 120 kg N/ ha significantly increased the plant height of oat (145.3 cm) at 50 per cent flowering stage.

Khan *et al*. (2014) reported that significantly highest plant height (118.3 cm) of oat was observed with 100 per cent organic as compared to other treatments of organic fertilizers under agroclimatic conditions of Peshawar, Pakistan.

Iqbal *et al.* (2014) carried out an experiment at Faisalabad, Pakistan and found that significantly highest plant height (140.33 cm) was obtained with application of 100 per cent N from urea which was closely followed by application of 50 per cent nitrogen from urea and 50 per cent nitrogen from poultry manure.

Raj and Vyakaranahal (2014) carried out an experiment at Dharwad and found that significantly highest plant height (34.73cm) was recorded at 45 DAS with application of 100:60:40 N, P_2O_5, K_2O /ha + vermi-compost 5t /ha which was followed by 100:60:40 N, P_2O_5, K_2O/ha +FYM 10t /ha(32.82 cm).

Singh *et al*. (2015) reported from Lucknow that significantly highest plant height (157.7cm) of fodder oat was observed with the application of NPK (80:40:40) which was statistically at par with application of half NPK (40:20:20) +10 t FYM (143.5cm) whereas, the significantly lowest plant height (101.3 cm) was recorded in control.

Hembram and Kundu (2016) while conducting a field experiment at Alluvial zone of west Bengal recorded significantly highest plant height of oat (128.30cm) with GM+ 25 per cent

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N FYM+50 per cent NPK inorganic which was closely followed by GM+ 25 per cent N FYM+ 50 per cent Biofertilizer whereas, the lowest plant height (115.67cm) was found in control.

Kashyap *et al.* (2017) reported that significantly highest plant height (54.8 cm) was recorded with NPK (80:40:40 kg /ha) which was statistically at par with half dose of NPK + FYM + *PSB* + *Trichoderma* at 30 days after sowing (DAS) at Lucknow.

Biswas *et al*. (2019) conducted research at Bidhan Chandra Krishi Viswavidyalaya and revealed that highest plant height (99.4 cm) was recorded when 75% N through urea + rest N through vermicompost was applied

Pandey *et al*. (2020) studied the effect of integrated nutrient management on productivity of oat and observed that the highest plant height (116.1 cm) was recorded with 75% NPK+2.5t Vermicompost +10 kg Mn + 20kg S ha^{-1} followed by 100% NPK (115.0 cm).

Anjum *et al*. (2022) concluded that the highest plant height (144.7 cm) was observed under treatment (T_4) 50% RDF + 5 t ha^{-1} Farmyard Manure + seed inoculation azotobacter.

Kumari*et al*. (2023) observed that significantly taller plants (70.0 cm) were produced with inorganic nutrient managementwhich remained statistically at par with integrated nutrient management treatment (66.5 cm), which comprised of FYM @ 5 t/ha + 50 percent of recommended dose of fertilizers.

No. of tillers /m^2

Hasan and Shah (2000) concluded that with the increase in nitrogen levels the number of tillers/plant increased in oat. While Chellamuthu *et al*. (2000) reported that combined application of bio-fertilizers with N and P fertilizers increased the number of tillers per plant in bajra-napier hybrid grass.

Ahmad *et al*. (2011) while conducting an experiment at Faisalabad, Pakistan found that significantly more number of tillers of oat was observed with 150 kg N:60 kg P_2O_5 /ha(8.02) which was followed by 112 kg N:45 kg P_2O_5+750 kg poultry manure /ha(7.89) and 112 kg N:45 kg P_2O_5 + 1000 kg FYM /ha. Roshan *et al*. (2012) conducted an experiment at MP and reported that increasing nitrogen levels up to 120 N kg /ha significantly increased the number of tillers (440.3 /m^2) of forage oat at 50 per cent flowering stage.

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Dubey *et al*. (2013) conducted an experiment at Jabalpur (M.P) and evaluated the effect of nitrogen levels on green fodder yield of oat (*Avena sativa* L.) and revealed that increasing level of nitrogen dose up to 120 kg /ha increased the number of tillers (416.30 /m^2).

Singh *et al*. (2015) while working on fodder oat at Lucknow found that significantly highest number of tillers per plant (6.42) was observed with the application of NPK (80:40:40) which was followed by the half NPK +10 t FYM + *PSB*+ *Trichoderma* (6.32) whereas the significantly lowest number of tillers was observed by the treatment control (3.35).

Malik *et al.* (2015) while conducting an experiment in Hisar found that there was significantly increased in the number of tillers per meter row length of fodder oat with the application of N_{40}+P_{20} (103.7), N_{80}+P_{40} (110.50) and N_{120}+P_{60} (118.34) as compared to control (97.2).

Verma and Jeengar (2015) reported that significantly highest number of tillers /m^2 were obtained by the application of 120 kg N+60 kg P_2O_5+30 kg K_2O /hain fodder oat, under Udaipur, Rajasthan.

Kashyap *et al.* (2017) reported that the maximum number of tillers (4.0 tillers/plant) was recorded in treatment NPK (80:40:40 kg /ha) which was followed by treatment NPK + FYM + *PSB* + *Trichoderma* (4.0 tillers/plant), combination of half NPK (40:20:20 kg /ha) + FYM (3.6 tillers/plant) and control (2.3 tillers/plant) in fodder oat at 30 DAS under sodic soil conditions of Lucknow.

Saha *et al*. (2020) revealed that the use of 100% NPK + FYM@ 10 t/ha + $ZnSO_4$ @20 kg/ha + Borax @ 10 kg/ha showed the highest no. of tillers /plant.

Anjum *et al*. (2022) concluded that maximum no of tillers (780.35 m^2) was observed under treatment (T_4) 50% RDF + 5 t ha^{-1} Farmyard Manure + seed inoculation azotobacter.

Green biomass yield (q/ha)

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Working under Assam conditions, Suhrawardy and Kalita (2001) recorded the significantly highest green fodder yield in oats with the fertility level of 80 kg N+ 20 kg P_2O_5 + 20 kg K_2O/ha.

Kakol *et al*. (2003) working under Dharwad condition recorded significant and consistent increase in the green fodder yield of oats (37.05 t/ha) with increase in nitrogen application up to 150 kg /ha.

Application of 120 kg N + 60 kg P_2O_5 + 30 kg K_2O /ha significantly increased the green fodder yield of oats to the magnitude of 31.33 per cent over sole nitrogen application (Dadheech *et al*. 2005). Whereas Singh and Dubey (2007) reported significant increase in the green fodder yield of oats with increase in nitrogen rates up to 80 kg/ha.

Bhilare and Joshi (2008) while conducting a field experiment at Pantnagar to evaluate the response of oat (*Avena sativa* L.) to nitrogen levels revealed that the application of 160 kg N/hasignificantly produced highest green forage yield (445.3 q/ha) which was at par with 120 kg N/ha(428.9 q/ha).

Pathan and Bhilare (2009) while conducting an experiment on oat genotypes at Rahuri observed that, the application of 120 kg N/ha produced significantly highest green forage yield (316.97 q/ha) which was at par with 80 kg N/ha (310.82 q/ha).

Godara *et al.* (2012) reported that the highest green fodder yield of oats was obtained with integration of either vermicompost @ 5 t/ha or 10 t FYM/ha and Azotobacter with 75 percent RDF (306.4 q/ha) under Rajasthan condition.

Dubey *et al*. (2013) conducted a field experiment during *rabi* season of 2006-07 at Jabalpur (M.P) and reported that, the application of 120 kg N/ha produced significantly highest green forage yield of fodder oats (549.90 q/ha) than all other levels of nitrogen viz., 0, 40 and 80 kg N/ha.

Khan *et al*. (2013) reported from Pakistan that the maximum green fodder yield of oat was recorded by treatment 100 per cent organic (74.67 t/ha) which was followed by treatment 50 per cent inorganic and 50 per cent organic (74.40 t/ha) while minimum green fodder yield (45.067 t/ha) was obtained by control under subtropical conditions of Peshawar, Pakistan.

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Aalum *et al*. (2013) reported that the highest fertility level of 150 kg N +70 kg P_2O_5+40 kg K_2O /ha significantly improved the oats fodder yield to the tune of 7.58 per cent over 125 kg N +60 kg P_2O_5+30 kg K_2O/haunder temperate conditions of Kashmir.

Devi *et al.* (2014) carried out an experiment at Hisar and reported that among five levels of organic manures, application of vermicompost @ 10 t /ha resulted in maximum green fodder yield of oats.

Deva (2015) conducted a field experiment at Raipur to study the effect of nutrient management practices on fodder yield and quality of oat and noticed that application of 100 per cent RDF along with bio-fertilizers recorded the maximum green fodder yield (329.76 q/ha).

Verma and Jeengar (2015) reported that the application of 100 per cent NPK (120 kg N+ 60 kg P_2O_5 + 30 kg K_2O/ha) recorded the significantly highest green fodder yield of oats over N alone and N+P both under agroclimatic conditions of Udaipur, Rajasthan.

Malik *et al.* (2015) reported that significantly highest (518.32 q/ha) green fodder yield was found under treatment 120 kg N + 60 kg P_2O_5 /ha under semi-arid conditions of Hissar. Whereas, that lowest (106.0 q/ha) green fodder yield of oat was found under control.

Choudhary and Prabhu (2016) observed that graded application of fertilizers from 75 to 125 per cent RDF improved the green fodder yield of oat by 17.7 per cent.

Hembram and Kundu (2016) carried out an experiment at West Bengal and found that the highest green forage yield (376.00 q/ha) of fodder oat was obtained with the application of GM + 25 per cent N FYM + 50 per cent NPK inorganic.

Saha *et al*. (2020) revealed that the highest green biomass yield was achieved from the treatment with 100% NPK + FYM@ 10 t/ha + $ZnSO_4$ @20 kg/ha + Borax @ 10 kg/ha.

Anjum *et al*. (2022) concluded that maximum green forage yield (72.1 t ha) was observed under treatment (T_4) 50% RDF + 5 t ha^{-1} Farmyard Manure + seed inoculation azotobacter.

Mary *et al*. (2022) carried out a field experiment at Imphal, Manipur and found that application of 75% RDF along with 2t Poultry manure ha^{-1} (T_3) recorded maximum green forage yield (475.50 q ha^{-1}).

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Kumari*et al*. (2023) observed that the inorganic nutrient management (28.04 t/ha) resulted in significantly higher green fodder yields of oat, which was statistically at par with integrated nutrient management treatment (26.30 t/ha) comprised of FYM @ 5 t/ha + 50 percent of recommended dose of fertilizers.

Dry biomass yield (q/ha)

Working under temperate conditions of Kashmir, Hasan and Shah (2000) reported the significant increase in dry fodder yield of oats with 160 kg N/han. While Suhrawardy and Kalita (2001) recorded the highest dry fodder yield of oats with fertility level 80 kg N+ 20 kg P_2O_5 + 20 kg K_2O/ha.

Kakol *et al*. (2003) working under Dharwad condition recorded significant and consistent increase in the dry matter yield (7.01 t/ha) of oats with increase in nitrogen application up to 150 kg/ha.

Application of 120 kg N + 60 kg P_2O_5 + 30 kg K_2O /ha significantly increased 31.33 percent of dry fodder yield of oats over sole nitrogen (Dadheech *et al*. 2005).

While Sharma and Verma (2005) reported that the green fodder and dry matter yield in oats recorded significant and consistent increase with increase in the level of nitrogen from 50 to 150 kg/ha. Further, phosphorus application at 40 kg/ha, although at par with 60 kg /ha, recorded significant increase in green fodder yield over 20 kg P_2O_5 /ha, whereas dry matter yield remained unaffected with different phosphorus levels.

Bhilare and Joshi (2008) conducted a field experiment at Pantnagar and revealed that the application of 160 kg N /ha produced the highest dry matter yield (83.7 q/ha) of fodder oat which was at par with 120 kg N/ha(81.1 q/ha). Similarly Pathan and Bhilare (2009) from Rahuri observed that, the application of 120 kg N/ha produced significantly highest dry matter yield (56.20 q/ha).

Khanday *et al*.(2009) reported that seed and straw yields of oat increased significantly upto15 t/ha of FYM application under temperate conditions of Kashmir.

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Malik and Paynter (2010) working in Australia reported that combined application of 80 kg N + 100 kg K ha recorded the highest hay yield of oats compared to other N and K levels.

Ahmad *et al*. (2011) reported from Faisalabad that among the different sources of fertilizers recommended dose of inorganic fertilizers 150 kg N+60 kg P_2O_5 /ha produced significantly highest dry matter per tiller (5.01g) of oat which was closely followed by the treatment 112 kg N + 45 kg P_2O_5 + 750 kg poultry manure /ha(4.55g) and 112 kg N + 45 kg P_2O_5 + 1000 kg FYM /ha (4.36g).

Godara *et al.* (2012) reported that significantly highest dry matter yield of oat was found when 100 per cent RDF was applied with 5 t vermicompost /ha.

Aalum *et al*. (2013) pastulate that the highest fertility level of 150 kg N +70 kg P_2O_5+40 kg K_2O /ha significantly improved the oats yield with 5.63 per cent over 125 kg N +60 kg P_2O_5+30 kg K_2O /ha when grown under temperate zone of Kashmir.

Iqbal *et al.* (2014) found that significantly highest dry matter yield (8.9 tons /ha) of oat was found by application of 100 per cent N from urea and it was closely followed by application of 50 per cent nitrogen from urea and 50 per cent nitrogen from poultry manure.

Deva (2015) while conducted a field experiment at Raipur found that plots fertilized with 100 per cent RDF + Bio-fertilizers recorded the maximum dry fodder yield (77.57 q/ha) of oat. Jat *et al.* (2015) carried out an experiment at Sardar Krushinagar and found that application of 125 kg N/ha + 75 kg P_2O_5 /ha resulted in highest dry fodder yield of oat.

Verma and Jeengar (2015) reported that balanced fertilization had significant effect on dry fodder yield of oat and found that significantly highest dry fodder yield was found in oats with the application of 100 per cent NPK (120 kg N + 60 kg P_2O_5 + 30 kg K_2O /ha), under arid conditions of Rajasthan.

Malik *et al.* (2015) carried out an experiment at Hisar and obtained significantly highest dry matter accumulation (93.80 g/m) under 120 kg N+60 kg P_2O_5 /hawhereas, the significantly lowest dry matter accumulation (20.8 g/m) of oat was found under control. Graded application of fertilizers from 75 to 125 per cent of RDF improved dry fodder yield of oat by 18.4 per cent (Chaudhary and Prabhu 2016).

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Hembram and Kundu (2016) carried out an experiment at West Bengal and found highest dry matter yield (62.125 q /ha) of oats with the application of GM+25 per cent N FYM+50 per cent NPK inorganic.

Verma *et al*. (2016) studied the effect of FYM on yield and nutrient uptake of oat and obtained significantly highest yield of fodder oat with the application of 10 t FYM /ha under Navsari, Gujarat conditions.

Kashyap *et al.* (2017) carried out an experiment at Lucknow and found that maximum grain yield (34.9 q/ha) of oat was recorded with NPK (80:40:40 kg /ha) which was significantly higher than all the treatments except NPK (40:20:20 kg/ha) + FYM (10 t /ha).

Saha *et al*. (2020) revealead that the highest dry biomass yield was achieved from the treatment with 100% NPK + FYM@ 10 t/ha + $ZnSO_4$ @20 kg/ha + Borax @ 10 kg/ha.

Anjum *et al*. (2022) concluded that maximum dry matter yield (11.8 t ha^{-1}) was observed under treatment (T_4) 50% RDF + 5 t ha^{-1} Farmyard Manure + seed inoculation azotobacter.

Mary *et al*. (2022) carried out a field experiment at Imphal, Manipur and found that application of 75% RDF along with 2 t Poultry manure ha^{-1} (T3) recorded maximum dry fodder yield (91.31 q ha^{-1}).

Kumari*et al*. (2023) observed that the inorganic nutrient management gavesignificantly higher dry fodder yields (5.49 t/ha) of oat, which was statistically at par with integrated nutrient managementtreatment (5.15 t/ha) comprised of FYM @ 5 t/ha + 50 percent of recommended dose of fertilizers.

Effect on quality parameters

Singh and Dubey (2008) reported that addition of FYM @ 5t /haalong with seed inoculation with *Azotobacter* improved the quality of fodder oat with respect to protein content and digestibility.

Godara *et al.* (2012) conducted a field experiment at Ajmer, Rajasthan and found that the highest crude protein yield of fodder oat was recorded in those treatments where 100 per cent RDF+ 5t of vermicompost was used and it was followed by 75 per cent RDF+ 5t vermicompost.

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Waheed *et al*. (2012) found that in fodder oats the maximum crude protein (10.76 per cent) was produced in those treatment where inorganic sources (N: P_2O_5 @ 150:60 kg /ha) of fertilizers were applied followed by treatments where combination of inorganic and organic sources of fertilizer were used i.e., N:P_2O_5 @ 112:45 kg/ha+ poultry manure @ 750 kg/ha and N:P_2O_5 @ 112:45 kg/ha + Farm yard manure @ 1000 kg/ha respectively.

Khan *et al*. (2013) pastulated that maximum crude protein (10.10 per cent) in oat was recorded where 100 per cent inorganic fertilizers were used while minimum crude protein (5.3 per cent) was produced where 100 per cent organic treatments were applied.

Dubey *et al*. (2013) conducted a field experiment at Jabalpur, (M.P) and reported that, increased levels of nitrogen up to 120 kg N/ha produced the significantly highest crude protein yield (9.38 kg/ha) in fodder oat Jehangir *et al*. (2013) also reported the similar results.

Iqbal *et al.* (2014) found the better quality of forage oat in terms of crude protein percentage by application of 100 per cent N from urea which was followed by application of 50 per cent nitrogen from urea and 50 per cent nitrogen from poultry manure.

Khan *et al*. (2014) recommended that for higher nutritive values in oat the integrated application of organic and inorganic fertilizers in the ratio of 50 per cent inorganic and 50 per cent organic is to be applied.

Ratan *et al.* (2016) reported that the application of nitrogen up to 80 kg/ha resulted in significant increase of crude protein content and fodder yield of oat over control. Further they reported that increase in the dose up to 120 kg N/ha could not show any significant improvement in content and yield of crude protein.

Dahipahle *et al*. (2017) found that significantly highest values of crude protein, crude fiber, Acid Detergent Fiber and Neutral Detergent Fiber by oat were recorded with the application of 100 kg N/ha.

Pandey *et al*. (2020) revealed that application of 75% NPK + 2.5 t Vermicompost ha^{-1} +10 kg Mn + 20 kg S ha^{-1} gave highest protein content (9.44%) being at par with 100% NPK (9.50%) and 75% NPK + 2.5t Vermicompost ha^{-1}+ 20 kg S ha^{-1} (9.38%) and maximum value of protein

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yield (602 kg ha^{-1}) proved significantly superior to other treatments in respect of protein content and yield.

Saha *et al*. (2020) revealed that the combined application of $ZnSO_4$ and Borax at their higher rates (20 kg/ha and 10 kg/ha, respectively) along with 100% NPK + FYM @ 10t/ha exhibited the highest nitrogen content and crude protein percent.

Anjum *et al*. (2022) concluded that highest crude protein (10.22%), total ash (34.6%) and ether-extractable fat (4.5%) was observed under treatment (T_4) 50% RDF + 5 t ha^{-1} Farmyard Manure + seed inoculation azotobacter.

Yadav *et al*. (2022) revealed that inclusion of legume (cowpea) in the rotation and integrated application of organic and inorganic sources of nutrients via 75% recommended dose of fertilizer (RDF)+Zn + plant growth promoting rhizobacteria (PGPR)+residual farm yard manure (R-FYM) and 100%RDF + Zn + R-FYM significantly increased the productivity and primary fodder quality traits- Crude protein (CP), ether extract (EE) and total ash yield.

Effect on soil properties

Agrawal *et al*. (2000) carried out an experiment on clay loam soil of Jabalpur and stated that an addition of organics either in the form of FYM or vermicompost @ 10 t/ha enhanced the organic carbon content of soil and make it porous by reducing the bulk density. Ahmad *et al*. (2011) reported from Faisalabad that it is better to use inorganic sources as they were more effective and quick in response while organic sources were more environmental friendly than inorganic sources.

Khan *et al*. (2014) reported that the application of organic materials with inorganic fertilizer maintains soil fertility and also helps in proper nutrition of crop.

Singh *et al*. (2015) while working on experiment at Lucknow found that application of 10 t FYM half NPK slightly decreased the pH from 8.5 to 8.4, electrical conductivity from 0.32dS/m to 0.22 dS/m but effectively increased the organic carbon status from 3.7 g/kg to 3.8 g/kg.

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Kumar *et al*. (2017) reported that integrated nutrient management (INM) improved crop productivity and soil fertility status rather than mineral fertilizers alone and found that judicious use of manures and fertilizers in integrated manner is best alternative for maintaining crop productivity, while maintaining soil fertility status in forage crops. He further reported that, organic manures has been found to be promising in arresting the decline in productivity through correction of deficiency of secondary and micronutrients and influencing the physical and biological properties of soil.

Kumar *et al.* (2017) indicated that the application of chemical fertilizers integrated with organic manures in equal proportion improved the nutrient status of soil.

Pandey *et al*. (2020) observed that highest amount of soil organic carbon (4.4 g kg^{-1}), N content (185.6 $kgha^{-1}$), P content (16.5 $kgha^{-1}$), K content (134.5 $kgha^{-1}$), in post harvest soil was noted with 75% NPK+2.5t Vermicompost +10kg Mn+20 kg S and inclusion of S and Mn also enhanced their uptake by oat crop under semi-arid condition of Agra region of Uttar Pradesh.

Effect on nutrient uptake

Bhat *et al*. (2000) reported that total nitrogen (110.3 kg/ha), phosphorus (10.6 kg/ha) and potassium (213.2 kg/ha) uptake was significantly highest in oat with150 kg N/ha followed by 120 and 90 kg N/ha under temperate Kashmir.s

Sharma (2009) reported that nitrogen, phosphorus and potassium uptake in fodder oats increased significantly and consistently from 82.8 to 158.2, 19.5 to 42.6 and 42.4 to 79.0 kg/ha with increase in nitrogen application from 0 to 150 kg/ha, respectively.

Devi *et al*. (2010) concluded that vermi-compost @ 10 t/haresulted in the maximum nutrient uptake of fodder oat followed by FYM @ 10 t/ha.

Verma *et al.* (2016) reported from Gujarat that application of 10 t/ha FYM increased the nutrient uptake of oat crop over control treatment. They further suggested, this increase in uptake is might be due to improved physical, chemical and biological properties of soil by the addition of FYM and this improve the root growth and development and thereby uptake of nutrients.

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Kumar *et al.* (2017) indicated that the application of chemical fertilizers integrated with organic manures in equal proportion improved the nutrient status of soil.

Pandey *et al*. (2020) revealed that the uptake of N,K, S and Mn by oat crop was highest at 75% NPK+2.5t Vermicompost +10kg Mn+20kg S ha^{-1} and lowest in control. Phosphorus uptake by the crop was recorded maximum with 100% NPK alone.

Dinesh *et al*. (2021) carried out a field experiment and found that application of 75% RDF + PGPR + Panchagavya spray and 50% RDF +25% FYM+ PGPR + Panchagavya spray significantly enhanced the nutrient content and uptake of fodder oats over the control.

Effect on relative economics

Singh *et al*. (2005) obtained the highest net returns of Rs. 13,360 /ha and B: C ratio of 2.07 in oat by the application of nitrogen up to 80 kg/ha along with seed inoculation with azotobactor as well as addition of FYM @ 5 t/ha.

Khanday *et al.* (2009) reported the highest net returns of Rs.33,840 with 15 t FYM/ha followed by 20 t FYM/ha (Rs.32,112.7) and 10 t FYM/ha (Rs.30,792.5).

Jha *et al*. (2012) conducted a field investigation at Jabalpur (M.P.) and found that application of nitrogen @120 kg N/ha resulted in highest B: C ratio of 5.18 than other levels (0, 40, 80 kg N/ha) in fodder oat.

Iqbal *et al*. (2014) carried out an experiment at Faisalabad, Pakistan and found that 100 per cent N from urea exhibited maximum benefit-cost ratio (2.80) with net returns of Rs.123, 262 followed by 50 per cent N from poultry manure +50 per cent N from urea with benefit-cost ratio of 2.40 and net returns of Rs.92,906 in fodder oat.

Deva *et al*. (2014) reported that the under nutrient management, application of 100 per cent RDF+ bio-fertilizers recorded the maximum net realization of Rs 16,343 and B: C ratio of 1.47 in oat.

Malik *et al*. (2015) carried out an experiment at Hisar and found that highest net returns (Rs.27, 713/ha) of oats was obtained under 120 kg N+60 kg P_2O_5 /haand this decreased with decrease in fertility levels and the lowest net returns (Rs.13,550/ha) was recorded under control.

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Choudhary and Prabhu (2016) compared different fertility gradients on oat varieties in IGFRI-Jhansi and revealed that plots where 125 per cent RDF was used were economically more feasible by fetching the net returns and B: C ratio of Rs 18,780 and 1.13 respectively compared to 75 per cent RDF and 100 per cent RDF with net returns and B: C ratio of 18,780 and 1.13, respectively.

Dabhi *et al.(*2017) conducted an experiment at Anand, Gujarat and found that the highest net realization of Rs 46,913/ha and highest B: C ratio value of 2.75 was recorded in fodder oat with application of 120 kg N/ha.

Mary *et al*. (2022) carried out a field experiment at Imphal, Manipur and observed that the highest net monetary returns (60562 Rs ha^{-1}) with B: C ratio (2.75) were also recorded with the application of 75% RDF (60:40 NP) kg ha^{-1} along with 2 t poultry manure ha^{-1} .

Kumari *et al*. (2023) observed that the inorganic nutrient management obtained highest net returns of (₹ 54610) per ha followed by integrated nutrient management treatment of FYM @ 5 t/ha + 50 percent of recommended dose of fertilizers (₹ 40751 per ha).

CONCLUSION

From above researcher work it may be concluded to encourage farmers for use of Integrated nutrient management techniques in fodder oat for better yield, quality and profitability.

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