



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

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Authors' contributions

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

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ABSTRACT

Field experiments were carried out to Study the Integrated Nutrient Management to increase Productivity and Profitability in Dual Purpose Oat (*Avena sativa* L.) at Genetics and Plant Breeding Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh (UP), during *Rabi* season 2018-19. The experiment was laid out in Randomized block design (RBD) with three replications and nine treatments *viz.*, T1: Control, T2:

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RDF (100 kg N : 40 kg P₂O₅ : 40 kg K₂O 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 + ZnSO₄ @ 20 kg ha⁻¹ (soil application as basal), T7: T5+ ZnSO₄ @ 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 ZnSO₄ (0.5%) at just before flowering. Results revealed that higher yield 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 for T8: 75% RDN + Vermicompost @ 2t ha⁻¹ + PSB (soil) @ 1.5 kg ha⁻¹ + Azotobacter (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ (basal) + foliar spray of ZnSO₄ (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 had a significant effect on total biomass production, yield attributes, yield and profitability of oat.

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* has diploid, tetraploid and hexaploid species based on a basic chromosome number of $x=7$. Oat commonly known as *jai*, the center 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 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 their processed products are nowadays highly appreciated due to their medicinal values and it also rich in energy, protein, vitamin B, phosphorous and iron" [1]. "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 under nourishes the livestock of India compared to temperate countries" [1].

"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 other cereal straws" [2]. "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" [3].

"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" [4]. "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". [5]. Vermicompost is rich in plant nutrients and contain higher number of microorganism, which are responsible for decomposition process [6,7] reported that "vermicompost treated soils had lower pH and increased level of organic matter, primary nutrient, and soluble salts" [8] 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 secrete certain plant growth promoter which enhances the growth and quality of crops. Biofertilizers can indemnify 20-25% of chemical nutrient input, which are cost effective and eco-friendly. Azotobacter is a free living nitrogen fixing biofertilizer and fixes 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 biofertilizers like Azotobacter which fixes the nitrogen and improved the available nitrogen in soil and PSB improved the available phosphorus content in soil” [9].

“The foliar application of the micro nutrients is more effective than soil application” [10]. “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 improved when; it is used in combination with other elements like N & K in wheat” [11].

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* season 2018-19 at Genetics and Plant Breeding farm, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Ayodhya (U.P.). Study location is situated at 26° 47' North latitude and 82° 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°C to 37.5 °C 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 (Recommended Dose of Fertilizer) (100 kg N : 40 kg P₂O₅ : 40 kg K₂O ha⁻¹), T3: 75 % RDN (Recommended Dose of Nitrogen) + Vermicompost @ 2 t ha⁻¹, T4: T3 + PSB (soil application @ 1.5 kg ha⁻¹), T5: T4 + Azotobacter (seed treatment @ 10g kg⁻¹ seed), T6: T5 + ZnSO₄ 20 kg ha⁻¹ (soil application as basal), T7: T5+ ZnSO₄ 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 ZnSO₄ (0.5%) at just before flowering. The size of each plot was (12 m²) 4.0 m in length and 3.0 m in breadth. Each experiment included 27 treatments.

2.4 Agronomic Practices

The fields were irrigated one week before sowing for good seed bed preparation and germination. The field was prepared by three ploughing out of which one ploughing was done by disc harrow followed by two ploughing done 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 were done separately in each plot as per treatments. Application of vermicompost was done @ 2 tonne per hectare at the time of last ploughing. In the recommended dose of fertilizer 100-40-40 kg ha⁻¹ (N, P₂O₅, K₂O). Half dose of nitrogen and a full dose of phosphorus and potash were given as basal dose and remaining nitrogen applied as a top dressing in two equal splits; 25% at 40 DAS and 25% at after first cut of oat and was given. Similarly in 75% RDN per plots, half of nitrogen was applied as basal and remaining nitrogen as top dressed in the 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, ZnSO₄ 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 was sprayed over the seed and well mixed and dried in a shade place. The desired quantity of healthy and clean seeds was 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 profitability were 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 the Benefit: Cost 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 [12]. 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 are 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 viz. length of panicle (37.80cm), number of grain panicle⁻¹(52.66), panicle weight (9.30g) and test weight (48.10g) were recorded with application of 75% RDN + Vermicompost @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + Azotobacter (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ (basal application) + foliar spray of ZnSO₄ (0.5 %) 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 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 [13] and [14].

3.2 Yields

3.2.1 Green forage yields (q ha⁻¹)

Green forage yield presented in (Table 1) depicted in Fig. 1 reveals 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 @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + Azotobacter (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ (basal application) + foliar spray of ZnSO₄ (0.5 %) at just before flowering and minimum green forage yield was recorded in control plots. The inoculation of seeds may have improved nitrogen fixation, increasing the amount of nitrogen available, which in turn raised the yield of green fodder because nitrogen stimulates vegetative growth. Similar, results were also reported by [15-18].

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 the assimilatory system in plants. Dried stalk yield refers to the function of maximum nutrients accumulation in plant biomass, statistically maximum dry matter yield (90.60 q ha⁻¹) at first cut (55 DAS) was recorded in 75% RDN + Vermicompost @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + Azotobacter (seed treatment) @ 10 g kg⁻¹ of

seed + ZnSO₄ @ 20 kg ha⁻¹ (basal plication) + foliar spray of ZnSO₄ (0.5 %) just before flowering and minimum was recorded in control plots. It could be because nitrogen-fixing and growth-promoting bacteria increase dry matter yield by raising nitrogen availability and boosting plant dry matter accumulation in the vegetative parts [19] reported an increase of 10-15 % in green and dry forage yield of oat through seed inoculation. Similar results were also reported by [20,21,15] and [16].

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 @ 2 t ha⁻¹ + PSB (Soil) @ 1.5 kg ha⁻¹ + Azotobacter

(seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ basal + foliar spray of ZnSO₄ @ 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 the 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 [20,22,16,14,5] and [23] in oat.

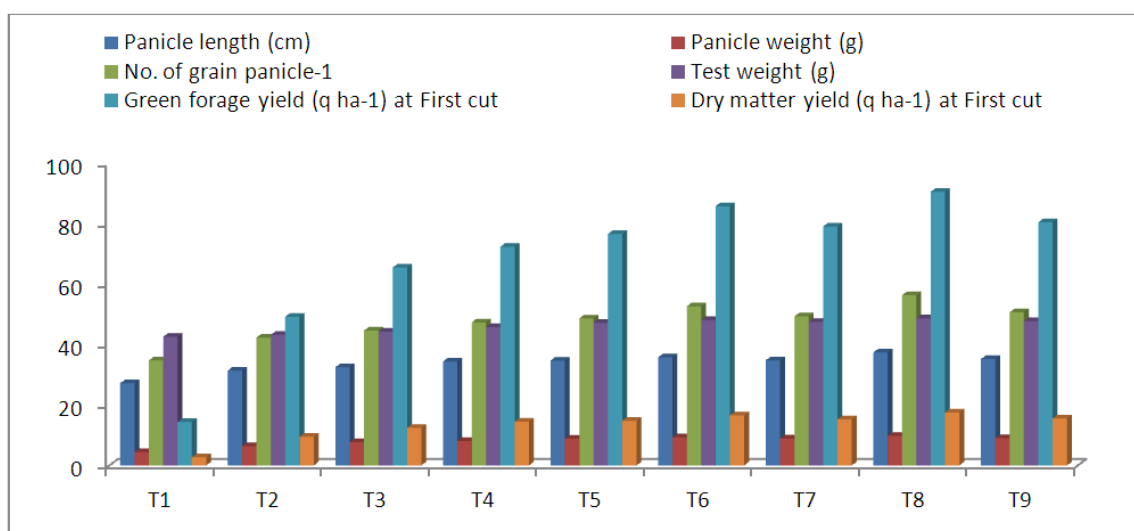


Fig. 1. Effect of Integrated nutrient management on yield attributes of oat crop

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) at First cut	Dry matter yield (q ha ⁻¹) 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
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	-	-	-	-

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 higher population in the 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 [24,25,20,26,27]. 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 [28] in wheat. The effect of different nutrient management practices on harvest index was found non-significant and these results corroborated with the finding of [29].

3.3 Profitability

The higher cost (Table 2) of cultivation (INR 30464 ha⁻¹) was incurred with 75% RDN + Vermicompost @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + *Azotobacter* (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ (basal application) + foliar spray of ZnSO₄ (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 @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + *Azotobacter* (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ (basal application) + foliar spray of ZnSO₄ (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 @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + *Azotobacter* (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 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 the cost of cultivation with these treatments compared to control plot. These results corroborated with the finding of [18,30,31].

4. CONCLUSION

In the field experiment the use of organic and inorganic fertilizers or nutrient significantly effect on Oat yield, yield attributes and economics. Considering the aforesaid conclusions, the application of 75 % RDN (75 kg N ha⁻¹) + vermicompost @ 2 t ha⁻¹ + PSB (soil application) @ 1.5 kg ha⁻¹ + *Azotobacter* (seed treatment) @ 10 g kg⁻¹ of seed + ZnSO₄ @ 20 kg ha⁻¹ (basal application) and foliar spray of ZnSO₄ (0.5 %) just before flowering may be safely recommended for good quality fodder, grain production and profitability of dual purpose oat.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Tiwana US, Puri KP, Chaudhary DP. Fodder productivity and quality of multicut oat grown pure and in mixed with different seed rates of sarson. Forage Research. 2008;33(4):224-226.
2. Stevens EJ, Armstrong KW, Bezar HJ, Griffin WB, Hampton JG. (2004) . Fodder Oats: An Overview. Available: www.fao.org/ag/AGP/AGPC/doc/pasture/spectopics/fodder_oats596.pdf
3. Strychar R, Webster FH, Wood PJ. World oat production, trade and usage. Oats: Chemistry and Technology. 2011;77-94.
4. Sharma SK, Bhunia SR. Response of oat (*Avena sativa* L.) to cutting management, method of sowing and nitrogen. Indian Journal of Agronomy. 2001;46(3):563-567.
5. Patel JR, Rajagopal S. Response of oats (*Avena sativa* L.) to nitrogen and phosphorus levels. Indian J. Agron. 2002; 47(1):134-137.

6. Olle M. The effect of vermicompost based growth substrates on tomato growth. *Journal of Agricultural Science*. 2016; 1(27):38-41.
7. SRamnarain YI, Ansari AA, Ori L. Vermicomposting of different organic materials using the epigeic earthworm *Eisenia foetida*. *International Journal of Recycling of Organic Waste in Agriculture*. 2019;8(1):23-36.
8. Wong WS, Zhong HT, Cross AT, Yong JWH. Plant biostimulants in vermicomposts: Characteristics and plausible mechanisms. *The chemical biology of plant biostimulants*. 2020;155-180.
9. Umadevi, Singh KP, Sehwaq M, Kumar S. Effect of nitrogen levels, organic manures and *Azotobacter* inoculation on nutrient uptake of multicut oats. *Forage Research*. 2010;36(1):9-14.
10. Arif M, Chohan MA, Ali S, Gul R, Khan S. Response of wheat to foliar application of nutrients. *J. Agric. Biol. Sci.* 2006;1(4):30-34.
11. Morales F, Ancín M, Fakhret D, González-Torralba J, Gámez AL, Seminario A, Aranjuelo I. Photosynthetic metabolism under stressful growth conditions as a bases for crop breeding and yield improvement. *Plants*. 2020;9(1):88.
12. Gomez KA, Gomez AA. *Statistical procedure for agricultural research with emphasis on rice*. 2nd Ed. IRRI, Los Banos, Philippine; 1976.
13. Khanday B A, Samoon AR, Waseem R, Khanday J, Bahar FA. Integrated nutrient management for seed production of oat (*Avena sativa L.*) under temperate conditions of Kashmir. *International J. of Agricultural Sciences*. 2009;5(1):145-147.
14. Singh D, Nainwal RC, Tewari SK. Integrated nutrient management in non traditional crop oat (*Avena sativa L.*) under partially reclaimed soil. *An International Journal*. 2015;10(5):2499-2502.
15. Godara AS, Gupta US, Singh R. Effect of integrated nutrient management on herbage, dry fodder yield and quality of oat (*Avena sativa L.*). *Forage Research*. 2012;38(1):59-61.
16. Rana DS, KB Singh, Gupta AK, Dhaka, S Arya. Response of fodder sorghum (*Sorghum bicolor L.*) to zinc and iron. *Forage Res*. 2013;39:45- 47.
17. Dahipahle AV, Sharma N, Kumar S, Singh H, Kashyap SK, Kumar V. Appropriate nitrogen management: A tool for potential fodder oat (*Avena sativa L.*) production. *International Journal of Current Microbiology and Applied Science*. 2017; 6(5):1860-1865.
18. Patel KM, Patel DM, Gelot DG, Patel IM. Effect of integrated nutrient management on green forage yield, quality and nutrient uptake of fodder sorghum (*Sorghum bicolor L.*). *International Journal of Chemical Studies*. 2018;6(1):173-176.
19. Anitha S, Srinivasan E, Singh R. *Cowpea Agronomy*. Cowpea in India. 2004;136-167.
20. Sheoran RS, Rana DS, Grewal RPS. Influence of *Azotobacter* inoculations in conjugations with graded doses of nitrogen on forage yield of oats (*Avena sativa L.*) *Forage Research*. 2002;28(1):8-12.
21. Singh VP, Verma SS, Chandra R. Effect of fertility level with biofertilizer and cutting management on seed yield of oat. *Forage Research*. 2005;31(1):57-58.
22. Ashok K, Rajgopal DS, Lalit K. Effect of vermicompost, poultry manures and *Azotobacter* inoculation on growth, yield and nutrient uptake of baby corn. *Indian Journal of Agronomy*. 2008;34(4):342-347.
23. Devi U, Joon RK, Sewhag M, Kumar J. Growth studies of multicut oats (*Avena sativa L.*) as influenced by levels of nitrogen, organic manures and *Azotobacter* inoculation. *Forage Research*. 2009;35:152-156.
24. Agrawal SB, Tomar SS, Bhaduria AKS, Kewat ML. Response of fodder oats (*Avena sativa L.*) to methods of *Azotobacter* inoculation under various levels of nitrogen. *Ann. Agri. Res*. 2002;23(4):692-696.
25. Deva S. Effect of tillage practices and nutrient management on fodder yield of oat, soil fertility and microbial population. *The Bioscane An International quarterly journal of life science*. 2015;10(1):173-176.
26. Sharma KC. Integrated nitrogen management in fodder oats (*Avena sativa L.*) in hot arid ecosystem of Rajasthan. *Indian Journal of Agronomy*. 2009;54(4):459-464.
27. Patel TU, Arvadia MK, Patel DD, Thanki JD, Patel HM. Response of oat (*Avena sativa L.*) to cutting management and times of nitrogen application. *Crop Research and Research on Crops*. 2013;14(3):902-906.

28. Soylu S, Sade B, Topal A, Akgun N, Gezgin S. Responses of irrigated durum and bread wheat cultivars to boron application in a low boron calcareous soil. *Turk. J. Agric.* 2005; 29:275-286.
29. Sharma KC, Verma RS. Effect of chemical and biofertilizers on growth behavior of multicut fodder oats (*Avena sativa L.*), Range Manag Agrofor. 2004;25:57-60.
30. Malik P, Midha LK, Arya S, Joshi UN. Effect of cutting and fertility levels on quality of oats (*Avena sativa L.*). *Forage Research.* 2015;40(4):257-258.
31. Iqbal A, Iqbal MA, Nabeel F, Khan HZ, Akbar N, Abbas RN. Economic and sustainable forage oat (*Avena sativa L.*) production as influenced by different sowing techniques and sources of nitrogen. *American-Eurasian Journal of Agriculture and Environmental Sciences.* 2014;14(10):1035-1040.

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