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INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON QUALITY, PLANT NUTRIENT UPTAKE AND RESIDUAL SOIL FERTILITY OF FODDER OAT (*AVENA SATIVA* L.)

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ABSTRACT

A field experiment was conducted at Agronomy field, College of Agriculture, Central Agricultural University, Imphal (Manipur) during the *Rabi* season of 2021-22 with the objectives to study the effect of chemical fertilizer, poultry manure and their integration on fodder quality, plant nutrient uptake and post-harvest soil fertility. The experiment was replicated thrice and employed a randomized block design (RBD) with seven treatments. To verify the objectives, the plant and soil samples were analysed and recorded. The results of the experiment revealed that there was significant variation among the different treatments. The maximum crude protein content (11.88%) and crude protein yield (10.85 q ha^{-1}), nitrogen content (1.9%), potassium content (1.37%), NPK uptake by plant and available NPK in residual soil were recorded in the treatment with the application of 75% RDF (recommended dose of fertilizer) along with 2 t poultry manure ha^{-1}. Whereas the minimum crude protein content, crude protein yield, plant nutrient content and NPK uptake were observed in the treatment where only 1 t of Poultry Manure ha^{-1} was applied and the minimum available NPK in residual soil were recorded in the treatment T_1 where the crop received only chemical fertilizers. On the basis of the above findings, it can be concluded that integrated nutrient management involving 75 % RDF along with 2 t PM ha^{-1} was found to be the most effective in terms of quality, plant nutrient uptake and improved soil fertility for fodder oat cultivation compared to sole application of poultry manures or chemical fertilizers.

***Key words*:** Fodder oat, Quality, Nutrient uptake, Residual soil fertility, INM.

Introduction

Besides agriculture, livestock plays a pivotal role in enhancing the country's economic status and the increase in livestock population will also affect the availability of organic wastes which in turn can boost agricultural production. To maintain good health and potential of animals in terms of draught, milk, meat and wool, feeding of good quality fodder is highly important. However, one of the major problems behind the low production and productivity of livestock is due to unavailability of nutritious feeds during the lean period. There is a need to abridge this vast gap between demand and supply of the fodder by increasing fodder acreage and fodder productivity per unit area per unit time. Oat can be cultivated successfully in fallow lands along with proper nutrient management for obtaining maximum yield from the available area.Oat forage can be used as green fodder, straw, hay or silage.It provides soft and palatable fodder rich in crude protein (10-12%), fat, vitamin B-1 and minerals such as phosphorus and iron. Oat being a fast growing and high yielding fodder crop, it requires a large quantity of nitrogenous fertilizers for enhancing production of quality herbage and the growth of fodder oat is directly related to the nutrient supply (Singh and Dubey, 2007). However, application of high dose of nitrogenous fertilizers leads to soil and water pollution in the long run and can also raise the possibilities of nitrate hazards to livestock. Hence, a judicious combination of chemical fertilizers and organic manures can be of vital importance in order to achieve optimum and quality yield of fodder oats and maintain soil fertility status in crops.Balanced fertilizer use along with organic manure is considered as promising agro-technique to sustain yield, increase fertilizer-use efficiency and restore soil fertility (Verma *et al.,* 2016). Different types of organic manures like crop stubbles, animal urine, poultry manure, compost and biochar, when added to soil results increase in microbial population which ultimately improve in soil health as well as the sustainability of the soil is achieved (Sharif *et al*., 2003). It was also reported that compared to other organic manure sources, poultry manure is more readily provides phosphorus to plants (Garg and Bahla, 2008).

Keeping all the above points in view, the research was conducted with the following objectives to assess the effect of chemical fertilizer, poultry manure and their integration on fodder quality, plant nutrient uptake and post-harvest soil fertility.

Materials and Methods

A field experiment was conducted at Agronomy field, College of Agriculture, Central Agricultural University, Imphal (Manipur) during the *Rabi* season of 2021-22. The soil of the experimental field was clayey in texture, acidic in reaction (5.47 pH) with high organic carbon content (1.14%), medium in available nitrogen (284.77 kg ha^{-1}), medium in available P_2O_5 (21.65 kg ha^{-1}) and medium in available K_2O (215.08 kg ha^{-1}). The experiment was laid out in a randomized block design (RBD) with three replications consisted of seven treatments *viz*., 100% RDF (60:40 NP) kg ha^{-1} (T_1), 75% RDF + 1 t Poultry manure ha^{-1} (T_2), 75% RDF + 2 t Poultry manure ha^{-1} (T_3), 50% RDF + 1 t Poultry manure ha^{-1} (T_4), 50% RDF + 2 t Poultry manure ha^{-1} (T_5), 1 t Poultry manure ha^{-1} (T_6) and 2 t Poultry manure ha^{-1} (T_7). Fifty per cent of the different dose of nitrogen and full dose of P_2O_5 were applied as per treatment in the experimental plot just before sowing of the crop as basal dose. Remaining fifty percent nitrogen was applied in two splits - one at 35 DAS and second at 70 DAS. Different doses of poultry manures were applied according to the treatments at the time of final land preparation before sowing. The oat variety gown for study was JHO-822 at a seed rate of 100 kg ha^{-1} and the fodder crop was harvested at 50% flowering. The procedure followed for recording different observations are given below.

1. Crude protein content (%)

The crude protein content in fodder was calculated by multiplying nitrogen content (%) of produce from each plot with a factor 6.25 (A.O.A.C., 2005).

Crude protein content = N content (%) x 6.25

2. Crude protein yield (q ha^{-1})

The dry matter yield in q ha^{-1} was converted into crude protein yield in quintal per hectare on the basis of crude protein content;

$$\text{CPY (q ha}^{-1}\text{)} = \frac{\text{Crude protein \%} \times \text{Dry matter (q ha}^{-1}\text{)}}{100}$$

3. NPK content (%)

Total nitrogen in plant samples was determined by Kjeldahl's method of nitrogen determination as described by Jackson (1973). To analyze phosphorus content, one gram of plant sample and 10 ml of di-acid mixture was digested over a sand bath till a clear colourless solution was obtained. Then a known volume of the digested samples was taken for total phosphorus content determination in fodder oats by adopting the Vanadomolybdophosphoric yellow color method as described by Jackson (1973). The total potassium content was estimated by atomizing the diluted digest to a calibrated flame photometer under suitable measuring conditions as described by Jackson (1973).

4. Plant NPK Uptake (kg ha^{-1})

The uptake of nutrients by fodder oat was worked out for different treatments by multiplying the nutrient content and dry matter yield of fodder oat as given in the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \text{Nutrient concentration (\%)} \times \text{Yield (q ha}^{-1}\text{)}$$

5. Soil analysis

For soil analysis, soil samples were collected randomly prior to commencement of the experiment from the top 20 cm depth from several spots at the experimental site and for post-harvest, soil samples were collected from 0-15 cm depth with the help of soil auger from each experimental plots and samples from three replication were mixed together treatment wise. The samples were dried properly in shade. After grinding, the soil samples were allowed to pass through 2 mm sieve and stored for chemical analysis of soil.

The pH of the experimental soil was determined with digital pH meter by using soil water suspension of 1: 2.5 as described by Jackson (1973). The organic carbon (OC) content was determined as described by Walkley and Black, 1934.The available N content of the soil samples was determined by using the alkaline potassium permanganate method (Subbiah and Asija, 1956). The available phosphorus content of soil was determined by following Bray and Kurtz' method (Jackson, 1973) and the available potassium was extracted from soil using neutral N ammonium acetate at 1:5 soil; the extract ratio and the concentration of potassium present in the extract was determined by using a flame photometer as described by Jackson, (1973).

6. Statistical analysis

All the data pertaining to the present investigation were computed for statistical analysis by using Fischer's method of analysis of variance (ANOVA) and interpreted as out lined by Gomez and Gomez (1984). The level of significance use in 'F' and 'T' tests was 0.05 probability. Standard error of mean and critical differences has been provided. Wherever 'F' ratio was found non-significant the critical difference has not been mentioned but indicated as 'NS'. The interpretation of data was however based on 5% probability levels. Critical difference values were calculated wherever the 'F' test was found to be significant.

Table 1: Effect of integrated nutrient management on crude protein content and crude protein yield of fodder oat.

Treatments	Crude protein content (%)	Crude protein yield (q ha^{-1})
T_1 100% RDF (60:40 NP) kg ha^{-1}	10.44	7.79
T_2 75% RDF + 1 t Poultry Manure ha^{-1}	10.81	8.67
T_3 75% RDF + 2 t Poultry Manure ha^{-1}	11.88	10.85
T_4 50% RDF + 1 t Poultry Manure ha^{-1}	10.06	7.35
T_5 50% RDF + 2 t Poultry Manure ha^{-1}	11.38	9.96
T_6 1 t Poultry Manure ha^{-1}	8.75	4.87
T_7 2 t Poultry Manure ha^{-1}	9.25	6.10
SEm$\pm$	**0.19**	**0.36**
CD (P =0.05)	**0.58**	**1.10**

Results and Discussion

Crude Protein Content (%)

It is evident from the data presented in Table 1 that the crude protein content in fodder oat was significantly higher under INM treatments than 100% RDF (N:P 60:40 kg ha^{-1}) and application of organic manures alone. Maximum crude protein content (11.88 %) was obtained in treatment T_3 (75% RDF + 2 t PM ha^{-1}). However, it was found to be statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) with a value of 11.38 %. While minimum (8.75%) crude protein content was recorded in the treatment T_6 where the crop received only 1 t of poultry manures and was remain at par with T_7 where the crop received 2 t of poultry manures recording 9.25 % of crude protein content. Increase in crude protein content with integrated use of chemical fertilizers and poultry manures might be due adequate availability of nutrients which leads to higher nutrients uptake especially nitrogen being the constituent of amino acids and proteins, and phosphorus being the energy carrier (ATP) for the metabolic processes might have directly contributed to higher photosynthetic activity and higher synthesis of protein content. Therefore, increase in nitrogen content in fodder oat with higher dose of chemical fertilizers along with poultry manures increased synthesis of protein. Similar results were also reported by Bhagade*et al*. (2008) and Yadav *et al.* (2010), Godara*et al*. (2012) and Dabhi*et al*. (2017).

Crude Protein Yield (q ha^{-1})

The data presented in Table 1 indicated that crude protein yield was significantly affected by different treatments of nutrient management. It is observed that application of 75% RDF along with 2 t PM ha^{-1} (T_3) recorded maximum crude protein yield (10.85 q ha^{-1}) and, it was found to be statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) recording 9.96 q ha^{-1}. While minimum (4.87 q ha^{-1}) crude protein yield was recorded in the treatment T_6 where the crop received only organic manures *i.e.*, 1 t PM ha^{-1}. The improvement in quality might be due to adequate availability of nitrogen as it is an essential constituent of chlorophyll, protoplasm, protein and nucleic acids which enhances the protein synthesis and resulted higher crude protein content as well as crude protein yield. Higher CPY might be due to better accumulation of dry matter and crude protein content. This finding was in line with Dhar (2006), who reported that application of 50% RDF (NPK :40:20:0) + 5 t vermicompost ha^{-1} + 5 t FYM ha^{-1} gave significantly higher crude protein yield of fodder oat than other treatments.

Nitrogen content in fodder oat

A perusal of Table 2 indicated that nitrogen content on fodder oat was significantly affected by different treatments of nutrient management. T_3 (75% RDF + 2 t PM ha^{-1}) recorded highest (1.90 %) nitrogen content. However, it was statistically at par with T_5 (50% RDF +2 t PM ha^{-1}), T_2 (75% RDF +1 t PM ha^{-1}) and T_1 (100% RDF *i.e.* 60:40 N: P_2O_5 kg ha^{-1}). Application of only 1 t of poultry manure ha^{-1} (T_6) recorded significantly lower nitrogen content on green fodder oat (1.40%) but it was remained at par with treatment T_7 (2 t PM ha^{-1}) recording 1.48 % nitrogen content.

Table 2: Effect of integrated nutrient management on nutrient uptake of fodder oat.

Treatments	Nitrogen content (%)	Nitrogen uptake (Kg ha^{-1})	Phosphorus content (%)	Phosphorus uptake (Kg ha^{-1})	Potassium content (%)	Potassium uptake (Kg ha^{-1})
T_1 100% RDF (60:40 NP) kg ha^{-1}	1.67	124.68	0.23	17.17	1.15	85.86
T_2 75% RDF + 1 t Poultry Manure ha^{-1}	1.73	138.73	0.22	17.64	1.19	95.43
T_3 75% RDF + 2 t Poultry Manure ha^{-1}	1.90	173.49	0.26	23.74	1.37	125.09
T_4 50% RDF + 1 t Poultry Manure ha^{-1}	1.61	117.61	0.22	16.07	1.09	79.62
T_5 50% RDF + 2 t Poultry Manure ha^{-1}	1.82	159.36	0.25	21.89	1.29	112.95
T_6 1 t Poultry Manure ha^{-1}	1.40	77.91	0.19	10.57	1.08	60.10
T_7 2 t Poultry Manure ha^{-1}	1.48	97.64	0.19	12.53	1.09	71.91
SEm$\pm$	**0.08**	**5.33**	**0.02**	**0.78**	**0.04**	**3.64**
CD (P =0.05)	**0.24**	**16.42**	**NS**	**2.41**	**0.14**	**11.22**

Phosphorus content in fodder oat

Data pertaining to phosphorus content in fodder oat presented in Table 2 was found non-significant as influenced by various treatments of integrated nutrient management, chemical fertilizers and organic manures. However, numerically higher phosphorus content (0.26%) in fodder oat was observed under INM in the treatment T_3 (75% RDF + 2 t PM ha^{-1}) and T_5 (50% RDF +2 t PM ha^{-1}) recording 0.25 % as compared to application of chemical fertilizers alone or poultry manures alone. While the least (0.19 %) phosphorus content were recorded in the treatment T_6 and T_7 where the crop received only 1 t of poultry manures and 2 t of poultry manures, respectively.

Potassium content in fodder oat

The data on Potassium content in fodder oat have been presented in Table 2 and reveals that Potassium content in fodder oat as influenced by various treatments of nutrient managements was found to be significantly affected. T_3 (75% RDF + 2 t PM ha^{-1}) recorded maximum (1.37 %) potassium content. However, it was statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) recording 1.29 % of potassium content. While, application of only 1 t of poultry manure ha^{-1} (T_6) recorded significantly lower potassium content on green fodder oat (1.08 %) but it was remained at par with treatment T_7 (2 t PM ha^{-1}) and T_4 (50% RDF +1 t PM ha^{-1}), recording 1.09% each of potassium content.Higher potassium content in fodder oat under integrated nutrient management might be due to higher yield of fodder oat as a result of better growth and yield attributing characters containing higher availability of potassium to the fodder crop throughout the crop period. The combined application of inorganic fertiliser and poultry manure might have improved mineralization or enhanced the availability of potassium to crops, which in turn directly increased potassium content.

NPK uptake (Kg ha^{-1})

Data presented in Table 2 showed that there were significant variations in nitrogen uptake, phosphorus uptake and potassium uptake as influenced by different treatments of nutrient management. Highest nitrogen uptake (173.49 kg ha^{-1}) was observed in T_3 (75% RDF + 2 t PM ha^{-1}) and was found to be statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) recording 159.36 kg ha^{-1}. While, least nitrogen uptake (77.91kgha^{-1}) was recorded in T_6 (1 t PM ha^{-1}). Similarly, highest phosphorus uptake (23.74 kg ha^{-1}) was recorded in T_3 (75% RDF + 2 t PM ha^{-1}). However, it was found to be statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) recording 21.89 kg ha^{-1}. Whereas, the least phosphorus uptake (10.57 kg ha^{-1}) was found in T_6 (1 t PM ha^{-1}) which was also at par with treatment T_7 (2 t PM ha^{-1}) recording 12.53 kg ha^{-1} of phosphorus uptake. Significantly higher potassium uptake was showed in the treatment where integration of organic and inorganic fertilizers was given over sole application of chemical fertilizers and poultry manures. The maximum potassium uptake (125.09 kg ha^{-1}) was recorded in treatment T_3 (75% RDF + 2 t PM ha^{-1}) while the minimum potassium uptake (60.10 kg ha^{-1}) was observed in T_6 (1 t PM ha^{-1}).

It is evident that NPK uptake by crop increased significantly with increase in higher doses of integrated nutrients application. Similar result was reported by Chaturvedi *et al.* (2020), where nitrogen content and uptake by crop were significantly increased with the increase in nitrogen levels. The higher uptake of NPK might be due higher dry matter yield of fodder oat as a result of higher growth and yield attributes and due to higher NPK content which results in higher nutrient uptake. The findings are in close proximity with Ayeni and Adetunji (2010) and Jehangir *et al.* (2013).

Table 3: Effect of Integrated Nutrient Management on chemical properties of soil after harvest of fodder oat.

	Treatments	Soil pH	OC (%)	Available N (Kg ha^{-1})	Available P_2O_5 (Kg ha^{-1})	Available K_2O (Kg ha^{-1})
T_1	100% RDF (60:40 NP) kg ha^{-1}	5.47	1.13	282.16	30.00	217.06
T_2	75% RDF + 1 t Poultry Manure ha^{-1}	5.48	1.15	311.35	36.56	226.23
T_3	75% RDF + 2 t Poultry Manure ha^{-1}	5.49	1.16	325.17	38.22	230.17
T_4	50% RDF + 1 t Poultry Manure ha^{-1}	5.48	1.15	302.56	35.07	225.46
T_5	50% RDF + 2 t Poultry Manure ha^{-1}	5.49	1.16	316.27	37.16	227.27
T_6	1 t Poultry Manure ha^{-1}	5.48	1.14	285.56	31.34	222.78
T_7	2 t Poultry Manure ha^{-1}	5.49	1.16	297.58	31.72	224.61
	SEm±	**0.02**	**0.01**	**5.29**	**1.17**	**1.37**
	CD (P =0.05)	**NS**	**NS**	**15.92**	**3.59**	**4.22**

Effect of INM on chemical soil properties after harvesting of crop

The data regarding residual soil pH, organic carbon, available nitrogen, phosphorus and potassium in the soil after harvest of the crop as influenced by various treatments are presented in Table 3. The data presented in Table 3 revealed that there was non-significance effect of different treatments of nutrient management including INM on soil pH and organic carbon content of the soil after harvest of oat crop. The data indicated that pH of soil was observed in the range 5.47 to 5.49 pH which is acidic in nature and the organic carbon content of soil was found in the range of 1.13 to 1.16 % in the soil.

From the Table 3, it was revealed that different treatments showed significant residual effect on available NPK in the soil after harvest of the crop. Maximum available nitrogen content (325.17 kg ha^{-1}) was recorded in T_3 (75% RDF + 2 t PM ha^{-1}) and was found to be statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) and T_2 (75% RDF + 1 t PM ha^{-1}) recording 316.27 kg ha^{-1} and 311.35 kg ha^{-1}, respectively. While, the minimum available nitrogen content (282.16 kg ha^{-1}) was recorded in the treatment T_1 where the crop received only chemical fertilizer. However, it was remained at par with T_6 where the crop received only 1 t of poultry manures recording 285.56 kg ha^{-1}.

With the increase dose of poultry manures application, there was increased in available phosphorus content of soil. Maximum available phosphorus content (38.22 kg ha^{-1}) was recorded in T_3 (75% RDF + 2 t PM ha^{-1}). However, it was found to be statistically at par with T_5 (50% RDF + 2 t PM ha^{-1}), T_2 (75% RDF + 1 t PM ha^{-1}) and T_4 (50% RDF + 1 t PM ha^{-1}) recording 37.16 kg ha^{-1}, 36.56kg ha^{-1}, and 35.07 kg ha^{-1}, respectively. While, the minimum available phosphorus content (30.00 kg ha^{-1}) was recorded in the treatment T_1 where the crop received only chemical fertilizers. However, it was remained at par with T_6 where the crop received only 1 t of poultry manures recording 31.34 kg ha^{-1}.

Maximum available potassium content (230.17 kg ha^{-1}) was also observed in T_3 (75% RDF + 2 t PM ha^{-1}) and was found to be statistically at par with T_5 (50% RDF +2 t PM ha^{-1}) and T_2 (75% RDF + 1 t PM ha^{-1}) recording 227.27 kg ha^{-1} and 226.23 kg ha^{-1} respectively. While, the minimum available potassium content (217.06 kg ha^{-1}) was recorded in the treatment T_1 where the crop received only chemical fertilizers.

The status of NPK in soil at harvest was found increased due to integrated nutrient management as compared to initial status of the soil. This might be due to combine application of chemical fertilizers along with poultry manures and the higher buildup of nitrogen, phosphorus and potassium was observed in the plot receiving higher proportion of poultry manures. More NPK nutrient concentration in soil after harvest of crop might be due to prolong availability of nutrient from poultry manures and enhanced mineralization of soil nutrients by creating better soil environment. These results are in accordance with finding of Ayeni and Adetunji (2010) who reported that combined application of NPK fertilizer with poultry manure increased soil nutrients and performance of crop. Similar results are also reported by Dhakal*et al.* (2016) and Naresh *et al.* (2018).

Conclusion

On the basis of the above findings, the treatment 75 % RDF along with 2 t PM ha^{-1} was found to be the most effective in terms of quality, plant nutrient content and uptake for fodder oat cultivation, outperforming sole application of poultry manure or chemical fertilizers. Moreover, it was also observed that incorporating poultry manures with chemical fertilizers increases soil pH, OC and available NPK in the residual soil of the experimental field. Therefore, it can be inferred that integrating chemical fertilizer and poultry manure resulted in better fodder quality, enhanced plant nutrient uptake and improved residual soil fertility compared to sole application of poultry manure or chemical fertilizers.

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