*__Original Research Article__*

# Integrated Nutrient Management to increase Productivity and Profitability in Dual Purpose Oat (*Avena sativa* L.)


## Abstract

A field experiment was conductedat Genetics and Plant Breeding Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh,during*Rabi* season 2018-19 to Studies on Integrated Nutrient Management to increase Productivity and Profitability in Dual Purpose Oat (*Avena sativa* L.).The experimental field design was RBD with three replications and nine treatments. T1: Control, T2: RDF (100 kg N : 40 kg $P_2O_5$ : 40 kg $K_2O$ $ha^{-1}$), T3: 75 % RDN +Vermicompost @ 2t $ha^{-1}$, T4: T3 + PSB (soil application @ 1.5 kg $ha^{-1}$), T5: T4 + Azotobacter (seed treatment @10g $kg^{-1}$ seed), T6: T5 + $ZnSO_4$ @ 20 kg $ha^{-1}$ (soil application as basal ), T7: T5+ $ZnSO_4$@ 15 kg $ha^{-1}$ (soil application as basal), T8: T6 + Foliar spray of ZnSO4 (0.5%) at just before flowering, T9: T7 + Foliar spray of $ZnSO_4$ (0.5%) at just before flowering.Results revealed that higheryield attributes*viz*.panicle length (37.40cm), panicle weight (9.80g), number of grain $panicle^{-1}$(56.33), test weight (48.70g), green forage yield (90.60 q $ha^{-1}$), dry matter yield (17.51 q $ha^{-1}$), yield parameters *viz*.grain yield (16.51 q $ha^{-1}$), straw yield (72.97 q $ha^{-1}$) and profitability*viz*. gross income (INR 82069.5 $ha^{-1}$), net income (INR 51605.5 $ha^{-1}$) and B:C ratio (1.69) of oat forT8: 75% RDN + Vermicompost @ 2t $ha^{-1}$ + PSB (soil) @ 1.5 kg $ha^{-1}$ + *Azotobacter*(seed treatment) @ 10 g $kg^{-1}$ of seed + $ZnSO_4$ @ 20 kg $ha^{-1}$ (basal) + foliar spray of $ZnSO_4$ (0.5%) at just before flowering of oat as compared to the control.Whereas, application of organic and inorganic fertilizers in combinations*viz*., Nitrogen, Phosphorus, Potassium, Vermicompost, Phosphorus Solubilizing Bacteria (PSB), *Azotobacter*and Zinc hadsignificant effect on total biomass production, yield attributes, yield and profitability of oat.


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***Keywords***-*Oat; INM; PSB; Azotobacter; Vermicompost; Yield attributes; Yield; Profitability*


## 1. INTRODUCTION

Oat (*Avena sativa* L.) is a constituent of family *Poaceae*. The genus *Avena*as such incorporates, diploid, tetraploid and hexaploid species based on a basic chromosome number of x=7. Oat commonly known as *jai*, thecenter of origin of oat is Asia Minor. Oat is an important cereal crop which is mainly grown for fodder during *Rabi* season. Oat provides a very nutritious fodder (protein 13- 15%) especially suited to milch animals. Being a cool season crop it requires a long span of season with lower mean daily temperature. Oat is mainly confined to temperate countries

**Comment [G3]:** Please clarify the phrase and in India grown in some of the states i.e. Uttar Pradesh, Bihar, Punjab, Jammu Kashmir, Himachal Pradesh, Uttarakhand, West Bengal etc. Oat grains and its processed products are now a days highly appreciated due to its medicinal values and it also rich in energy, protein, vitamin B, phosphorous and iron (Tiwana*et al*., 2008). Expected green fodder deficiency will be about 64.9% and dry fodder deficiency up to 24.9% in 2025, but still fodder cultivated area is only 4-5% of total cropped area which under nourishes the livestock of India compared to temperate countries.

The nutritive value of forage oat is high with dry matter digestibility in excess of 75 per cent when fed to dairy cattle. Oat straw is softer, palatable and more acceptable to livestock than the other cereal straws (Stevens *et al.*, 2004). The chemical composition of green fodder of oat on dry matter basis contains 7.0 -10.5 % crude proteins, 55-63 % neutral detergent fiber, 30-32 % acid detergent fiber, 22.0-23.5 % cellulose and 17-20 % hemicelluloses when harvested at 50 % flowering stage of crop. Oat is also used as straw, hay or silage and its grain makes a good feed particularly for horses, sheep and poultry.

Growth, yield and quality of economic output depend on several factors, among which mineral nutrition is an important one. Integrated nutrient management which combines two or more than two sources of nutrient input is a holistic way forward to sustain the productivity as well as ecosystem. In oat crop commonly done two cuttings at different stages, but 1st cut at 60 DAS and 2nd cut at 50% flowering gave the better growth and yield (Sharma and Bhunia, 2001). As compared to single cut multicut crops absorb more nutrients, which directly influence the nitrogen content, protein content and other quality parameters of the crop. The interaction effect of nitrogen and phosphorus levels on plant height, leaf length, leaf width, leaf: stem ratio (green and dry), leaf area per plant, leaf area index, leaf and stem weight (green and dry) per plant, green and dry fodder yield per plant and green and dry fodder yield q $ha^{-1}$ of oat were non-significant at first cut, second cut (at harvest) and in the mean values. (Patel and Rajgopal, 2002). Vermicompost is rich in plant nutrients and contain higher number of microorganism, which are responsible for decomposition process (Olle, 2016). (Ramnarain, *et al.*,2019) reported that vermicompost treated soils had lower pH and increased level of organic matter, primary nutrient, and soluble salts. (Wong *et al*., 2020) reported that vermicompost, especially those from animal waste sources, usually contained more mineral elements than plant growth media. Nutrients content in vermincompost generally are N- 1.5-2.10 %, P- 1.5-1.70 % and K 1.4-1.6 %. Biofertilizers, containing the living strains of different nutrient transforming and/or mobilizing microbes which not only provide access to fixed nutrients, but also secrets certain plant growth promoter which enhance the growth and quality of crops. Biofertilizers can indemnity 20-25% of chemical nutrient input, which are cost effective and eco-friendly. Azotobacter is a free living nitrogen fixing biofertilizer and fix about 20-30kg N/ha per cropping season in soil. Application of 100 per cent RDF along with biofertilizers increased available nutrient content in soil after harvest of the oat crop because of residual effect of fertilizers applied and

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biofertilizerslike Azotobacter whichfixes the nitrogen and improved the available nitrogen in soil and PSB improved the available phosphorus content in soil (Umadevi*et al.*, 2010).

The foliar application of the micro nutrients is more effective than soil application (Arif et al., 2006). Zinc is also involved in various metabolic activities of plant such as photosynthesis, respiration and assimilation of organic compound to sink. The efficacy of such type element is improvedwhen; it is used in combination with other elements like N & K in wheat (Morales*et al*., 2020).

The objectives of the experiments were to find out effect of nutrient management practices on green forage yield, grain yield and quality in dual purpose oats and to work out the production profitability of dual - purpose oats

## 2. Materials and Methods

**2.1 Experimental site:** The experiment was carried out during *rabi*season2018-19 at Genetics and Plant Breeding farm, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Ayodhya (U.P.). Study locationis situated at 26º 47' North latitude and 82º 12' East longitudes with an altitude of 113 meters above mean sea level.

**2.2 Geography and climate:** Geographically, the experimental site falls under sub humid, sub- tropical climate of Indo-gangatic plains (IGP) having alluvial calcareous soil. The weekly minimum and maximum temperature during the crop season ranged from 3.5 ºC to 37.5 ºC respectively and average relative humidity, evaporation and sunshine hours ranged from 56.6 % to 76.6 %, 2.6 to 7.2 mm/day and 3.6 to 9.4 hrs/day, respectively.

**2.3 Experimental details:** An experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. T1: Control, T2: RDF (100 kg N : 40 kg $P_2O_5$ : 40 kg $K_2O$ $ha^{-1}$), T3: 75 % RDN +Vermicompost @ 2t $ha^{-1}$, T4: T3 + PSB (soil application @ 1.5 kg $ha^{-1}$), T5: T4 + Azotobacter (seed treatment @10g $kg^{-1}$ seed), T6: T5 + $ZnSO_4$ 20 kg $ha^{-1}$ (soil application as basal ), T7: T5+ $ZnSO_4$ 15 kg $ha^{-1}$ (soil application as basal), T8: T6 + Foliar spray of $ZnSO_4$ (0.5% ) at just before flowering, T9: T7 + Foliar spray of $ZnSO_4$ (0.5% ) at just before flowering. The size of each plot was (12 $m^2$) 4.0 m length and 3.0 m breadth. Each experiment included 27 treatments.

**2.4 Agronomic practices:** The field was irrigated one week before sowing for good seed bed preparation and germination. The field was prepared by threeploughing out of which one ploughing was done by disc harrow followed by two ploughingdone with cultivators and planking was done after each ploughing for making soil pulverized suited to the sowing and germination of dual purpose oat crop.

**2.5 Application of fertilizers:** All the application fertilizers was done separately in each plot as per treatments. Application of vermicompostwas done @ 2 tonne per hectare at the time of last ploughing. In the recommended dose of fertilizer 100-40-40 kg $ha^{-1}$(N, $P_2O_5$, $K_2O$). Half dose of nitrogen and full dose of phosphorus and potash was given as basal dose and remaining nitrogen applied as top dressing in two equal splits; 25% at 40 DAS and 25% at after

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first cut of oat and was given. Similarly in 75% RDN per plots, half nitrogen was applied as basal and remaining nitrogen as top dressed in same manner as in case of RDF.

The application of Phosphorus solubilizing bacteria @ 1.5 kg $ha^{-1}$ inoculants mixed with fine powdered vermicompost and broadcasted the mixture at the time of last ploughing. In experimental field, $ZnSO_4$ applied @ 15 kg and 20 kg $ha^{-1}$ as basal dose at the time of sowing and foliar spray (0.5%) was done at just before flowering of the crop.

**2.6 Seed and sowing:** Oat variety NDO-2 (Narendra Jai -2) selected for this study. It is a dual purpose (fodder and grain) oat crop variety suitable for irrigated condition under normal and salt affected soils of U.P. NDO-2 is released in 2012 by State Varietal Released Committee (SVRC) and notified in 2013. It has potential to produce 110-120 q $ha^{-1}$ green forage and 15.5-20.5 q $ha^{-1}$ grains when cultivated as dual purpose oat. Seed rate was used as 100 kg $ha^{-1}$. seed treatment was done with *Azotobacter*.One kg of seed treated with 10g of *Azotobacter*inoculants it was sprayed over the seed and well mixed and dried in shade place. The desired quantity of healthy and clean seeds were sown manually in rows after opening the furrow by using kudali. These furrows were later covered manually. The sowing of all plots was done on 14 November, 2018.As the crop was grown for dual purpose (fodder and grain). Its harvesting was done with the help of sickle at 55 DAS for green fodder and left for seed production. The oat crop was harvested when attained the physical maturity.

**2.7 Observations recorded:** The observed parameters yield attributes, yield and profitabilitywere characterized as length of panicle, panicle weight, number of grain $panicle^{-1}$, test weight of grain, green forage yield, dry matter yield, grain yield, straw yield, gross income, net income and B:C ratio had to be determined. Data obtained was exposed to the proper method for statistical analysis of variance difference among mean of different treatments as described by (Gomez and Gomez, 1976). The treatments means were compared using the Least Significant Differences (LSD) test at 5% level of probability by using the Randomized Block Design (RBD) model as obtained by Co.Stat 6.311, 1998-2005 as statistical program.

## 3. Results and Discussion

### 3.1 Yield Attributes

Yield attributes is the resultant of the vegetative and reproductive development of the plants. The entire yield attributes *viz.* length of panicle, number of grain $panicle^{-1}$, panicle weight and test weight increased significantly with nutrient management practices except test weight (Table 1) and depicted in (Fig. 1). Significantly, highest values of all the yield contributing characters,themaximum values were recorded with 75% RDN + Vermicompost @ 2t $ha^{-1}$ + PSB (soil application) @ 1.5 kg $ha^{-1}$ + Azotobacter (seed treatment) @ 10 g $kg^{-1}$ of seed + $ZnSO_4$ @ 20 kg $ha^{-1}$(basal application) + foliar spray of $ZnSO^4$ (0.5%) at just before flowering and minimum value was recorded in control plot. This might be due to improvement in nutrient supply with Vermicompost and bio-fertilizers which improvement of the soil physio-chemical and biological properties by

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providing essentials microbes. It also increased the activity of soil enzyme responsible for conversion of unavailable form of nutrients to available form as similar, results were also reported by (Khanday*et al*., 2009), and (Singh *et al*., 2015).

### 3.2 Yields

**3.2.1 Green forage yields (q ha$^{-1}$):** Green forage yield presented in (Table 1) depicted in Fig 1reveals the total biomass attained by the plant during its life cycle under prevailing conditions and shows that significantly maximum green forage yield at first cut with the treatment having 75% RDN + Vermicompost @ 2t ha$^{-1}$ + PSB (soil application) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO^4$ @ 20 kg ha$^{-1}$(basal application) + foliar spray of $ZnSO_4$ (0.5%) at just before flowering and minimum green forage yield was recorded in control plots. The inoculation of seeds might have enhanced nitrogen fixation which increased the availability of nitrogen, as nitrogen triggers the vegetative growth and ultimately increase the green forage yield. Similar, results also reported by (Godara*et al*., 2012), (Rana*et al.*, 2013), (Dahipahle*et al*., 2017), and (Patel *et al*., 2018).

**3.2.2 Dry matter yields (q ha$^{-1}$):** Dry forage production presented in(Table 1) and depicted in (fig. 1) is basically a measure of photosynthetic efficiency of assimilatory system in plants. Dried stalk yield refers to the function of maximum nutrients accumulation in plant biomass, statistically maximum dry matter yield at first cut (55 DAS) was recorded in 75% RDN + Vermicompost @ 2t ha$^{-1}$ + PSB (soil application) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$(basal plication) + foliar spray of $ZnSO_4$ (0.5%) at just before flowering and minimum was recorded in control plots. It might be due to the fact that growth promoting and nitrogen fixingbacteria increase dry matter yield by increasing nitrogen availability and promoting plant dry matter accumulation in the vegetative parts. (Anitha*et al*., 2004) reported an increase of 10-15 % in green and dry forage yield of oat through seed inoculation. Similar results were also reported by (Sheoran*et al*., 2002), (Singh *et al.*, 2005), (Godara*et al*., 2012) and (Rana*et al*., 2013).

**3.2.3 Grain and straw yields (q ha$^{-1}$):** Seed and straw yields (Table 2)of oat progressively enhanced due to application of 75% RDN + Vermicompost @ 2t ha$^{-1}$ + PSB (Soil) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$ basal+ foliar spray of $ZnSO_4$ @ 0.5% at just before flowering recorded significantly, highest seed yield (16.70 q ha$^{-1}$) and straw yield (72.97 q ha$^{-1}$), and minimum seed and straw yield were noted in control plot.The better effect of nitrogen, vermicompost might be attributed to rapid expansion of dark green foliage which could intercept and utilize more incident light energy in the production of carbohydrates through the process of photosynthesis. Increased, seed and straw yields may be attributed to the improvement in growth attributes due to nitrogen application. The results were in agreement with those of (Sheoran*et al*., 2002), (Ashok *et al*., 2008), (Rana*et al*., 2013), (Singh *et al*., 2015), (Patel and Rajagopal, 2002) and(Devi *et al*., 2009) in oat. Inoculation of seed with Azotobacter and soil application of PSB registered significantly highest seed and straw yield over control. The highest yield under bacterial strain inoculation might be due to buildup of their

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higher population in soil at different growth stages viz., sowing, tillering and flowering which in turn helped in fixation of more atmospheric nitrogen over control. The increase in seed and straw yields was attributed remarkable improvement in almost all parameters of yield under bio-fertilizers treatments. These findings are in conformity with the results of (Agarwal *et al*., 2002), (Deva, 2015), (Sheoran*et al*., 2002), (Sharma, 2009), (Patel *et al*., 2013). The foliar application of zinc at reproductive growth stage increased significantly the grain and straw yields of dual purpose oat. Similar,results were observed by (Soylu*et al*., 2005) in wheat. The effect of different nutrient management practices on harvest index was found non- significant and these result corroborated with finding of (Sharma and Verma, 2004).

**3.3Profitability**

The higher cost (Table 2) of cultivation (INR 30464 ha$^{-1}$) was incurred with 75% RDN + Vermicompost @ 2t ha$^{-1}$ + PSB (soil application) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$(basal application) + foliar spray of $ZnSO_4$ (0.5%) at just before flowering of dual purpose oat due to higher cost of manure, fertilizers and bio-fertilizers (vermicompost, zinc sulphate, azotobacter and PSB).The maximum gross (Table 2) return (INR 82069.5 ha$^{-1}$) and net return (INR 51605.5 ha$^{-1}$) were obtained with 75% RDN + Vermicompost @ 2t ha-1 + PSB (soil application) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$ (basal application) + foliar spray of $ZnSO_4$ (0.5%) at just before flowering due to highest green forage yield, grain yield and straw yield which showed highest net return per rupee investment (INR 1.69) followed by 75% RDN + Vermicompost @ 2t ha$^{-1}$ + PSB (soil application) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$ (basal application) which recorded INR 1.51 as net income per rupee investment and it was mainly due to higher green forage yield , grain and straw yields and lesser increase in cost of cultivation with these treatments compared to control plot. These results corroborated with the finding of (Patel *et al*., 2018), (Malik *et al*., 2015), (Iqbal *et al*., 2014).

**Table 1: Effect of Integrated Nutrient Management on yield attributes of Oat crop.**

| Treatments | Panicle length (cm) | Panicle weight (g) | No. of grain panicle$^{-1}$ | Test weight (g) | Green forage yield (q ha$^{-1}$) | Dry matter yield (q ha$^{-1}$) |
|---|---|---|---|---|---|---|
| | | | | | at First cut | at First cut |
| $T_1$ | 27.20 | 4.40 | 34.76 | 42.60 | 14.40 | 2.69 |
| $T_2$ | 31.40 | 6.40 | 42.33 | 43.20 | 49.20 | 9.49 |
| $T_3$ | 32.50 | 7.70 | 44.66 | 44.30 | 65.50 | 12.46 |
| $T_4$ | 34.40 | 8.10 | 47.33 | 45.80 | 72.40 | 14.50 |
| $T_5$ | 34.70 | 8.80 | 48.66 | 47.20 | 76.60 | 14.79 |



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| **$T_6$** | 35.80 | 9.30 | 52.66 | 48.10 | 85.80 | 16.57 |
| **$T_7$** | 34.80 | 8.90 | 49.33 | 47.50 | 79.10 | 15.27 |
| **$T_8$** | 37.40 | 9.80 | 56.33 | 48.70 | 90.60 | 17.51 |
| **$T_9$** | 35.20 | 9.00 | 50.66 | 47.80 | 80.50 | 15.54 |
| SEm ± | 0.93 | 0.32 | 1.36 | 2.07 | 3.18 | 0.57 |
| LSD (P ≥0.05) | 2.78 | 0.96 | 4.08 | NS | 9.54 | 1.70 |

**Table 2: Effect of Integrated Nutrient Management on Yield and Profitability of Oat crop.**

| **Treatments** | **Yield** | | **Profitability** | | | |
|---|---|---|---|---|---|---|
| | **Grain yield (q ha$^{-1}$)** | **Straw yield (q ha $^{-1}$)** | **Total cost of cultivation (INR ha$^{-1}$)** | **Gross income (INR ha$^{-1}$)** | **Net income (INR ha$^{-1}$)** | **B:C ratio** |
| **$T_1$** | 6.51 | 27.21 | 23026 | 27376.5 | 4350.5 | 0.18 |
| **$T_2$** | 12.50 | 53.12 | 27781 | 57182 | 29401 | 1.06 |
| **$T_3$** | 13.10 | 56.06 | 29364 | 62851 | 33487 | 1.14 |
| **$T_4$** | 13.80 | 59.47 | 29514 | 67034.5 | 37520.5 | 1.27 |
| **$T_5$** | 14.20 | 61.77 | 29714 | 69599.5 | 39885.5 | 1.34 |
| **$T_6$** | 15.40 | 67.30 | 30314 | 76135 | 45821 | 1.51 |
| **$T_7$** | 14.50 | 62.93 | 30164 | 71195 | 41031 | 1.36 |
| **$T_8$** | 16.70 | 72.97 | 30464 | 82069.5 | 51605.5 | 1.69 |
| **$T_9$** | 14.80 | 64.67 | 30314 | 72774.5 | 42460.5 | 1.4 |
| SEm ± | 0.47 | 2.46 | - | - | - | - |
| LSD (P ≥0.05) | 1.41 | 7.36 | - | - | - | - |

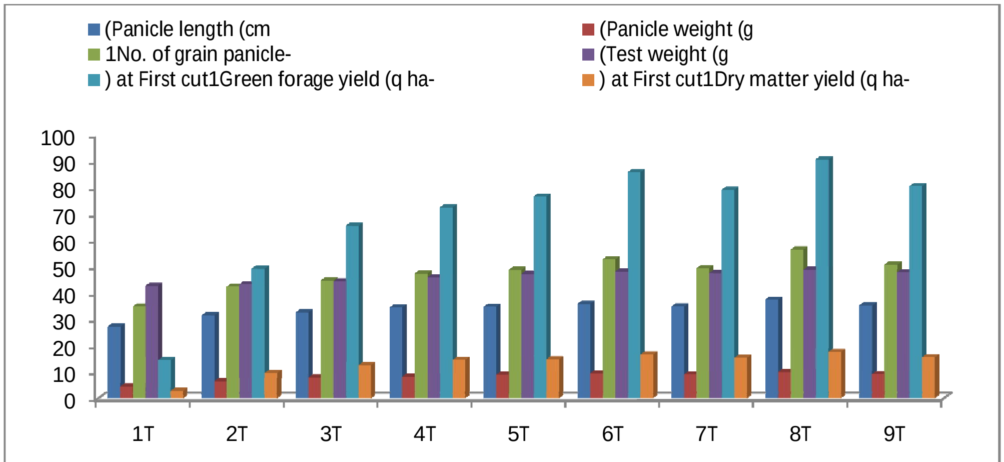


**Fig.1- Effect of Integrated Nutrient Management on yield attributes of Oat crop.**

## 4. CONCLUSION

In the present research, the use of organic and inorganic fertilizers, or integrated nutrient management significantly affected Oat yield. Considering the aforesaid conclusions, the application of 75 % RDN (75 kg N ha$^{-1}$) in presence of vermicompost @ 2t ha$^{-1}$ + PSB (soil application) @ 1.5 kg ha$^{-1}$ + *Azotobacter* (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$ (basal application) and foliar spray of $ZnSO_4$ (0.5%) at just before flowering may be safely recommended for quality fodder and grain production of dual purpose oat. On the basis of profitability it may be concluded that application of 75% RDN (75 kg N ha$^{-1}$) in presence of vermicompost @ 2t ha$^{-1}$ + PSB (soil application) @ 1.5 kg ha$^{-1}$ + Azotobacter (seed treatment) @ 10 g kg$^{-1}$ of seed + $ZnSO_4$ @ 20 kg ha$^{-1}$ (basal application) and foliar spray of $ZnSO_4$ (0.5%) at just before flowering of dual purpose oat was found more remunerative which recorded the net income per rupee investment of 1.69.

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**Comment [G43]:** It does not appear in the text.

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