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Productivity and Profitability of Fodder oat (*Avena sativa* L.) as Affected by Integrated Nutrient Management: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Fodder oats (*Avena sativa* L.) is 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 integrated nutrient management in fodder oats cultivation. Organic inputs such as farmyard manure, compost, and green manure enhance soil quality while inorganic

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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 the application of Farmyard Manure @ 5 t/ha + 50 percent of the 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}. Higher net returns per ha were obtained by integrated nutrient management treatment of FYM @ 5 t/ha + 50 percent of the 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 the yield and quality of fodder oat besides enhancing profitability.

Keywords: Integrated nutrient management; nutritional quality; soil health; productivity; farmyard manure; green manure.

1. 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 cover certain times of the year when there are shortages [1]. 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 [2]. 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 [3]. 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 [4]. 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 [5]. 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 [6].

2. EFFECT OF INTEGRATED NUTRIENT MANAGEMENT

2.1 Effect on Growth Characters

2.1.1 Plant height (cm)

Bhilare and Joshi [7] reported “a significant increase in the plant height (158.6 cm) with an increase in levels of nitrogen from 0 to 160 kg/ha in fodder oat under Pantnagar conditions”.

Pathan and Bhilare [8] conducted “a field experiment at Rahuri and observed a significant increase in plant height (129.70 cm) of fodder oat with an increase in nitrogen levels up to 120 kg N/ha”.

Ahmad et al. [9] “while experimenting in Faisalabad, Pakistan put forth that the 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. [10] conducted a field experiment at Ajmer, Rajasthan and revealed that the 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 percent RDF +10t FYM (105.7 cm) seed inoculation with azotobacter whereas, significantly lowest plant height was recorded in treatment 100 percent RDF.

Roshan et al. [11] reported from Madhya Pradesh that increasing nitrogen levels up to 120 kg N/ ha significantly increased the plant height of oats (145.3 cm) at 50 percent flowering stage.

Khan et al. [12] reported that the significantly highest plant height (118.3 cm) of oat was observed with 100 percent organic as compared to other treatments of organic fertilizers under agroclimatic conditions of Peshawar, Pakistan.

Iqbal et al*.* [13] carried out an experiment at Faisalabad, Pakistan and found that significantly highest plant height (140.33 cm) was obtained with the application of 100 percent N from urea which was closely followed by the application of 50 percent nitrogen from urea and 50 per cent nitrogen from poultry manure.

Raj and Vyakaranahal [14] experimented Dharwad. They found that the significantly highest plant height (34.73cm) was recorded at 45 DAS with an 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. [15] reported from Lucknow that the 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 [16] while conducting a field experiment at the Alluvial zone of West Bengal recorded significantly highest plant height of oat (128.30cm) with GM+ 25 percent N FYM+50 percent NPK inorganic which was closely followed by GM+ 25 percent N FYM+ 50 percent Biofertilizer whereas, the lowest plant height (115.67cm) was found in control.

Kashyap et al*.* [17] reported that significantly highest plant height (54.8 cm) was recorded with NPK (80:40:40 kg /ha) which was statistically at par with a half dose of NPK + FYM + *PSB* + *Trichoderma* at 30 days after sowing (DAS) at Lucknow.

Biswas et al. [18] conducted research at Bidhan Chandra Krishi Viswavidyalaya and revealed that the highest plant height (99.4 cm) was recorded when 75% N through urea + rest N through vermicompost was applied

Pandey et al. [19] studied the effect of integrated nutrient management on the productivity of oats. They 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. [6] 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. [20] observed that “significantly taller plants (70.0 cm) produced with inorganic nutrient management which remained statistically at par with integrated nutrient management treatment (66.5 cm), which comprised of FYM @ 5 t/ha + 50 percent of the recommended dose of fertilizers”.

2.1.2 No. of tillers /m^2

Hasan and Shah [21] concluded that “with the increase in nitrogen levels the number of tillers/plants increased in oats”. While Chellamuthu et al. (2000) reported that “the 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. [9] while experimenting in Faisalabad, Pakistan found that a 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. [11] experimented with 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 percent flowering stage.

Dubey et al. [22] conducted an experiment at Jabalpur (M.P) and evaluated the effect of nitrogen levels on green fodder yield of oats (*Avena sativa* L.) and revealed that increasing the level of nitrogen doses up to 120 kg /ha increased the number of tillers (416.30 /m^2).

Singh et al. [15] while working on fodder oat at Lucknow found that the 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. [23] while experimenting 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 [24] 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 /ha in foddesr oat, under Udaipur, Rajasthan.

Kashyap et al. [17] 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. [25] 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. [6] 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.

2.1.3 Green biomass yield (q/ha)

Working under Assam conditions, Suhrawardy and Kalita [26] 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. [27] 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 [28]. Whereas Singh and Dubey [29] reported significant increase in the green fodder yield of oats with increase in nitrogen rates up to 80 kg/ha.

Bhilare and Joshi [7] 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/ha significantly 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 [8] 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. [10] 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. [22] 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. [30] 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.

Aalum et al. [31] 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/ha under temperate conditions of Kashmir”.

Devi et al. [32] 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 [33] 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 [24] 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. [34] 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 [35] 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 [16] 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. [25] 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. [6] 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. [1] 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})”.

Kumari et al. [20] 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”.

2.2 Dry Biomass Yield (q/ha)

Working under temperate conditions of Kashmir, Hasan and Shah [21] reported the a significant increase in dry fodder yield of oats with 160 kg N/ha n. While Suhrawardy and Kalita [26] recorded the highest dry fodder yield of oats with a fertility level of 80 kg N+ 20 kg P_2O_5 + 20 kg K_2O/ha.

Kakol et al. [27] working under Dharwad condition recorded a significant and consistent increase in the dry matter yield (7.01 t/ha) of oats with an 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 [28].

While Sharma and Verma [36] reported that the green fodder and dry matter yield in oats recorded a significant and consistent increase with an 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 a 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 [7] 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 [8] from Rahuri observed that, “the application of 120 kg N/ha produced significantly highest dry matter yield (56.20 q/ha)”.

Khanday et al. [37] reported that seed and straw yields of oats increased significantly upto15 t/ha of FYM application under temperate conditions of Kashmir.

Malik and Paynter [23] working in Australia reported that a 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. [9] 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. [10] reported that the significantly highest dry matter yield of oats was found when

100 per cent RDF was applied with 5 t vermicompost /ha.

Aalum et al. [31] postulate 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. [13] found that the significantly highest dry matter yield (8.9 tons /ha) of oat was found by application of 100 percent N from urea and it was closely followed by the application of 50 percent nitrogen from urea and 50 percent nitrogen from poultry manure.

Deva [38] while conducting 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) experimented Sardar Krushinagar and found that the application of 125 kg N/ha + 75 kg P_2O_5 /ha resulted in highest dry fodder yield of oats.

Verma and Jeengar [24] reported that balanced fertilization had a significant effect on the dry fodder yield of oat and found that the 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. [23] 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 /ha whereas, the significantly lowest dry matter accumulation (20.8 g/m) of oat was found under control. Graded application of fertilizers from 75 to 125 percent of RDF improved dry fodder yield of oat by 18.4 percent [35].
Hembram and Kundu [16] experimented West Bengal and found the highest dry matter yield (62.125 q /ha) of oats with the application of GM+25 percent N FYM+50 percent NPK inorganic.

Verma et al. [39] studied the effect of FYM on yield and nutrient uptake of oat and obtained the significantly highest yield of fodder oat with the application of 10 t FYM /ha under Navsari, Gujarat conditions.

Kashyap et al. [17] experimented with Lucknow and found that the 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. [25] revealed 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. [6] 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. [1] 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. [20] observed that the inorganic nutrient management gave significantly higher dry fodder yields (5.49 t/ha) of oat, which was statistically at par with integrated nutrient management treatment (5.15 t/ha) comprised of FYM @ 5 t/ha + 50 percent of the recommended dose of fertilizers.

3. EFFECT ON QUALITY PARAMETERS

Singh and Dubey [29] reported that the addition of FYM @ 5t /ha along with seed inoculation with *Azotobacter* improved the quality of fodder oat concerning protein content and digestibility.

Godara et al. [10] 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 percent RDF+ 5t of vermicompost was used and it was followed by 75 percent RDF+ 5t vermicompost.

Waheed et al. [40] found that in fodder oats the maximum crude protein (10.76 per cent) was produced in those treatments where inorganic sources (N: P_2O_5 @ 150:60 kg /ha) of fertilizers were applied followed by treatments where the 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. [30] postulated 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 percent organic treatments were applied.

Dubey et al. [22] 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. [13] found a better quality of forage oats in terms of crude protein percentage by application of 100 percent N from urea which was followed by application of 50 percent nitrogen from urea and 50 percent nitrogen from poultry manure.

Khan et al. [12] recommended that for higher nutritive values in oat the integrated application of organic and inorganic fertilizers in the ratio of 50 percent inorganic and 50 percent organic is to be applied.

Ratan et al. [41] reported that the application of nitrogen up to 80 kg/ha resulted in a significant increase in crude protein content and fodder yield of oats over control. Further they reported that an increase in the dose up to 120 kg N/ha could not show any significant improvement in the content and yield of crude protein.

Dahipahle et al. [42] 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. [19] 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 yield (602 kg ha^{-1}) proved significantly superior to other treatments in respect of protein content and yield.

Saha et al. [25] 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. [6] concluded that the 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. [43] 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.

4. EFFECT ON SOIL PROPERTIES

Agrawal et al. [44] experimented on the 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 making it porous by reducing the bulk density. Ahmad et al. [9] 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 environmentally friendly than inorganic sources.

Khan et al. [12] reported that the application of organic materials with inorganic fertilizer maintains soil fertility and also helps in the proper nutrition of crops.

Singh et al. [15] 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.

Kumar et al. [45] reported that an 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 the best alternative for maintaining crops productivity, while maintaining soil fertility status in forage crops. He further reported that, organic manures is 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. [46] indicated that the application of chemical fertilizers integrated with organic

manures in equal proportion improved the nutrient status of soil.

Pandey et al. [19] observed that highest amount of soil organic carbon (4.4 g kg^{-1}), N content (185.6 kg ha^{-1}), P content (16.5 kg ha^{-1}), K content (134.5 kg ha^{-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.

5. EFFECT ON NUTRIENT UPTAKE

Bhat et al. [47] 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 [48] 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 an increase in nitrogen application from 0 to 150 kg/ha, respectively.

Devi et al. [49] concluded that vermi-compost @ 10 t/ha resulted in the maximum nutrient uptake of fodder oat followed by FYM @ 10 t/ha.

Verma et al. [39] reported from Gujarat that the application of 10 t/ha FYM increased the nutrient uptake of oat crops over the control treatment. They further suggested, that this increase in uptake might be due to improved physical, chemical and biological properties of soil by the addition of FYM and this improves the root growth and development and thereby uptake of nutrients.

Kumar et al. [45] indicated that the application of chemical fertilizers integrated with organic manures in equal proportion improved the nutrient status of soil.

Pandey et al. [19] 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.

6. EFFECT ON RELATIVE ECONOMICS

Singh et al. [50] obtained the highest net returns of Rs. 13,360 /ha and B: C ratio of 2.07 in oats by the application of nitrogen up to 80 kg/ha along with seed inoculation with azotobactor as well as the addition of FYM @ 5 t/ha.

Khanday et al. [37] 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. [51] conducted a field investigation at Jabalpur (M.P.) and found that application of nitrogen @120 kg N/ha resulted in the highest B: C ratio of 5.18 than other levels (0, 40, 80 kg N/ha) in fodder oat.

Iqbal et al. [13] experimented Faisalabad, Pakistan and found that 100 percent N from urea exhibited a maximum benefit-cost ratio (2.80) with net returns of Rs.123, 262 followed by 50 percent N from poultry manure +50 percent N from urea with a benefit-cost ratio of 2.40 and net returns of Rs.92,906 in fodder oat.

Deva et al. [38] reported that under nutrient management, the application of 100 percent RDF+ bio-fertilizers recorded the maximum net realization of Rs 16,343 and B: C ratio of 1.47 in oat.

Malik et al. [34] carried out an experiment at Hisar and found that the highest net returns (Rs.27, 713/ha) of oats were obtained under 120 kg N+60 kg P_2O_5 /ha and this decreased with a decrease in fertility levels and the lowest net returns (Rs.13,550/ha) was recorded under control.

Choudhary and Prabhu [35] compared different fertility gradients on oat varieties in IGFRI-Jhansi and revealed that plots where 125 percent 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 percent RDF and 100 per cent RDF with net returns and B: C ratio of 18,780 and 1.13, respectively.

Dabhi et al. [52] experimented in 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 an application of 120 kg N/ha.

Mary et al. [1] 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. [20] observed that the inorganic nutrient management obtained the highest net returns of (54610) per ha followed by integrated nutrient management treatment of FYM @ 5 t/ha + 50 percent of the recommended dose of fertilizers (40751 per ha).

7. CONCLUSION

From the above researchers work it may be concluded that farmers for use Integrated nutrient management techniques in fodder oats for better yield, quality and profitability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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