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Effect of integrated nutrient management on yield and economics of fodder oat (*Avena sativa* L.)

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Abstract
A field experiment was carried out during *Rabi* 2021-22 at the Research field of Agronomy, Central Agricultural University, Imphal (Manipur) to assess the effect of chemical fertilizer, poultry manure and their integration on yield of fodder oat and to study the economic feasibility of the different treatments. The experiment was laid out in a randomized block design (RBD) with three replication consisted of seven treatments. The maximum green fodder yield (475.50 q ha^{-1}), dry matter content (19.6%), dry matter yield (91.31 q ha-^{1}), per day productivity of green fodder (5.75 q ha^{-1} day^{-1}) and per day productivity of dry fodder (1.10 q ha^{-1} day^{-1}) were recorded with the application of 75% RDF + 2 t poultry manure ha^{-1} while maximum days taken to 50% flowering was recorded in the treatment which received only 1 t PM ha^{-1}. From economic point of view, 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}. Integrated nutrient management involving 75% RDF + 2 t PM ha^{-1} was found to be the most effective in terms of fodder yield production and economics for fodder oat cultivation as compares to the sole application of poultry manures or chemical fertilizers.

Keywords: Fodder oat, integrated nutrient management, poultry manure, yield, economics

Introduction

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. In Manipur during the winter season, the animals depends mainly on paddy straw and semi-dried standing grasses found in fallow lands leading to poor performance of draught animals and low productivity of livestock. 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. Identification of suitable fodder crops, varieties, suitable cultivation practices and nutrient management are necessary to boost fodder production on marginal and wastelands in the state.

Oat (*Avena sativa* L.) is one of the most important cereal forage crop of *Rabi* season and 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. 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) [16]. 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. The integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards (Ahmad *et al.*, 1996) [1]. Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. Poultry manure improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration in contrast to inorganic fertilizer. (Deksissa *et al.*, 2008) [5]. Therefore, the following research was proposed to study the effect of chemical fertilizer, poultry manure and their integration on yield of fodder oat and the economics of the treatment.

Materials and Methods

A field experiment was conducted at the Reseach field of Agronomy, College of Agriculture, Central Agricultural University, Imphal (Manipur) during the *Rabi* season of 2021-22. The experiment was laid out in a randomized block design (RBD) with three replication 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 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 crop variety 'JHO-822' @ 100 kg ha^{-1} was used for the experimentation with a spacing 20 cm (row-row) and harvesting was done at 50% flowering stage. The green fodder harvested from net plot was weighed and then converted into quintal ha^{-1} to obtain green fodder yield. Simultaneously, a random sample of 500 g was taken from each net plot, chopped well and first dried in sun and then oven dried at 65-70 °C till constant weight. On the basis of these samples, the green fodder yields were converted into dry fodder yields and were expressed as q ha^{-1}. Per day productivity of green fodder and dry fodder yield was obtained by dividing the yield with total number of days taken to harvesting. For the economics, the treatment wise gross monetary returns were worked out by considering the prevailing market prices of the produce during the year of experimentation. Net return was calculated by subtracting cost of cultivation from gross return of the respective treatment and expressed as net returns in Rs.ha^{-1} and the Benefit: Cost ratio of each treatment was worked out by dividing gross return by cost of cultivation of respective treatments. The data recorded from the field was statistically analyzed by using Fischer's method of analysis of variance (ANOVA) and treatment means were compared following critical differences (CD) suggested by Gomez and Gomez (1984) [7] for significance at 5%.

Results and Discussion

Effect of integrated nutrient management on green fodder yield (q ha^{-1}): The data pertaining to the green fodder yield as influence by integrated nutrient management in fodder oat is presented in Table 1 and it is obvious that there was significant variation in green fodder yield due to different treatments. It is observed that application of 75% RDF along with 2 t PM ha^{-1} (T_3) recorded maximum forage yield (475.50 q ha^{-1}) followed by T_5 (455.33 q ha^{-1}), T_2 (438.17 q ha^{-1}), T_1 (424.22 q ha^{-1}), T_4 (419.39 q ha^{-1}), T_7 (389.67 q ha^{-1}) and the minimum green forage yield (359.00 q ha^{-1}) was observed in the treatment where the crop received only organic manures *i.e.* 1 t PM ha^{-1} (T_6). These might be due to high vigour of growth parameters *viz*. plant height, number of tillers, number of leaves, dry matter accumulation and leaf stem ratio. Moreover, it might be due to the fact that the combine effect of inorganic fertilizer along with poultry manures which is rich in nitrogen, phosphorus, potassium and other minerals nutrients increased the growth of the fodder oat which eventually increased the fodder yield. These finding are closely related with the findings of Oad *et al*. (2004) [11] who reported that maize growth parameters were significantly affected with the incorporation of FYM and nitrogen levels and the maximum maize fodder yield was recorded where 120 kg N ha^{-1} along with 3 t FYM ha^{-1} was applied.

Effect of integrated nutrient management on dry matter content (%)

As per the data on the Table 1, it was observed that the dry matter content was affected significantly by different nutrient management. Maximum dry matter content (19.60%) was recorded in the treatment T_3 (75% RDF + 2 t PM ha^{-1}) followed by T_5 (50% RDF + 2 t PM ha^{-1}), T_2 (75% RDF + 1 t PM ha^{-1}), T_1 (100% RDF *i.e.* 60:40 N: P_2O_5 kg ha^{-1}), T_4 (50% RDF + 1 t PM ha^{-1}), T_7 (2 t PM ha^{-1}) and the lowest dry matter content (15.50%) was obtained in T_6 (1 t PM ha^{-1}). However, T_3 (75% RDF + 2 t PM ha^{-1}) was found to be statistically at par with T_5 (50% RDF + 2 t PM ha^{-1}) recording 19.23% dry matter content. This results are in line with Iqbal *et al*. (2014) [8], Pandey (2018) [12] and Yadav and Singh (2018) [17] who reported that incorporation of inorganic fertilizer along with organic sources had positive and significant effect on green forage yield and dry matter yield of oat crop.

Effect of integrated nutrient management on dry matter yield (q ha^{-1})

The data pertaining to the dry matter yield as influence by integrated nutrient management in fodder oat is presented in Table 1 and it is obvious that there was significant variation in dry matter yield due to different treatments. It is observed that application of 75% RDF along with 2 t PM ha^{-1} (T_3) recorded maximum dry fodder yield (91.31 q ha^{-1}) followed by T_5 (87.56 q ha^{-1}), T_2 (80.19 q ha^{-1}), T_1 (74.66 q ha^{-1}), T_4 (73.05 q ha^{-1}), T_7 (65.97 q ha^{-1}) and the minimum dry fodder yield (55.65 q ha^{-1}) was obtained in the treatment where the crop received only organic manures *i.e.* 1 t PM ha^{-1} (T_6). It was observed that dry fodder yield increased with increased in dosage of chemical fertilizers and organic manures and the higher yield of dry fodder produced by the use of poultry manure may be attributable to the continuous mineralization of organic manure, increased soil's ability to naturally supply nutrients, and favourable impacts on the soil's biological characteristics, which raised forage yield. This finding was also supported by Akongwubel *et al.* (2012) [2], Iqbal *et al.* (2014) [8] and Aziz *et al.* (2020) [3].

Table 1: Effect of integrated nutrient management on green forage yield, dry matter content and dry matter yield of fodder oat

Treatments		Green fodder yield (q ha^{-1})	Dry matter content (%)	Dry matter yield (q ha^{-1})
T_1	100% RDF (60:40 NP) kg ha^{-1}	424.22	17.60	74.66
T_2	75% RDF + 1 t Poultry Manure ha^{-1}	438.17	18.30	80.19
T_3	75% RDF + 2 t Poultry Manure ha^{-1}	475.50	19.60	91.31
T_4	50% RDF + 1 t Poultry Manure ha^{-1}	419.39	17.42	73.05

T_5	50% RDF + 2 t Poultry Manure ha^{-1}	455.33	19.23	87.56
T_6	1 t Poultry Manure ha^{-1}	359.00	15.50	55.65
T_7	2 t Poultry Manure ha^{-1}	389.67	16.93	65.97
S.Em+		6.10	0.41	1.05
CD (P =0.05)		18.80	1.25	3.24

Effect of integrated nutrient management on days taken to 50% flowering (Harvesting stage)

As per the data presented on the Table 2, it was revealed that number of days taken to reach 50% flowering stage for harvesting was significantly affected by different nutrient management treatments. Maximum number of days taken to reach 50% flowering was recorded in T_6 (88 days) where the crop received only 1 t PM ha^{-1} which was followed by T_7 (2 t PM ha^{-1}), T_1 (100% RDF) and T_4 (50% RDF + 1 t PM ha^{-1}) recording 85 days each. While minimum days taken (83 days) to reach 50% flowering were observed in the treatment T_3 (75% RDF along with 2 t PM ha^{-1}) and T_5 (50% RDF with 2 t PM ha^{-1}). It is evident from the data (Table 2) that integrated used of inorganic fertilizer and poultry manures took minimum days to 50% flowering stage as compared to sole application of inorganic fertilizer and poultry. This might be due to balanced nutrients supply to the crop throughout its growing period and it was also observed that higher the dosages of inorganic and organic manures applied, lesser is the days to 50% flowering. This result was in close conformity with the findings of Sheoran and Rana (2005) [15] who reported that that application of 10 t ha^{-1} vermicompost or 10 t ha^{-1} FYM along with 75% recommended doses of fertilizers resulted minimum days to 50% flowering stage.

Effect of integrated nutrient management on per day productivity of green fodder yield (q ha^{-1} day^{-1})

It is revealed from data presented in Table 2 that there was significant variation in green fodder yield per day productivity among different treatments. Per day productivity of green fodder yield gradually increased with the advancement in the growth stages of the crop under all treatments but the rate of increase was comparatively maximum in T_3 (5.75 q ha^{-1} day^{-1}) followed by T_5 (5.46 q ha^{-1} day^{-1}), T_2 (5.18 q ha^{-1} day^{-1}), T_1 (4.99 q ha^{-1} day^{-1}), T_4 (4.91 q ha^{-1} day^{-1}), T_7 (4.57 q ha^{-1} day^{-1}) and the minimum per day productivity of green fodder (4.09 q ha^{-1} day^{-1}) was obtained in the treatment where the crop received only 1 t PM ha^{-1} (T_6). These results are closely related to the findings of Oad *et al.* (2004) [11], who found that the application of 3000 kg FYM combined with 120 kg N ha^{-1} greatly increased the output of maize fodder and had a significant impact on the parameters of maize plant growth.

Effect of integrated nutrient management on per day productivity of dry fodder yield (q ha^{-1} day^{-1})

An interpretation of the data given in the Table 2 reveals that different nutrient treatments significantly affected dry fodder yield per day productivity. Significantly higher per day productivity of dry fodder yield was recorded in T_3 (1.10 q ha^{-1} day^{-1}) followed by T_5 (1.05 q ha^{-1} day^{-1}), T_2 (0.95 q ha^{-1} day^{-1}), T_1 (0.88 q ha^{-1} day^{-1}), T_4 (0.86 q ha^{-1} day^{-1}), T_7 (0.77 q ha^{-1} day^{-1}) and the minimum per day productivity of dry fodder yield (0.63 q ha^{-1} day^{-1}) was obtained in the treatment where the crop received only 1 t PM ha^{-1} (T_6). However, T_3 (75% RDF + 2 t PM ha^{-1}) was found to be statistically at par with T_5 (50% RDF + 2 t PM ha^{-1}). Increased productivity could be result of applying nutrients through both inorganic fertiliser and poultry manure, as this treatment produced higher values of growth parameters. The results are in line with the findings of Jayanthi *et al.* (2002) [9], Godara *et al.* (2012) [6] and Chongloi and Sharma (2019) [4].

Table 2: Effect of integrated nutrient management on days taken to harvesting stage, per day productivity of green fodder and dry fodder of fodder oat

Treatments		Days to 50% flowering (Harvesting)	Per day productivity of green fodder (q ha^{-1} day^{-1})	Per day productivity of dry fodder (q ha^{-1} day^{-1})
T_1	100% RDF (60:40 NP) kg ha^{-1}	85.00	4.99	0.88
T_2	75% RDF + 1 t Poultry Manure ha^{-1}	85.00	5.18	0.95
T_3	75% RDF + 2 t Poultry Manure ha^{-1}	83.00	5.75	1.10
T_4	50% RDF + 1 t Poultry Manure ha^{-1}	85.00	4.91	0.86
T_5	50% RDF + 2 t Poultry Manure ha^{-1}	83.00	5.46	1.05
T_6	1 t Poultry Manure ha^{-1}	88.00	4.09	0.63
T_7	2 t Poultry Manure ha^{-1}	85.00	4.57	0.77
S.Em+		0.79	0.08	0.03
CD (P =0.05)		2.42	0.24	0.09

Economics of fodder oat as influenced by different treatment: From the presented data in Table 3, it is observed that the highest total cost of cultivation (Rs 34538 ha^{-1}) was recorded in T_3 (75% RDF + 2 t PM ha^{-1}) followed by T_1 and T_2 with the values of Rs 33258 ha^{-1} and Rs 33163 ha^{-1} respectively while the lowest (Rs 27977 ha^{-1}) cost of cultivation was observed in T_6 (1 t poultry manure ha^{-1}). Regarding income generated, the highest gross return (Rs 95100 ha^{-1}) was recorded in T_3 (75% RDF + 2 t PM ha^{-1}) followed by T_5 (Rs 91066 ha^{-1}) and T_2 (Rs 87634 ha^{-1}) and the lowest gross return (Rs 71800 ha^{-1}) was recorded in T_6. also reported higher gross return with 50% recommended dose of NPK along with vermicompost 5 t ha^{-1} + FYM 5 t ha^{-1} in forage sorghum. From the data provided, it was also further revealed that highest net return (Rs 60562 ha^{-1}) was recorded in T_3 (75% RDF + 2 t PM ha^{-1}) and was followed by T_5 (50% RDF + 2 t PM ha^{-1}) recording Rs 57981 ha^{-1} while the lowest net returns was observed in T_6 (Rs 43823 ha^{-1}). The highest benefit cost ratio (2.75) was observed in the treatment T_3 (75% RDF + 2 t PM ha^{-1}) and T_5 (50% RDF + 2 t PM ha^{-1}) with the same value while the lowest B:C ratio was recorded in T_1 (2.55). These results indicated that combine used of both chemical fertilizers and poultry manures gives higher yield and monetary returns over sole application of chemical fertilizer or poultry manures. Increase in gross return, net return and benefit cost ratio might be due to higher fodder yield and less input cost. Similar results have been reported by Ram and Dhaliwal (2012) [13], Shahid *et al*. (2015) [14] and Kumar *et al.* (2017) [10].

Table 3: Effect of integrated nutrient management on Cost of cultivation, gross income, net returns and cost benefit ratio of fodder oat

Treatments		Total cost of cultivation (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net Returns (Rs ha^{-1})	Benefit cost ration
T_1	100% RDF (60:40 NP) kg ha^{-1}	33258	84844	51586	2.55
T_2	75% RDF + 1 t Poultry Manure ha^{-1}	33163	87634	54471	2.64
T_3	75% RDF + 2 t Poultry Manure ha^{-1}	34538	95100	60562	2.75
T_4	50% RDF + 1 t Poultry Manure ha^{-1}	31710	83878	52168	2.65
T_5	50% RDF + 2 t Poultry Manure ha^{-1}	33085	91066	57981	2.75
T_6	1 t Poultry Manure ha^{-1}	27977	71800	43823	2.57
T_7	2 t Poultry Manure ha^{-1}	29352	77934	48582	2.66

Conclusion

On the basis of the experimental findings, it was observed that integrated nutrient management involving 75% RDF kg ha^{-1} + 2 t PM ha^{-1} was found to be significantly higher in terms of green fodder yield, dry matter content, dry matter yield and from economic point of view, the highest net monetary returns and B: C ratio were also recorded with the application of 75% RDF (60:40 NP) kg ha^{-1} along with 2 t poultry manure ha^{-1}, which was closely followed by T_5 (50% RDF + 2 t Poultry Manure ha^{-1}). Thus, it can be concluded that combined application of organic and inorganic fertilizer was found to be more effective as compares to the sole application of poultry manures or chemical fertilizers.

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