

1 Original Research Article

2  
3 **Integrated Nutrient Management to increase Productivity and Profitability in Dual**  
4 **Purpose Oat (*Avena sativa* L.)**

5  
6 **Abstract**

7 A field experiment was conducted at Genetics and Plant Breeding Research Farm,  
8 Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya,  
9 Uttar Pradesh, during Rabi season 2018-19 to study on Integrated Nutrient Management to  
10 increase Productivity and Profitability in Dual Purpose Oat (*Avena sativa* L.). The experimental  
11 field design was RBD with three replications and nine treatments. T1: Control, T2: RDF (100 kg  
12 N : 40 kg P<sub>2</sub>O<sub>5</sub> : 40 kg K<sub>2</sub>O ha<sup>-1</sup>), T3: 75 % RDN + Vermicompost @ 2t ha<sup>-1</sup>, T4: T3 + PSB  
13 (soil application @ 1.5 kg ha<sup>-1</sup>), T5: T4 + Azotobacter (seed treatment @ 10g kg<sup>-1</sup> seed),  
14 T6: T5 + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (soil application as basal), T7: T5 + ZnSO<sub>4</sub> @ 15 kg ha<sup>-1</sup>  
15 (soil application as basal), T8: T6 + Foliar spray of ZnSO<sub>4</sub> (0.5%) at just before flowering,  
16 T9: T7 + Foliar spray of ZnSO<sub>4</sub> (0.5%) at just before flowering. Results revealed that higher yield  
17 attributes viz. panicle length (37.40cm), panicle weight (9.80g), number of grain panicle<sup>-1</sup> (56.33),  
18 test weight (48.70g), green forage yield (90.60 q ha<sup>-1</sup>), dry matter yield (17.51 q ha<sup>-1</sup>), yield  
19 parameters viz. grain yield (16.51 q ha<sup>-1</sup>), straw yield (72.97 q ha<sup>-1</sup>) and profitability viz. gross  
20 income (INR 82069.5 ha<sup>-1</sup>), net income (INR 51605.5 ha<sup>-1</sup>) and B:C ratio (1.69) of oat for T8:  
21 75% RDN + Vermicompost @ 2t ha<sup>-1</sup> + PSB (soil) @ 1.5 kg ha<sup>-1</sup> + Azotobacter (seed treatment)  
22 @ 10 g kg<sup>-1</sup> of seed + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (basal) + foliar spray of ZnSO<sub>4</sub> (0.5%) at just before  
23 flowering of oat as compared to the control. Whereas, application of organic and inorganic  
24 fertilizers in combinations viz., Nitrogen, Phosphorus, Potassium, Vermicompost, Phosphorus  
25 Solubilizing Bacteria (PSB), Azotobacter and Zinc had significant effect on total biomass  
26 production, yield attributes, yield and profitability of oat.

27  
28 **Keywords**-Oat; INM; PSB; Azotobacter; Vermicompost; Yield attributes; Yield; Profitability

29  
30 **1. INTRODUCTION**

31  
32 Oat (*Avena sativa* L.) is a constituent of family *Poaceae*. The genus *Avena* as such incorporates,  
33 diploid, tetraploid and hexaploid species based on a basic chromosome number of  $x=7$ .  
34 Oat commonly known as *jai*, the center of origin of oat is Asia Minor. Oat is an important cereal  
35 crop which is mainly grown for fodder during Rabi season. Oat provides a very nutritious fodder  
36 (protein 13- 15%) especially suited to milch animals. Being a cool season crop it requires a long  
37 span of season with lower mean daily temperature. Oat is mainly confined to temperate countries

Comment [A1]: The sentence structure in the abstract needs to be rearranged: Aims, study design, place and duration of study, methodology, results, and conclusion

38 and in India grown in some of the states i.e. Uttar Pradesh, Bihar, Punjab, Jammu Kashmir,  
39 Himachal Pradesh, Uttarakhand, West Bengal etc. Oat grains and its processed products are now  
40 a days highly appreciated due to its medicinal values and it also rich in energy, protein, vitamin  
41 B, phosphorous and iron (Tiwana *et al.*, 2008). Expected green fodder deficiency will be about  
42 64.9% and dry fodder deficiency up to 24.9% in 2025, but still fodder cultivated area is only  
43 4-5% of total cropped area which under nourishes the livestock of India compared to temperate  
44 countries.

45  
46 The nutritive value of forage oat is high with dry matter digestibility in excess of 75 per cent  
47 when fed to dairy cattle. Oat straw is softer, palatable and more acceptable to livestock than the  
48 other cereal straws (Stevens *et al.*, 2004). The chemical composition of green fodder of oat on  
49 dry matter basis contains 7.0 -10.5 % crude proteins, 55-63 % neutral detergent fiber, 30-32 %  
50 acid detergent fiber, 22.0-23.5 % cellulose and 17-20 % hemicelluloses when harvested at 50 %  
51 flowering stage of crop. Oat is also used as straw, hay or silage and its grain makes a good feed  
52 particularly for horses, sheep and poultry.

Comment [A2]: Reference..??

53  
54 Growth, yield and quality of economic output depend on several factors, among which mineral  
55 nutrition is an important one. Integrated nutrient management which combines two or more than  
56 two sources of nutrient input is a holistic way forward to sustain the productivity as well as  
57 ecosystem. In oat crop commonly done two cuttings at different stages, but 1st cut at 60 DAS  
58 and 2nd cut at 50% flowering gave the better growth and yield (Sharma and Bhunia, 2001).  
59 As compared to single cut multicut crops absorb more nutrients, which directly influence the  
60 nitrogen content, protein content and other quality parameters of the crop. The interaction effect  
61 of nitrogen and phosphorus levels on plant height, leaf length, leaf width, leaf: stem ratio (green  
62 and dry), leaf area per plant, leaf area index, leaf and stem weight (green and dry) per plant,  
63 green and dry fodder yield per plant and green and dry fodder yield  $q\ ha^{-1}$  of oat were  
64 non-significant at first cut, second cut (at harvest) and in the mean values. (Patel and Rajgopal,  
65 2002). Vermicompost is rich in plant nutrients and contain higher number of microorganism,  
66 which are responsible for decomposition process (Olle, 2016). (Ramnarain, *et al.*, 2019) reported  
67 that vermicompost treated soils had lower pH and increased level of organic matter, primary  
68 nutrient, and soluble salts. (Wong *et al.*, 2020) reported that vermicompost, especially those from  
69 animal waste sources, usually contained more mineral elements than plant growth media.  
70 Nutrients content in vermincompost generally are N- 1.5-2.10 %, P- 1.5-1.70 % and K 1.4-1.6 %.  
71 Biofertilizers, containing the living strains of different nutrient transforming and/or mobilizing  
72 microbes which not only provide access to fixed nutrients, but also secretes certain plant growth  
73 promoter which enhance the growth and quality of crops. Biofertilizers can indemnity 20-25% of  
74 chemical nutrient input, which are cost effective and eco-friendly. Azotobacter is a free living  
75 nitrogen fixing biofertilizer and fix about 20-30kg N/ha per cropping season in soil.  
76 Application of 100 per cent RDF along with biofertilizers increased available nutrient content in  
77 soil after harvest of the oat crop because of residual effect of fertilizers applied and biofertilizers

78 like Azotobacter which fixes the nitrogen and improved the available nitrogen in soil and PSB  
79 improved the available phosphorus content in soil (Umadeviet *al.*, 2010).

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

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

88

## 89 **2. Materials and Methods**

90

91 **2.1 Experimental site:** The experiment was carried out during *rab* season 2018-19 at  
92 Genetics and Plant Breeding farm, Acharya Narendra Deva University of Agriculture and  
93 Technology, Narendra Nagar, Ayodhya (U.P.). Study location is situated at 26° 47' North latitude  
94 and 82° 12' East longitudes with an altitude of 113 meters above mean sea level.

95 **2.2 Geography and climate:** Geographically, the experimental site falls under sub humid,  
96 sub- tropical climate of Indo-gangatic plains (IGP) having alluvial calcareous soil. The weekly  
97 minimum and maximum temperature during the crop season ranged from 3.5 °C to 37.5 °C  
98 respectively and average relative humidity, evaporation and sunshine hours ranged from  
99 56.6 % to 76.6 %, 2.6 to 7.2 mm/day and 3.6 to 9.4 hrs/day, respectively.

100 **2.3 Experimental details:** An experiment was laid out in Randomized Block Design (RBD)  
101 with nine treatments and three replications. T1: Control, T2: RDF (100 kg N : 40 kg P<sub>2</sub>O<sub>5</sub> : 40 kg  
102 K<sub>2</sub>O ha<sup>-1</sup>), T3: 75 % RDN +Vermicompost @ 2t ha<sup>-1</sup>, T4: T3 + PSB (soil application  
103 @ 1.5 kg ha<sup>-1</sup>), T5: T4 + Azotobacter (seed treatment @10g kg<sup>-1</sup> seed), T6: T5 + ZnSO<sub>4</sub>  
104 20 kg ha<sup>-1</sup> (soil application as basal ), T7: T5+ ZnSO<sub>4</sub> 15 kg ha<sup>-1</sup> (soil application as basal),  
105 T8: T6 + Foliar spray of ZnSO<sub>4</sub> (0.5% ) at just before flowering, T9: T7 + Foliar spray of ZnSO<sub>4</sub>  
106 (0.5% ) at just before flowering. The size of each plot was (12 m<sup>2</sup>) 4.0 m length and 3.0 m  
107 breadth. Each experiment included 27 treatments.

108 **2.4 Agronomic practices:** The field was irrigated one week before sowing for good seed bed  
109 preparation and germination. The field was prepared by three ploughing out of which one  
110 ploughing was done by disc harrow followed by two ploughing done with cultivators and  
111 planking was done after each ploughing for making soil pulverized suited to the sowing and  
112 germination of dual purpose oat crop.

113 **2.5 Application of fertilizers:** All the application fertilizers was done separately in each plot as  
114 per treatments. Application of vermicompost was done @ 2 tonne per hectare at the time  
115 of last ploughing. In the recommended dose of fertilizer 100-40-40 kg ha<sup>-1</sup>(N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O).  
116 Half dose of nitrogen and full dose of phosphorus and potash was given as basal dose and  
117 remaining nitrogen applied as top dressing in two equal splits; 25% at 40 DAS and 25% at after

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

120 The application of Phosphorus solubilizing bacteria @ 1.5 kg ha<sup>-1</sup> inoculants mixed with fine  
121 powdered vermicompost and broadcasted the mixture at the time of last ploughing.  
122 In experimental field, ZnSO<sub>4</sub> applied @ 15 kg and 20 kg ha<sup>-1</sup> as basal dose at the time of sowing  
123 and foliar spray (0.5%) was done at just before flowering of the crop.

124 **2.6 Seed and sowing:** Oat variety NDO-2 (Narendra Jai -2) selected for this study. It is a dual  
125 purpose (fodder and grain) oat crop variety suitable for irrigated condition under normal and salt  
126 affected soils of U.P. NDO-2 is released in 2012 by State Varietal Released Committee (SVRC)  
127 and notified in 2013. It has potential to produce 110-120 q ha<sup>-1</sup> green forage and  
128 15.5-20.5 q ha<sup>-1</sup> grains when cultivated as dual purpose oat. Seed rate was used as 100 kg ha<sup>-1</sup>.  
129 seed treatment was done with *Azotobacter*. One kg of seed treated with 10g of  
130 *Azotobacter* inoculants it was sprayed over the seed and well mixed and dried in shade place. The  
131 desired quantity of healthy and clean seeds were sown manually in rows after opening the furrow  
132 by using kudali. These furrows were later covered manually. The sowing of all plots was done on  
133 14 November, 2018. As the crop was grown for dual purpose (fodder and grain). Its harvesting  
134 was done with the help of sickle at 55 DAS for green fodder and left for seed production. The oat  
135 crop was harvested when attained the physical maturity.

136 **2.7 Observations recorded:** The observed parameters yield attributes, yield and profitability  
137 were characterized as length of panicle, panicle weight, number of grain panicle<sup>-1</sup>, test weight of  
138 grain, green forage yield, dry matter yield, grain yield, straw yield, gross income, net income and  
139 B:C ratio had to be determined. Data obtained was exposed to the proper method for statistical  
140 analysis of variance difference among mean of different treatments as described by  
141 (Gomez and Gomez, 1976). The treatments means were compared using the Least Significant  
142 Differences (LSD) test at 5% level of probability by using the Randomized Block Design (RBD)  
143 model as obtained by Co.Stat 6.311, 1998-2005 as statistical program.

### 144 3. Results and Discussion

#### 146 3.1 Yield Attributes

147 Yield attributes is the resultant of the vegetative and reproductive development of the plants.  
148 The entire yield attributes viz. length of panicle, number of grain panicle<sup>-1</sup>, panicle weight and  
149 test weight increased significantly with nutrient management practices except test weight (Table  
150 1) and depicted in (Fig. 1). Significantly, highest values of all the yield contributing  
151 characters, the maximum values were recorded with 75% RDN + Vermicompost @ 2t ha<sup>-1</sup> + PSB  
152 (soil application) @ 1.5 kg ha<sup>-1</sup> + *Azotobacter* (seed treatment) @ 10 g kg<sup>-1</sup> of seed + ZnSO<sub>4</sub> @  
153 20 kg ha<sup>-1</sup> (basal application) + foliar spray of ZnSO<sub>4</sub> (0.5%) at just before flowering and  
154 minimum value was recorded in control plot. This might be due to improvement in nutrient  
155 supply with Vermicompost and  
156 bio-fertilizers which improvement of the soil physio-chemical and biological properties by

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

## 161 3.2 Yields

162 **3.2.1 Green forage yields ( $q\ ha^{-1}$ ):** Green forage yield presented in (Table 1) depicted in Fig  
163 1 reveals the total biomass attained by the plant during its life cycle under prevailing conditions  
164 and shows that significantly maximum green forage yield at first cut with the treatment having  
165 75% RDN + Vermicompost @  $2t\ ha^{-1}$  + PSB (soil application) @  $1.5\ kg\ ha^{-1}$  + Azotobacter  
166 (seed treatment) @  $10\ g\ kg^{-1}$  of seed +  $ZnSO_4$  @  $20\ kg\ ha^{-1}$  (basal application) + foliar spray of  
167  $ZnSO_4$  (0.5%) at just before flowering and minimum green forage yield was recorded in control  
168 plots. The inoculation of seeds might have enhanced nitrogen fixation which increased the  
169 availability of nitrogen, as nitrogen triggers the vegetative growth and ultimately increase the  
170 green forage yield. Similar, results also reported by (Godaraet *et al.*, 2012), (Rana *et al.*, 2013),  
171 (Dahipahleet *et al.*, 2017), and (Patel *et al.*, 2018).

172 **3.2.2 Dry matter yields ( $q\ ha^{-1}$ ):** Dry forage production presented in (Table 1) and depicted in  
173 (fig. 1) is basically a measure of photosynthetic efficiency of assimilatory system in plants. Dried  
174 stalk yield refers to the function of maximum nutrients accumulation in plant biomass,  
175 statistically maximum dry matter yield at first cut (55 DAS) was recorded in 75% RDN +  
176 Vermicompost @  $2t\ ha^{-1}$  + PSB (soil application) @  $1.5\ kg\ ha^{-1}$  + Azotobacter (seed treatment)  
177 @  $10\ g\ kg^{-1}$  of seed +  $ZnSO_4$  @  $20\ kg\ ha^{-1}$  (basal application) + foliar spray of  $ZnSO_4$  (0.5%) at just  
178 before flowering and minimum was recorded in control plots. It might be due to the fact that  
179 growth promoting and nitrogen fixing bacteria increase dry matter yield by increasing nitrogen  
180 availability and promoting plant dry matter accumulation in the vegetative parts. (Anithaet *et al.*,  
181 2004) reported an increase of 10-15 % in green and dry forage yield of oat through seed  
182 inoculation. Similar results were also reported by (Sheoranet *et al.*, 2002), (Singh *et al.*, 2005),  
183 (Godaraet *et al.*, 2012) and (Rana *et al.*, 2013).

184 **3.2.3 Grain and straw yields ( $q\ ha^{-1}$ ):** Seed and straw yields (Table 2) of oat progressively  
185 enhanced due to application of 75% RDN + Vermicompost @  $2t\ ha^{-1}$  + PSB (Soil) @  $1.5\ kg\ ha^{-1}$   
186 + Azotobacter (seed treatment) @  $10\ g\ kg^{-1}$  of seed +  $ZnSO_4$  @  $20\ kg\ ha^{-1}$  basal + foliar spray of  
187  $ZnSO_4$  @ 0.5% at just before flowering recorded significantly, highest seed yield ( $16.70\ q\ ha^{-1}$ )  
188 and straw yield ( $72.97\ q\ ha^{-1}$ ), and minimum seed and straw yield were noted in control plot. The  
189 better effect of nitrogen, vermicompost might be attributed to rapid expansion of dark green  
190 foliage which could intercept and utilize more incident light energy in the production of  
191 carbohydrates through the process of photosynthesis. Increased, seed and straw yields may be  
192 attributed to the improvement in growth attributes due to nitrogen application. The results were  
193 in agreement with those of (Sheoranet *et al.*, 2002), (Ashok *et al.*, 2008), (Rana *et al.*, 2013),  
194 (Singh *et al.*, 2015), (Patel and Rajagopal, 2002) and (Devi *et al.*, 2009) in oat. Inoculation of  
195 seed with Azotobacter and soil application of PSB registered significantly highest seed and straw  
196 yield over control. The highest yield under bacterial strain inoculation might be due to buildup of

Comment [A3]: It is necessary to add a citation/reference as a comparison of the results of research that has been carried out for a more detailed discussion

197 their higher population in soil at different growth stages viz., sowing, tillering and flowering  
 198 which in turn helped in fixation of more atmospheric nitrogen over control. The increase in seed  
 199 and straw yields was attributed remarkable improvement in almost all parameters of yield under  
 200 bio-fertilizers treatments. These findings are in conformity with the results of (Agarwal *et al.*,  
 201 2002), (Deva, 2015), (Sheoran *et al.*, 2002), (Sharma, 2009), (Patel *et al.*, 2013). The foliar  
 202 application of zinc at reproductive growth stage increased significantly the grain and straw yields  
 203 of dual purpose oat. Similar, results were observed by (Soylu *et al.*, 2005) in wheat. The effect of  
 204 different nutrient management practices on harvest index was found non- significant and these  
 205 result corroborated with finding of (Sharma and Verma, 2004).

206

### 207 3.3 Profitability

208 The higher cost (Table 2) of cultivation (INR 30464 ha<sup>-1</sup>) was incurred with 75% RDN +  
 209 Vermicompost @ 2t ha<sup>-1</sup> + PSB (soil application) @ 1.5 kg ha<sup>-1</sup> + Azotobacter (seed treatment)  
 210 @ 10 g kg<sup>-1</sup> of seed + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (basal application) + foliar spray of ZnSO<sub>4</sub> (0.5%) at  
 211 just before flowering of dual purpose oat due to higher cost of manure, fertilizers and bio-  
 212 fertilizers (vermicompost, zinc sulphate, azotobacter and PSB). The maximum gross (Table 2)  
 213 return (INR 82069.5 ha<sup>-1</sup>) and net return (INR 51605.5 ha<sup>-1</sup>) were obtained with 75% RDN +  
 214 Vermicompost @ 2t ha<sup>-1</sup> + PSB (soil application) @ 1.5 kg ha<sup>-1</sup> + Azotobacter (seed treatment)  
 215 @ 10 g kg<sup>-1</sup> of seed + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (basal application) + foliar spray of ZnSO<sub>4</sub> (0.5%) at  
 216 just before flowering due to highest green forage yield, grain yield and straw yield which showed  
 217 highest net return per rupee investment (INR 1.69) followed by 75% RDN + Vermicompost  
 218 @ 2t ha<sup>-1</sup> + PSB (soil application) @ 1.5 kg ha<sup>-1</sup> + Azotobacter (seed treatment) @ 10 g kg<sup>-1</sup> of  
 219 seed + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (basal application) which recorded INR 1.51 as net income per rupee  
 220 investment and it was mainly due to higher green forage yield, grain and straw yields and lesser  
 221 increase in cost of cultivation with these treatments compared to control plot.  
 222 These results corroborated with the finding of (Patel *et al.*, 2018), (Malik *et al.*, 2015),  
 223 (Iqbal *et al.*, 2014).

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

**Comment [A4]:** It is necessary to add a citation/reference as a comparison of the results of research that has been carried out for a more detailed discussion

Treatments	Panicle length (cm)	Panicle weight (g)	No. of grain panicle <sup>-1</sup>	Test weight (g)	Green forage yield (q ha <sup>-1</sup> )	Dry matter yield (q ha <sup>-1</sup> )
					at First cut	at First cut
T <sub>1</sub>	27.20	4.40	34.76	42.60	14.40	2.69
T <sub>2</sub>	31.40	6.40	42.33	43.20	49.20	9.49
T <sub>3</sub>	32.50	7.70	44.66	44.30	65.50	12.46
T <sub>4</sub>	34.40	8.10	47.33	45.80	72.40	14.50
T <sub>5</sub>	34.70	8.80	48.66	47.20	76.60	14.79

<b>T<sub>6</sub></b>	35.80	9.30	52.66	48.10	85.80	16.57
<b>T<sub>7</sub></b>	34.80	8.90	49.33	47.50	79.10	15.27
<b>T<sub>8</sub></b>	37.40	9.80	56.33	48.70	90.60	17.51
<b>T<sub>9</sub></b>	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

225

226

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

Treatments	Yield		Profitability			
	Grain yield (q ha <sup>-1</sup> )	Straw yield (q ha <sup>-1</sup> )	Total cost of cultivation (INR ha <sup>-1</sup> )	Gross income (INR ha <sup>-1</sup> )	Net income (INR ha <sup>-1</sup> )	B:C ratio
<b>T<sub>1</sub></b>	6.51	27.21	23026	27376.5	4350.5	0.18
<b>T<sub>2</sub></b>	12.50	53.12	27781	57182	29401	1.06
<b>T<sub>3</sub></b>	13.10	56.06	29364	62851	33487	1.14
<b>T<sub>4</sub></b>	13.80	59.47	29514	67034.5	37520.5	1.27
<b>T<sub>5</sub></b>	14.20	61.77	29714	69599.5	39885.5	1.34
<b>T<sub>6</sub></b>	15.40	67.30	30314	76135	45821	1.51
<b>T<sub>7</sub></b>	14.50	62.93	30164	71195	41031	1.36
<b>T<sub>8</sub></b>	16.70	72.97	30464	82069.5	51605.5	1.69
<b>T<sub>9</sub></b>	14.80	64.67	30314	72774.5	42460.5	1.4
SEm ±	0.47	2.46	-	-	-	-
LSD (P ≥0.05)	1.41	7.36	-	-	-	-

227

228

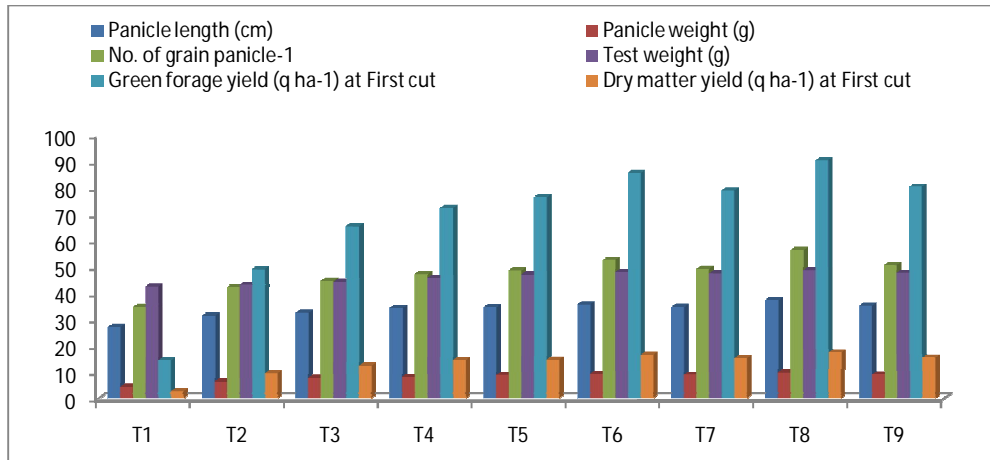


Fig.1- Effect of Integrated Nutrient Management on yield attributes of Oat crop.

Comment [A5]: Is the data in table 1 the same as the data in figure 1? If the data is the same, only one will appear

#### 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<sup>-1</sup>) in presence of vermicompost @ 2t ha<sup>-1</sup> + PSB (soil application) @ 1.5 kg ha<sup>-1</sup> + Azotobacter (seed treatment) @ 10 g kg<sup>-1</sup> of seed + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (basal application) and foliar spray of ZnSO<sub>4</sub> (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<sup>-1</sup>) in presence of vermicompost @ 2t ha<sup>-1</sup> + PSB (soil application) @ 1.5 kg ha<sup>-1</sup> + Azotobacter (seed treatment) @ 10 g kg<sup>-1</sup> of seed + ZnSO<sub>4</sub> @ 20 kg ha<sup>-1</sup> (basal application) and foliar spray of ZnSO<sub>4</sub> (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.

Comment [A6]: Sentences at the conclusion are rearranged to be more concise and clear

Comment [A7]: Acknowledgements needs to be added

#### REFERENCES

- Agrawal, S. B.; Tomar, S. S.; Bhaduria, A. K. S. and Kewat, M. L. (2002). Response of fodder oats (*Avena sativa* L.) to methods of *Azotobacter* inoculation under various levels of nitrogen. *Ann. Agri. Res.* 23(4): 692 – 696.
- Anitha, S., Srinivasan, E., & Singh, R. (2004). Cowpea Agronomy. *Cowpea in India*, 136-167.
- Arif, M., Chohan, M. A., Ali, S., Gul, R., & Khan, S. (2006). Response of wheat to foliar application of nutrients. *J. Agric. Biol. Sci.* 1(4), 30-34.

- 253 Ashok, K.; Rajgopal, D. S. and Lalit, K. (2008). Effect of vermicompost, poultry manures and  
254 Azotobacter inoculation on growth, yield and nutrient uptake of baby corn. *Indian Journal of*  
255 *Agronomy*, 34(4): 342-347.
- 256 Dahipahle, A. V.; Sharma, N.; Kumar, S.; Singh, H.; Kashyap, S. K. and Kumar V. (2017).  
257 Appropriate nitrogen management: A tool for potential fodder oat (*Avena sativa* L.) production.  
258 *International Journal of Current Microbiology and Applied Science*, 6(5): 1860-1865.
- 259 Deva, S. (2015). Effect of tillage practices and nutrient management on fodder yield of oat, soil  
260 fertility and microbial population *The Bioscane An International quarterly journal of life*  
261 *science*, 10(1):173-176.
- 262 Devi, U.; Joon, R. K.; Sewhag, M. and Kumar, J. (2009). Growth studies of multicut oats (*Avena*  
263 *sativa* L.) as influenced by levels of nitrogen, organic manures and *Azotobacter* inoculation.  
264 *Forage Research*, 35: 152-156.
- 265 Godara, A.S.; Gupta, U.S.; Singh, R. (2012). Effect of integrated nutrient management on  
266 herbage, dry fodder yield and quality of oat (*Avena sativa* L.). *Forage Research*. 38(1): 59-61.
- 267 Iqbal, A.; Iqbal, M. A.; Nabeel, F.; Khan, H.Z.; Akbar, N. and Abbas, R.N. (2014). Economic  
268 and sustainable forage oat (*Avena sativa* L.) production as influenced by different sowing  
269 techniques and sources of nitrogen. *American-Eurasian Journal of Agriculture & Environmental*  
270 *Sciences*, 14(10): 1035-1040.
- 271 Khanday, B A.; Samoon, A. R.; Waseem, R.; Khanday, J. and Bahar, F. A. (2009). Integrated  
272 nutrient management for seed production of oat (*Avena sativa* L.) under temperate conditions of  
273 Kashmir *International J. of Agricultural Sciences*, 5(1): 145-147.
- 274 Malik, P.; Midha, L. K.; Arya, S. and Joshi, U. N. (2015). Effect of cutting and fertility levels on  
275 quality of oats (*Avena sativa* L.). *Forage Research*, 40(4): 257-258.
- 276 Morales, F., Ancín, M., Fakhret, D., González-Torralba, J., Gámez, A. L., Seminario, A., ...  
277 & Aranjuelo, I. (2020). Photosynthetic metabolism under stressful growth conditions as a bases  
278 for crop breeding and yield improvement. *Plants*, 9(1), 88.
- 279 Olle, M. (2016). The effect of vermicompost based growth substrates on tomato growth. *Journal*  
280 *of Agricultural Science*, 1(27), 38-41.
- 281 Patel, J. R. and Rajagopal, S. (2002). Response of oats (*Avena sativa* L.) to nitrogen and  
282 phosphorus levels. *Indian J. Agron.* 47(1): 134-137.

Comment [A8]: ??

283 Patel, K. M.; Patel, D. M.; Gelot, D. G. and Patel, I. M. (2018). Effect of integrated nutrient  
284 management on green forage yield, quality and nutrient uptake of fodder sorghum (*Sorghum*  
285 *bicolor* L.). *International Journal of Chemical Studies*, 6(1):173-176.

286 Patel, T.U.; Arvadia, M.K.; Patel, D.D.; Thanki, J.D. and Patel, H.M. (2013). Response of oat  
287 (*Avena sativa* L.) to cutting management and times of nitrogen application. *Crop Research and*  
288 *Research on Crops*; 14(3):902-906.

289 Rajput, A. L.; Sing, D. P. and sing, S.P. (1995). Effect of soil and foliar application of nitrogen  
290 and zinc with farm yard manure on late sown wheat. *Indian Journal of Agronomy*. 40(4): 598-  
291 600.

292 Ramnarain, Y. I., Ansari, A. A., & Ori, L. (2019). Vermicomposting of different organic  
293 materials using the epigeic earthworm *Eisenia foetida*. *International Journal of Recycling of*  
294 *Organic Waste in Agriculture*, 8(1), 23-36.

295 Rana, D. S.; B. Singh, K.; Gupta, A. K.; Dhaka, and S. Arya. (2013). Response of fodder  
296 sorghum (*Sorghum bicolor* L.) to zinc and iron. *Forage Res.*, 39: 45- 47.

297 Sharma, K. C. (2009). Integrated nitrogen management in fodder oats (*Avena sativa* L.)  
298 in hot arid ecosystem of Rajasthan. *Indian Journal of Agronomy*, 54(4): 459-464.

299 Sharma, K. C. and Verma, R. S. (2004). Effect of chemical and biofertilizers on growth behavior of  
300 multicut fodder oats (*Avena sativa* L.), *Range ManagAgrofor*. 25: 57-60.

301 Sharma, S.K. and Bhunia, S.R. (2001). Response of oat (*Avena sativa* L.) to cutting  
302 management, method of sowing and nitrogen. *Indian Journal of Agronomy*, 46(3):563- 567.

303 Sheoran, R. S.; Rana, D. S. and Grewal, R. P. S. (2002). Influence of *Azotobacter* inoculations in  
304 conjugations with graded doses of nitrogen on forage yield of oats (*Avena sativa* L.) *Forage*  
305 *Research* 28(1): 8-12.

306 Singh, D.; Nainwal, R.C. and Tewari, S.K. (2015). Integrated nutrient management in non  
307 traditional crop oat (*Avena sativa* L.) under partially reclaimed soil *An International Journal* 10  
308 (5): 2499-2502.

309 Singh, V. P., Verma, S. S., & Chandra, R. (2005). Effect of fertility level with biofertilizer and  
310 cutting management on seed yield of oat. *Forage Research*, 31(1), 57-58.

311 Soyulu, S., B. Sade, A. Topal, N. Akgun and S. Gezgin. 2005. Responses of irrigated durum and  
312 bread wheat cultivars to boron application in a low boron calcareous soil. *Turk. J. Agric*. 29: 275-  
313 286.

314 Stevens, E. J.; Armstrong, K. W.; Bezar, H.J.; Griffin, W. B. and Hampton, J.G. (2004) .*Fodder*  
315 *Oats: An Overview*. Available at [www.fao.org/ag/AGP/AGPC/doc/pasture/spectopics/fodder](http://www.fao.org/ag/AGP/AGPC/doc/pasture/spectopics/fodder)  
316 [oats596.pdf](#).

317 Tiwana, U.S.; Puri, K.P. and Chaudhary, D.P. (2008). Fodder productivity and quality of  
318 multicut oat grown pure and in mixed with different seed rates of sarson *Forage Research* 33(4);  
319 224-226.

320 Umadevi ; Singh, K. P.; Sehwal, M. and Kumar, S. (2010). Effect of nitrogen levels, organic  
321 manures and Azotobacter inoculation on nutrient uptake of multicut oats. *Forage Research*.  
322 36(1): 9-14.

323 Wong, W. S., Zhong, H. T., Cross, A. T., & Yong, J. W. H. (2020). Plant biostimulants in  
324 vermicomposts: Characteristics and plausible mechanisms. *The chemical biology of plant*  
325 *biostimulants*, 155-180.

326 Gomez, K.A. and A.A. Gomez. 1976. Statistical procedure for agricultural research with  
327 emphasis on rice, 2nd Ed. IRRI, Los Banos, Philippine.  
328

UNDER PEER REVIEW