International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(6): 616-624
www.biochemjournal.com
Received: 02-04-2024
Accepted: 10-05-2024

Divya Chaudhary
M.Sc. Research Scholar, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Mohd Shah Alam
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Jay Nath Patel
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Yograj
Assistant Professor, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Corresponding Author:
Divya Chaudhary
M.Sc. Research Scholar, Department of Agronomy, School of Agriculture, Abhilashi University, Mandi, Himachal Pradesh, India

Effects of synthetic fertilizer, organic fertilizer, and bio-fertilizers on the yield and productivity of dual-purpose oat (*Avena sativa* L.) crops under mid-hill region Himachal Pradesh

Divya Chaudhary, Mohd Shah Alam, Jay Nath Patel and Yograj

DOI: https://doi.org/10.33545/26174693.2024.v8.i6Sh.1416

Abstract
A field study was carried out during *Rabi* season of 2022-2023 at the Research Farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) to evaluate the effects of synthetic fertilizer, organic fertilizer, and bio-fertilizers on the yield and productivity of dual-purpose oat (*Avena sativa* L.) crops under mid-hill region Himachal Pradesh. The experiment was laid out in randomized block design (RBD) with eight treatments and replicated thrice. The different treatment combination was T_1= Absolute control, T_2= RDN ($N:P_2O_5:K_2O$-100:40:40) kg ha^{-1}, T_3= 75% of RDN + 25% vermicompost @ 2 t ha^{-1}, T_4= T_3+ PSB @ 1.5 kg ha^{-1}, T_5= T_4+ Azotobacter (Seed treatment) @ 10 g/kg of seed, T_6= T_5+ $ZnSo_4$ @ 25 kg ha^{-1}, T_7= T_5 + $ZnSo_4$ @ 20 kg ha^{-1},T_8= T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stage (flowering+ panicle initiation). The maximum plant height (87.09), no. of tillers (359.12), dry matter accumulation (779.47), yield attributes *viz.* spike length (30.22), no. of effective tillers (354.11), no. of spikes (369.43), grain per spike (44.10) and yields *i.e.*, grain yield (13.74),straw yield (62.46), biological yield (76.03), green forage yield (85.30), dry forage yield (16.86) were recorded under treatment T_8= T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stage (flowering+ panicle initiation).The higher yield of dual purpose oats was achieved by treatment T_8 which proved significantly superior to other treatments. The minimum value of these parameters was recorded under control treatment. The use of inorganic fertilizer along with organic sources had positive and significant effect on growth and yield of oat crop.

Keywords: Phosphate solublizing bacteria (PSB), $ZnSo_4$, RDN (Recommended dose of nitrogen), Azotobactor, profitability

1. Introduction
Oat (*Avena sativa* L.) is a constituent of family Poaceae. Oat commonly known as *jai*, the center of origin of oat is Asia Minor. Oats offer extremely nutrient-dense (13-15%) fodder that is particularly well-suited for dairy cattle. It needs an extended growing season with a lower mean daily temperature because it is cool season crop. Oats are primarily grown in a few states, including Uttar Pradesh, Bihar, Punjab, Jammu & Kashmir, Himachal Pradesh, Uttrakhand, and West Bengal. Though, Oat is a new crop in India it is ranked 6th in the world cereals production statistics following Wheat, Rice, Barley, and Maize. It is presently cultivated on large scale in Uttar Pradesh (34%), Punjab (20%), and Bihar (16%) Haryana (9%) and Madhya Pradesh (6%) and to a limited extent, in certain part of Himachal Pradesh, Gujarat, Maharashtra, Orissa, and West Bengal (Chandey *et al.*, 2002) [6]. Due to its therapeutic properties and richness in iron, phosphorus, protein, energy, and vitamin B, oat grains and their processed derivatives are now highly valued (Tiwana *et al.*, 2008) [28].

India is primarily an agricultural nation, with 20.5 million people depending on cattle for a living (Singh 2020) [26]. The nation presently has a net shortage of 44% concentrate feed ingredients, 10.95% dry fodder, and 35.6% green fodder. Oat is a winter season muticut crop, having excellent growth, wider adaptability, capable of producing nutritious and palatable fodder to milch cattle (Pathan *et al.*, 2020) [21]. Oat being a dual purpose filed crop can be used as food for human and feed for human and livestock such as green fodder, straw, hay or silage. In oat crop commonly two cuttings at different as stages i.e., 1st cut at 60 DAS 2nd cut at 50% flowering gave the better growth and yield (Sharma and Bhunia, 2001) [25].

Cutting management is the one of the important factor influencing the fodder influencing crop growth, yield and quality. In general cutting management may fallow in fodder crops for higher yields. As compared to single cut muticut crops absorbs more nutrients, which directly influence the nitrogen content, protein content and other quality parameters of the crop. Cutting is one of the main factor to influence the green and dry forage (Patel *et al*. 2013) [20].

Nitrogen is one of the important constituents of the chlorophyll pigment and N fertilization not only increases the chlorophyll content but also increases the leaf area in plants which are responsible for maximizing, radiation load and the rate of photosynthesis leading to increasing biomass accumulation (Azeez 2009, Wortmaan *et al*. 2011) [4, 32]. The interaction effect of nitrogen and phosphorus levels on plant height, leaf height, 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 of oat were non-significant at first cut, second cut (at harvest) and in the mean values, (Patel and Rajgopal, 2002) [18]. Tripathi (2003) [29] also reported that the green and dry fodder yield of oats + Indian clover significantly increased with 80 kg P_2O_5 ha^{-1}.

The use of inorganic fertilizers for enhancing food grain production is unavoidable, given that the issue of food security poses challenges from the local to the global scale. Nevertheless, continuous use of inorganic fertilizers over the long-term brings challenges regarding soil health, which cause a yield reduction. (Rakshit *et al*. 2018) [22] observed that the continuous use of inorganic fertilizers worsens the soil bio-physiochemical characteristics, such as bulk density, porosity, electrical conductivity, soil organic carbon, available nitrogen, phosphorus and potassium, dehydrogenase activity, microbial biomass carbon, alkaline phosphate activity, acid phosphate activity, etc.

The use of organic manure provides these benefits, including better soil organic carbon content, increased sequestration of soil carbon, improved nitrogen fixation, and reduced harmful greenhouse gas emission. Application of 100% RDF along with biofertilizer increased available nutrient content in soil after harvest of oat crop because of residual effect of fertilizer applied and biofertilizer like azotobacter which fixes nitrogen and improves the available phosphorus content in soil (Umadevi *et al*. 2010) [30].

The integrated system method leads to sustainable agriculture and is a concept of ecological soundness that yields high output with significant fertilizer economy. Preserving and enhancing soil fertility to sustain crop yield over an extended period of time is the fundamental idea behind an integrated plant nutrition system. Singh (2017) [27] discovered that the utilization of various organic and inorganic sources was highly successful in achieving increased productivity, enhanced economy, and enhanced soil residual fertility. The combination of inorganic fertilizer materials and organic manures has been shown to be promising for stabilizing crop output, enhancing soil physical conditions, and preserving greater crop output, enhancing soil physical conditions, and preserving greater crop productivity.

2. Materials and Methods

2.1 Study area

The experiment entitled "studies on nutrient management for productivity enhancement in dual purpose oats under mid hill region of Himachal Pradesh" was carried out at the research farm of the School of Agriculture the University, Mandi (H.P.) during Rabi season of 2022-2023. The experimental farm is situated at 30^0 32' N latitude and 74^0 53' E longitudes, with an elevation of 1391 m above mean sea level. The soil of the experimental field was slightly acidic (pH 5.5) in reaction, medium in organic carbon (0.15%), EC (0.19 dsm^{-1}), low in available nitrogen (290 kg ha^{-1}) and medium in available phosphorus (15 kg ha^{-1}), potassium (156 kg ha^{-1}) and Zn (0.41 $mgkg^{-1}$).

2.2 Treatments and experimental design

The experiment was laid out in a randomized block design (RBD) with eight treatments and three replications. The treatments, *viz*., T_1 = Absolute control T_2 = RDN ($N:P_2O_5:K_2O$- 100:40:40) kg ha^{-1}, T_3 = 75% of RDN + 25% vermicompost @ 2 t ha^{-1}, T_4= T_3 + PSB @ 1.5 kg ha^{-1}, T_5 = T_4 + Azotobacter (Seed treatment) @ 10 g/kg of seed, T_6= T_5+ $ZnSo_4$ @ 25 kg ha^{-1}, T_7= T_6+ $ZnSo_4$ @ 20 kg ha^{-1},T_8= T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stage (flowering + panicle initiation). The net plot size was 1.7 m × 1.2 m= 2.04 m^2 and the gross plot size was 2.0 m × 1.7 m=3.4 m^2. Application of nutrients was accordingly to the treatments. Recommended dose of N, P and K were applied through Urea, DAP and MOP. Each plot received a different application of fertilizer based on the treatments. The suggested fertilizer dose is 100:40:40 kg ha^{-1} (N, P_2O_5, and K_20). Half dose of nitrogen and full dose of phosphorus and potash were applied at the time sowing. The remaining nitrogen was applied as a top dressing in two equal splits: 25% at the time first cut of oat (30 DAS) and other 25% after 45 DAS. Similar to RDF, half of the nitrogen delivered to each 75% RDN plot was used as basal, while the remaining nitrogen was top dressed.

At the time of the final ploughing, the application of 1.5 kg ha^{-1} of Phosphorus solublizing bacteria (PSB) inoculants combined with finely powdered vermicompost was dispersed. $ZnSo_4$ was given at basal doses of 20 kg and 25 kg ha^{-1} during seeding in the experimental field and a foliar spray (0.5% $ZnSo_4$) was applied right before the crop flowering and panicle initiation, according to the treatment. Seed rate used during the investigation was 7 kg. Seed was treated with Azotobacter, one kg of seed treated with 10 g of Azotobacter inoculants was mix with the seed and kept in a shade place. Seed was shown by line method. All of the plots were sown on November 7, 2022, considering that the crop was raised for both grain and fodder. At 30 DAS, it was harvested for green fodder using a sickle, and the remaining material was left for seed production. Once the crop reached physical maturity, the oats were harvested.

2.3 Data collection

Plants was selected randomly and marked from each plots, for the recording of growth and yield parameter and yield data. For data collection of plant height five randomly selected plants were tagged and height was measured from bottom of plant to the top leaf. In case of number of tiller area of 1 m^2 was marked inside the net plot, plants were counted and data were collected. The plant samples for dry matter accumulation well be taken at 30, 60, 90 DAS and at harvest after sowing from 0.25 m row length selected randomly from each plot. The samples were sun dried and then dried in oven at 72 °C ± 0.5 °C for 72 hours or till the constant were achieved. The dry matter was expressed in gram per meter row length. Number of effective tillers will be recorded by using a quadrate of one square meter in each plot as per procedure followed for counting number of tillers at each successive stage. Total no. of spikes was counted by using a quadrate of one square meter in each plot at the time of harvest. Five spikes will be selected randomly and their length measured. Figures of all the five spikes will be added and sum will be divided by 5 to get average spike length. It will be recorded in cm. Ten spikes will be select randomly from each plot and numbers of filled grain per ten spikes will be count and average number of grains per spike will be workout. Using a dial spring balance green forage yield for each treatment, the harvest of each net plot at the 30th day of assaying was precisely weighed in fractions of kilograms stated in q ha^{-1}.

In a similar manner, the net plot area is used to gather grain and straw yields. The crop was harvested at 2 May 2024, they were threshed, sun-dried, kept at 12% moisture content, and their weight was measured right away.

2.4 Statically analysis

The analysis of variance approach was used to statistically analyze the field data, and treatment means were compared using the critical differences (CD) proposed by Gomez and Gomez (1984) [10] to determine significance at 5%.Using 100 kg ha^{-1}, oat seeds were sowed in each plot during the second week of November. When it came time for irrigation, each plot received the same amount of water.

3. Result and Discussion

3.1 Plant height (cm)

The information concerning to plant height of dual purpose oats as affected by different nutrient treatments were recorded at 30,60,90 DAS and at harvest are presented in Table 1 and graphically shown in Fig. 1. According to the observation, at 30 DAS, plant height was found to be non-significantly affected by the treatments. However, the plant height was impacted significantly by different treatments at 60, 90, and at harvest during the investigation. At 60, 90 DAS and at harvest highest plant height (cm) were recorded under treatment T_8= T_7+ $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation) (65.50), (78.45) & (87.09) which was at par with T_6= T_5+ $ZnSo_4$ @ 25 kg ha^{-1} (63.21), (75.24) & (83.67). Whereas, the minimum plant height was recorded under treatment T_1= Absolute control (35.18), (50.12) & (54.02). Among the other treatments, T_7 recorded the highest plant height followed by $T_5>T_4>T_3>T_2$.

Increased nutrient availability is likely the cause of the increase in plant height seen in response to the application of 75% RDN+25% vermicompost @ 2 t ha^{-1} + PSB @ 1.5 kg ha^{-1} + Azotobacter (Seed treatment) @ 10 g kg^{-1} of seed + $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation). It's possible that the panicle initiation treatment and the foliar application of zinc sulfate immediately prior to flowering caused the plants to grow taller at later stage of crop during investigation. The increase in plant height may be attributed to increased availability of nutrients in soil. These results are in accordance with those reported by Pandey and Rana (2016) [16-17]. Similar result was found by Jadav *et al*. (2018) [12] and Sharma (2009) [24], Ravankar *et al*. (2005) [23].

Table 1: Effect of nutrient management on plant height in dual purpose oats

S.N.	Treatments	Plant height (cm)			
		30 DAS (1st cutting)	60 DAS	90 DAS	At Harvest
T_1	Absolute control (No fertilizers)	9.90	35.18	50.12	54.02
T_2	RDN ($N:P_2O_5:K_2O$-100:40:40) kg ha^{-1}	12.20	48.21	57.57	64.73
T_3	75% of RDN+ 25% vermicompost @ 2 t ha^{-1}	14.50	51.52	64.10	69.53
T_4	T_3 + PSB @ 1.5 kg ha^{-1}	15.20	56.78	69.17	75.69
T_5	T_4 +Azotobacter (Seed treatment) @ 10 g /kg of seed	17.20	59.74	71.81	78.75
T_6	T_5 + $ZnSo_4$ @ 25 kg ha^{-1}	19.53	63.21	75.24	83.67
T_7	T_6 + $ZnSo_4$ @ 20 kg ha^{-1}	18.30	60.37	73.35	81.72
T_8	T_7 + Foliar spray of $ZnSo_4$ (0.5%) at two *stage (flowering* + panicle initiation)	21.06	65.50	78.45	87.09
	CD at 5%	*NS*	*4.88*	*4.10*	*4.05*
	Sem±	*3.92*	*1.91*	*1.91*	*1.89*

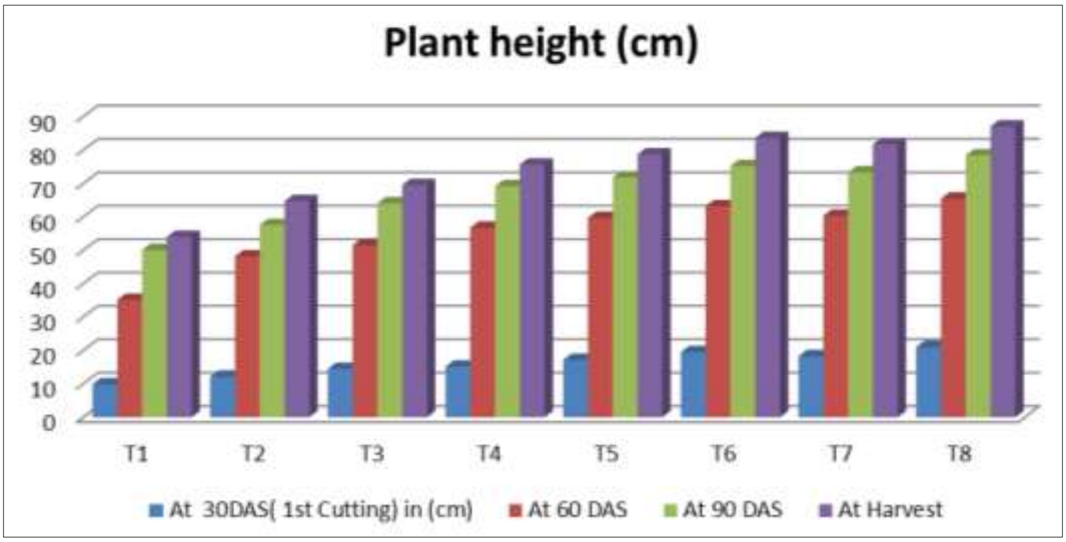

Fig 1: Effect of nutrient management on plant height in dual purpose oats

3.2 No. of tillers (m^{-2})
Data pertaining under Table-2 and Figure-2 displays the number of oat tillers counted during growth stages (30, 60, 90 DAS and at harvest) of crop. The various treatments had no significant influence on the number of tillers at 30 DAS. The number of tillers at 60, 90 and at harvest stages of crop growth was significantly impacted by different nutrient treatments, according to the data. The maximum number of tillers was recorded in treatment T_8 [(T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering+ panicle initiation)], which was comparable to treatment T_6 [T_5+ $ZnSo_4$ @ 25 kg ha^{-1})] this may be due to the increased nutrient availability. While the lowest number of tillers (78.14, 164.77, 182.43, 178.29) were recorded under T_1, i.e. Control at various growth stages of crop during the investigation.

Different nutrient management strategies did not significantly affect the number of tillers m^{-2} at 30 days post-sowing. This may be the case because the physical characteristics of the soil, the ambient factors, and the viability of the seed, the percentage of germination, and the percentage of pure seed all affect how well seeds germinate. With more nitrogen available, the proportion of leafiness increased dramatically, and the quantity of tillers per meter of row length is directly correlated with leafiness. The number of tillers is also influenced by the number of cuttings, which may be the outcome of effective use of natural resources such as light, water, and nutrients as well as little interplant competition. Similar results reported by Jadav *et al*., Laghari *et al*. (2010) [12] & Shiyal *et al*. (2020) [31].

Table 2: Effect of nutrient management on tillers m^{-2} in dual purpose oats

S.N.	Treatments	Number of tillers (m^{-2})			
		30 DAS	60 DAS	90 DAS	At Harvest
T_1	Absolute control	78.14	164.77	182.43	178.29
T_2	RDN (N:P_2O_5:K_2O-100:40:40) kg ha^{-1}	101.06	212.10	232.04	227.16
T_3	75% of RDN+ 25% vermicompost @ 2 t ha^{-1}	117.51	220.43	250.88	245.86
T_4	T_3+ PSB @ 1.5 kg ha^{-1}	120.37	234.50	271.36	264.34
T_5	T_4+Azotobacter (Seed treatment) @ 10 g /kg of seed	122.54	250.40	288.67	284.55
T_6	T_5+ $ZnSo_4$ @ 25 kg ha^{-1}	126.49	338.38	334.52	327.91
T_7	T_6+ $ZnSo_4$ @ 20 kg ha^{-1}	124.20	290.04	312.30	308.72
T_8	T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two *stage (flowering* + panicle initiation)	131.62	357.04	365.21	359.12
	CD at 5%	NS	24.98	33.83	36.93
	Sem±	15.04	11.64	15.77	17.21

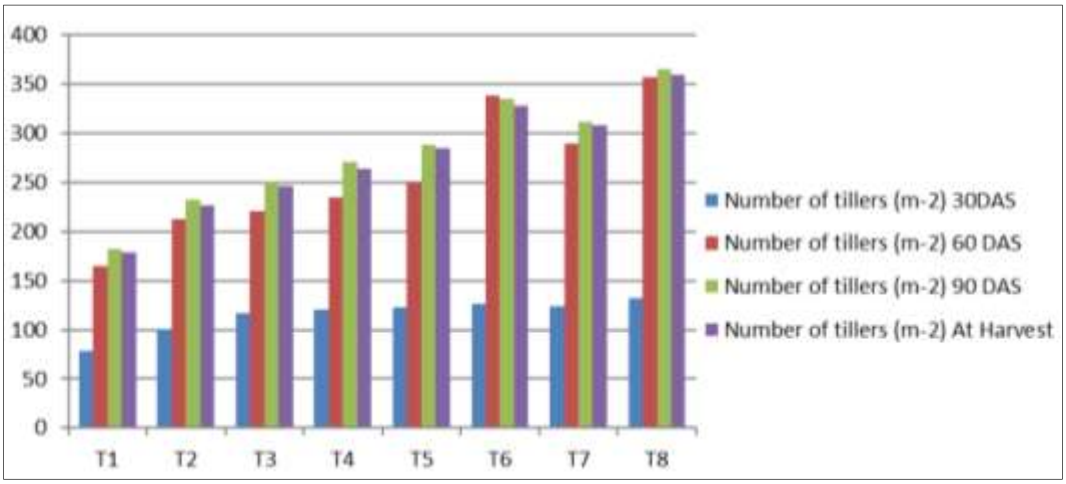

Fig 2: Effect of nutrient management on no. of tillers (m^{-2}) in dual purpose oats

3.3 Dry matter accumulation (g m^{-2})
The data regarding dry matter accumulation were presented in Table-3 and in fig.-3. In the early phases of crop growth (30 DAS) dry matter accumulation was not affected by different nutrient management strategies, but it was strongly influenced in later stages. The dry matter accumulation was significantly impacted by the various treatments at 60, 90, DAS and at harvest stages. Maximum dry matter accumulation was measured under treatment T_8 [T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation) (141.51), (451.63) (585.37), (779.47)] which was statistically at par with treatment T_6 [T_5+ $ZnSo_4$ @ 25 kg ha^{-1}, (130.67), (417.45), (543.64) and (748.56)]. T_7 was the treatment with the highest dry matter accumulation among the others, followed by T_5>T_4>T_3>T_2.

Dry matter accumulation is influenced by plant height, tiller count, and the output of both green and dry feed. At all growth phases, the adoption of different fertilizer management approaches significantly increased the accumulation of dry matter, with the exception of the 30 days after planting. Similar results were also published by Ahmad *et al*. (2011) [1] and Deva (2015) [8].

Table 3: Effect of nutrient management on dry matter accumulation (g m^{-2}) enhancement in dual purpose oats

S.N.	Treatments	Dry matter accumulation (g m^{-2})			
		30 DAS	60 DAS	90 DAS	At Harvest
T_1	Absolute control	78.12	290.72	435.15	482.77
T_2	RDN ($N:P_2O_5:K_2O$-100:40:40) kg ha^{-1}	105.10	339.65	478.21	596.67
T_3	75% of RDN+ 25% vermicompost @ 2 t ha^{-1}	108.33	352.58	500.58	620.40
T_4	T_3+ PSB @ 1.5 kg ha^{-1}	111.56	362.42	527.45	669.81
T_5	T_4+Azotobacter (Seed treatment) @ 10 g /kg of seed	115.32	382.27	534.23	682.65
T_6	T_5+ $ZnSo_4$ @ 25 kg ha^{-1}	130.67	417.45	543.64	748.56
T_7	T_6+ $ZnSo_4$ @ 20 kg ha^{-1}	124.74	401.80	530.41	726.44
T_8	T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two *stage (flowering* + panicle initiation)	141.51	451.63	585.37	779.47
	CD at 5%	NS	38.08	46.41	40.24
	Sem±	17.63	17.75	21.63	18.76

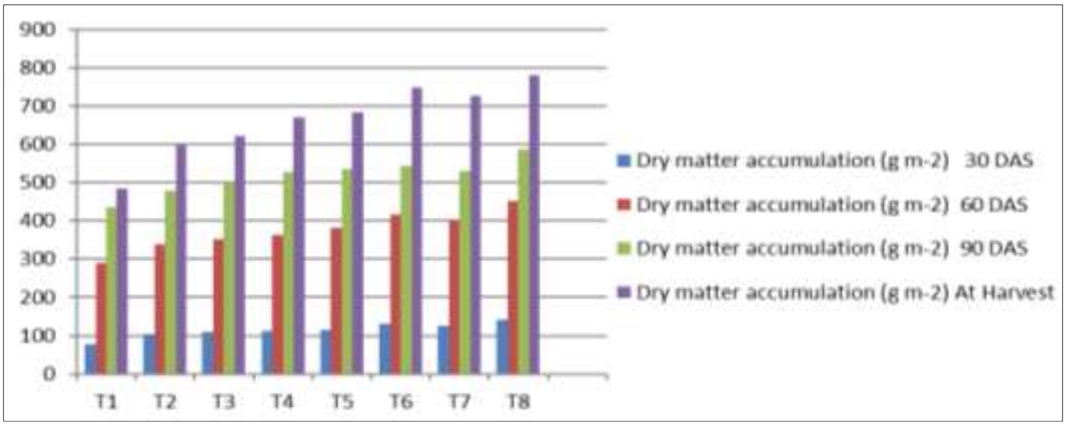

Fig 3: Effect of nutrient management on dry matter accumulation (g m^{-2}) in dual purpose oats

4. Yield and Yield attributes

4.1 Green forage yield (q ha^{-1})

Table-4 and fig-4 presents the data regarding the green forage yield of oat at 30 DAS (first cut) as influenced by different nutrient treatments. Diverse nutrient management strategies led to variations in the yield of green forage. The maximum green forage yield was observed under treatment T_8 [T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation) (85.30)] and was discovered to be noticeably better than the remaining nutrient management techniques. In the control plot, the lowest green forage yield was observed (12.42). The entire biomass that the plant has reached during its life cycle under the current conditions is disclosed by the green forage yield. Since nitrogen encourages vegetative development, it may have better nitrogen fixation, increasing nitrogen availability, and ultimately enhances the supply of green fodder through seed inoculation. Similar findings were also reported by Godara *et al*. (2012) [9], Dahipahle *et al*. (2017) [7], and Patel *et al*. (2018) [19].

4.2 Dry matter yield (q ha^{-1})

Dry forage production is essentially a measure of the photosynthetic efficiency of a plant's assimilatory system." Dried stalk yield" refers to the capacity of plant biomass to accumulate maximal amounts of nutrients. The dry matter yield of oat at 30 DAS (first cut) as affected by different treatments is shown graphically in Fig- 4 and is reported in Table-4. There were substantial differences in the dry matter yield among the different nutrient management strategies. The maximum dry matter yield recorded under treatment T_8 which was at par with treatment T_6 [T_5 + $ZnSO_4$ @ 25 kg ha^{-1}] it shown a notable improvement over the remaining nutrient management techniques. This could be because bacteria that fix nitrogen and promote growth increase the amount of dry matter that plants generate by increasing the availability of nitrogen and promoting the accumulation of dry matter in the plant's vegetative parts. In the control plot, the lowest green forage yield was observed. Mandal *et al*. (2000) [14] observed that oat seed inoculation increased the yield of green and dry fodder by 10% to 15%. Similar results were found by Godara *et al*. (2012) [9] and Rana *et al*. (2013) [11].

Table 4: Effect of nutrient management on green forage and dry forage yield for productivity enhancement in dual purpose oats

Sr. No	Treatments	Grain forage yield (q ha^{-1})	Dry forage yield (q ha^{-1})
		At first cutting	At first cutting
T_1	Absolute control	12.42	2.68
T_2	RDN ($N:P_2O_5:K_2O$-100:40:40) kg ha^{-1}	47.14	9.45
T_3	75% of RDN +25% vermicompost @ 2 t ha^{-1}	63.52	12.43
T_4	T_3 + PSB @ 1.5 kg ha^{-1}	70.42	14.47
T_5	T_4 +Azotobacter (Seed treatment) @ 10 g /kg of seed	74.63	14.72
T_6	T_5 + $ZnSo_4$ @ 25 kg ha^{-1}	81.14	16.10
T_7	T_6 + $ZnSo_4$ @ 20 kg ha^{-1}	77.04	15.25
T_8	T_7 + Foliar spray of $ZnSo_4$(0.5%) at two *stage (flowering* + panicle initiation)	85.30	16.86
	CD at 5%	6.37	1.20
	Sem±	2.97	0.56

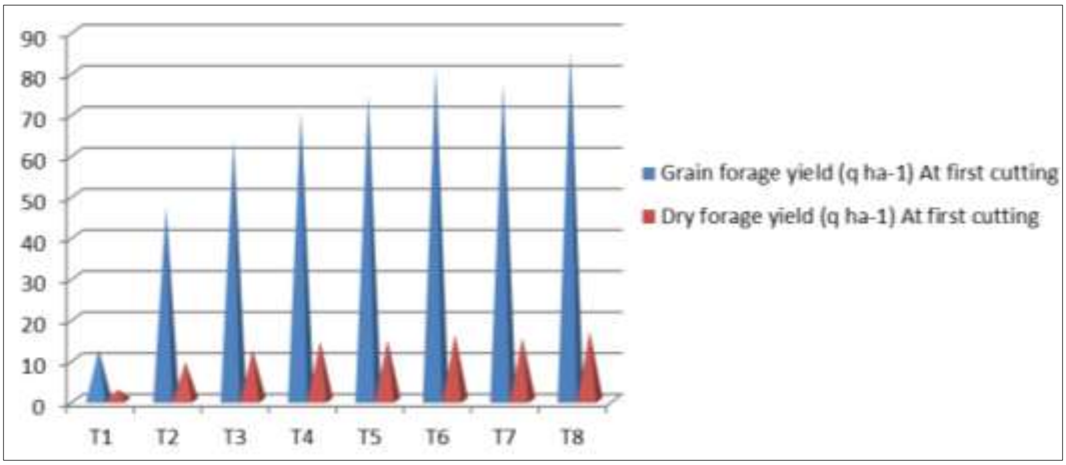

Fig 4: Effect of nutrient management on green forage and dry forage yield for productivity enhancement in dual purpose oats

Fig 4. Effect of nutrient management on green forage and dry forage yield in dual purpose oats

4.3 Length of spike (cm)

The spike length data were noted and presented in Table-4 and illustrates in Fig-4. The maximum spike length is seen in treatment T_8 [(T_7 + Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation)] which were at par with T_6 [T_5+ $ZnSo_4$ @ 25 kg ha^{-1}] and the minimum length of spike was observed under treatment T_1 absolute control.

4.4 No. of Effective tillers (m^{-2})

Number of effective tillers were counted, reported, and shown in Fig.-4 as well as in Table- 4. Across the several nutrient treatments, there were substantial differences in the quantity of tillers at different phases of the oat crop's growth. Maximum number of effective tillers was recorded under treatment T_8 [T_7 + Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation] which was comparable to T_6 [T_5+ $ZnSo_4$ @ 25 kg ha^{-1}]. None the less, with treatment T_1 (control), the minimum number of oat tillers was found at 30, 60, 90 DAS, and the harvest was recorded, respectively.

4.5 No. of spikes (m^{-2})

As seen in Fig.-4, the results for the number of spikes m^{-2} were noted and proved in Table-4. The result showed that the amount of spikes m^{-2} was significantly impacted by the different nutrient management treatments. The maximum number of spikes (m^{-2}) was recorded with treatment T_8 [T_7 + Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation] which was at par with T_6 [T_5+ $ZnSo_4$ @ 25 kg ha^{-1}] and lowest number of spikes was recorded under treatment (T_1) absolute control.

4.6 No. of grains spike^{-1}

The nutrient management treatments had a considerable impact on the number of grain spike^{-1}, as evidenced by the data, which are documented, presented, and depicted in Table-4 and Fig.4 The highest number of grain spike^{-1} recorded under T_8 [T_7 + Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation)] which were at par with T_6 [T_5+ $ZnSo_4$ @ 25 kg ha^{-1}] over the treatments. The lowest number of grain spike^{-1} recorded under treatment T_1 absolute control.

4.7 Test weight (g)

The test weight results for dual-purpose oats are shown in Table-4 and are shown graphically in Fig.-4. Numerically, the maximum test weight was observed with T_8-T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation) and minimum found under control plot. It is clear that the test weight was not significantly influenced by the various nutrient management practices. Shiyal *et al*. (2020) [31] also observed that test weight of oat was not found remarkably influenced due to INM treatments. According to Saha *et al*. 2020 [33], there is no discernible effect of chemical fertilizers, organic manure like FYM, or certain micronutrients like zinc and boron, either separately or in combination, on the test weight of oat seeds.

Nutrient management approaches resulted in a significant increase in the plant's production characteristics, which include test weight, number of effective tillers, number of spikes^{-2}, length of spike (cm), number of grains spike^{-1}, and number of grains. All the yield contributing characters had significantly higher values in the combination of chemical fertilizer, organic manure and bio fertilizer while the control plot had the lowest values. Vermicompost and bio-fertilizers, which improve the physio-chemical and biological properties of soil by providing microorganisms with the nutrients they require, may have enhanced nutrient delivery, which explained this. It also increased soil enzyme activity, which is what converts nutrients from their inaccessible to their accessible forms. Comparable results were found by Khandey *et al*. (2009) [13] & Shiyal *et al*. (2020) [31].

Table 5: Effect of nutrient management on yield attributes for productivity enhancement in dual purpose oats

Sr. No	Treatments	Spike Length (cm)	No. of effective tillers (m^{-2})	No. of spikes (m^{-2})	Grain per spike	Test weight (g)
T_1	Absolute control	13.71	159.19	278.36	35.04	38.67
T_2	RDN ($N:P_2O_5:K_2O$-100:40:40) kg ha^{-1}	18.76	206.39	290.14	36.12	40.24
T_3	75% of RDN+ 25% vermicompost @ 2 t ha^{-1}	19.53	215.06	310.63	36.90	41.40
T_4	T_3+ PSB @ 1.5 kg ha^{-1}	21.41	229.07	318.76	38.22	42.19
T_5	T_4+Azotobacter (Seed treatment) @ 10 g /kg of seed	24.53	245.24	336.45	39.54	42.29
T_6	T_5+ $ZnSo_4$ @ 25 kg ha^{-1}	28.30	333.50	349.79	43.64	44.56
T_7	T_6+ $ZnSo_4$ @ 20 kg ha^{-1}	26.90	285.47	342.52	41.32	44.16
T_8	T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two *stage (flowering* + panicle initiation)	30.22	354.11	369.43	44.10	44.80
	CD at 5%	2.99	27.87	19.76	NS	NS
	Sem±	1.39	12.99	9.21	6.10	1.96

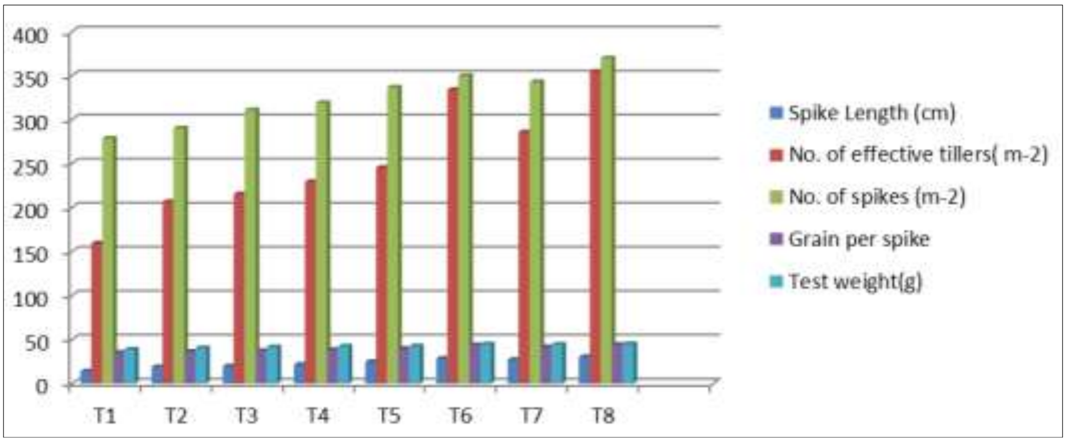

Fig 5: Effect of nutrient management on yield attributes in dual purpose oats

5. Yields of crop

Oat seed and straw yields were progressively increased as a result of applying chemical fertilizer at different stages of crop growth along with organic manure i.e., vermicompost, and biofertilizer like Azotobacter and PSB during the experiment. Continuous applications of nutrients throughout the crop growth period enhance the growth and yield parameters which results in higher grain yield straw yield. Lack of nutrients during critical crop growth stages results in least enhancement under grain and straw yield that was recorded under control plot.

5.1 Grain yield (q ha^{-1})

All nutrient management practices had a significant impact on grain yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index (q ha^{-1}) as evidenced by the data influenced by various nutrient management practices. The data regarding the grain yield, straw yield, biological yield and harvest index are presented in Table-5 and graphically depicted in Fig.-5. The highest grain yield were recorded under treatment T_8 [75% of RDN + 25% vermicompost @ 2 t ha^{-1} + PSB @ 1.5 kg ha^{-1}+ Azotobactor (Seed treatment) @10 g $kg^{-1}$of seed + Foliar spray of $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation)] which at par with treatment T_6 [75% of RDN + 25% @ 2 t ha^{-1}+PSB @ 1.5 kg ha^{-1} + Azotobactor (Seed treatment) @ 10 g kg^{-1} of seed + $ZnSo_4$@ 25 kg ha^{-1}]. The lowest grain yield was recorded under (T_1) absolute control.

Higher seed yields may be attributable to the improvement in growth attributes due to nitrogen application. Vermicompost may increase yields by providing additional nutrients and enhancing the biological and physical characteristics of the soil. Similar findings were reported by Singh and Patra (2017) [27] and Pandey and Chauhan (2016) [16-17]. The application of Borax or $ZnSo_4$ alone, at varying amounts, with or without FYM, did not significantly alter the grain yield of oats. The results unequivocally showed that a balanced nutrient use produced the maximum production (Hussain *et al*. 2013) [11]. Patel and Rajagopal (2002) [18] and Ashok *et al*. (2008) [3] state that the outcomes in oat were consistent.

5.2 Straw yield (q ha^{-1})

Table-5 and Fig.-5 give data on oats straw yield (q ha^{-1}) as influenced by various nutrient management strategies. The data shows that all nutrient management practices had a substantial impact on straw production. The maximum straw yield was recorded T_8, which is [(75% of RDN+ 25% vermicompost @ 2 t ha^{-1}+PSB @1.5 kg ha^{-1}+Azotobactor (Seedtreatment) @ 10 g $kg^{-1}$of seed + $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation)] which was at par with treatment T_6 [75% of RDN + 25% @ 2 t ha^{-1}+ PSB @ 1.5 kg ha^{-1}+ Azotobactor(Seed treatment) @ 10 g kg^{-1} of seed + Foliar spray of $ZnSo_4$ @ 25 kg ha^{-1}] and the minimum straw yield found under treatment T_1 i.e., absolute control where no nutrients were applied.

The highest straw yields were seen when Azotobacter was injected into the seed and PSB was applied to the soil. The substantial improvement in nearly all yield parameters under bio-fertilizer treatments was ascribed the rise in seed and straw yields. When zinc was typically to dual-purpose oat plants during the reproductive growth stage their grain and straw yields improved noticeably. According to Saha *et al*. (2020) [33], the treatment involving 100% NPK + FYM @ 10 t/ha + $ZnSo_4$ @ 20 kg/ha + Borax @ 10 kg/ha had the highest straw yield (7.93 t/ha). The results of Deva, S.

(2015) [8], Sharma (2009) [24], Pandey *et al*. (2020) [15] are consistent with these findings.

5.3 Harvest index
The data recorded on harvest index were given in table-5 and graphically illustrated in Fig.-5. It is evident that harvest index was not significantly affected due to different nutrient management practices but numerically minimum harvest index of dual purpose oat recorded with T_8 [75% of RDN + 25% vermicompost@ 2 t ha^{-1} + PSB @ 1.5 kg ha^{-1} + Azotobactor (Seed treatment) @ 10 g kg^{-1} of seed + $ZnSo_4$ (0.5%) at two stages (flowering + panicle initiation] and maximum was found under treatment T_1 control plots. According to Saha *et al*. (2020) [33], the treatment with 100% NPK + FYM @ 10 t/ha + $ZnSO_4$ @ 20 kg/ha + Borax @ 10 kg/ha (30.7%) had the highest harvest index. Bhatt *et al*. (2000) [5] corroborated a similar result.

Table 5: Effect of nutrient management on yield for productivity enhancement in dual purpose oats

Sr. No	Treatments	Grain Yield (qha^{-1})	Straw Yield (qha^{-1})	Biological Yield (qha^{-1})	Harvest Index (%)
1	Absolute control	5.40	25.21	30.61	17.64
2	RDN ($N:P_2O_5:K_2O$-100:40:40) kg ha^{-1}	9.45	43.30	52.65	17.94
3	75% of RDN + 25% vermicompost @2 t ha^{-1}	10.06	45.30	55.36	18.17
4	T_3 + PSB @ 1.5 kg ha^{-1}	10.23	51.43	61.66	16.59
5	T_4+Azotobacter (Seed treatment) @ 10 g /kg of seed	11.34	53.76	64.46	17.59
6	T_5 + $ZnSo_4$ @ 25 kg ha^{-1}	13.43	59.13	72.56	22.71
7	T_6 + $ZnSo_4$ @ 20 kg ha^{-1}	12.17	56.88	69.52	17.50
8	T_7+ Foliar spray of $ZnSo_4$ (0.5%) at two *stage (flowering* + panicle initiation)	13.74	62.46	76.03	18.07
	CD at 5%	0.97	5.17	5.43	NS
	Sem±	0.45	2.41	2.53	1.74

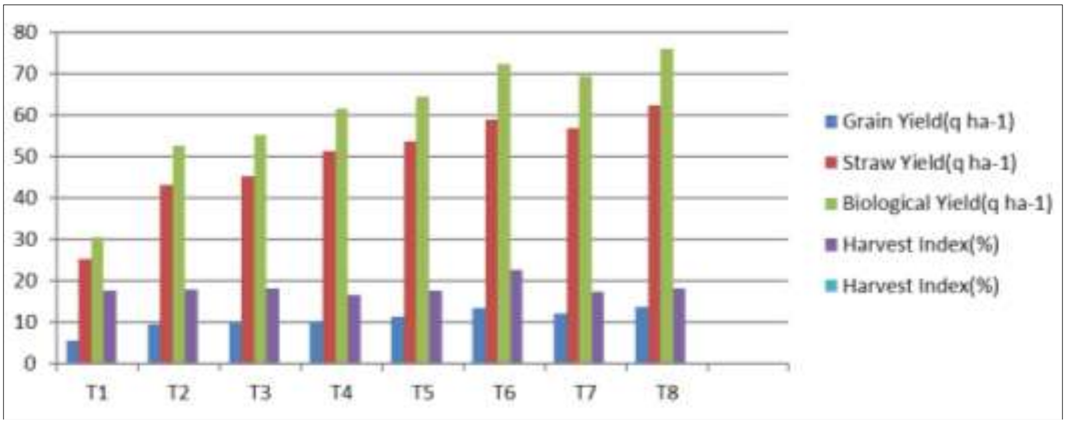

Fig 6: Effect of nutrient management on yield in dual purpose oats

6. Conclusion
From the experiment results, it may be concluded that the application of 75% of RDN+25%vermicompost @ 2 t ha^{-1}+PSB @ 1.5 kg ha^{-}+Azotobacter (Seed treatment) @10 g/kg of seed + $ZnSO_4$ @ 20 kg ha^{-1}+ Foliar spray of $ZnSo_4$ (0.5%) at two *stage (flowering* + panicle initiation) was found to be significantly higher in terms of growth, yield and yield attributes, which was closely followed by T_6 [(75% of RDN + 25% vermicompost @ 2 t ha^{-1}+ PSB @ 1.5 kg ha^{-1} + Azotobacter (Seed treatment) @ 10 g /kg of seed + $ZnSo_4$ @ 25 kg ha^{-1})]. Thus, it can be concluded that combined application of organic and inorganic fertilizer with biofertilizer was found to be more effective as compare to the sole application of fertilizer and also no application of nutrients.

7. References

1. Ahmad AH, Wahid A, Khalidi F, Fiaz N, Zammer MS. Impact of organic and inorganic sources of nitrogen and phosphorus fertilizers on growth, yield and quality of forage oat (*Avena sativa* L.). Cercetari Agronomici in Moldova. 2011;3(147):39-49.
2. Anonymous. 20th Livestock Census-2012 All India Report. Department of Animal Husbandry, Dairying and Fisheries, New Delhi, India; c2019.
3. Ashok K, Rajgopal DS, Lalit K. Effect of vermicompost, poultry manures and *Azotobacter* inoculums on growth, yield and nutrient uptake of baby corn. Indian Journal of Agronomy. 2008;34(4):342-347.
4. Azeez JO. Effects of nitrogen application and weed interference on performance of some tropical maize genotypes in Nigeria. Pedosphere. 2009;19(5):654-662.
5. Bhat MD, Singh KN, Amarjit Bali, Shah MH. Grain yield of oat (*Avena sativa*) as influenced by sowing time and nitrogen levels under temperate conditions of Kashmir. Indian Journal of Agronomy. 2000;45(1):199-204.
6. Chandy KT. Low-cost booklets on crop production, animal husbandry, environment, natural resource management and product value addition. Cereal and Millet Production CMPS; c2002.
7. 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 Sciences. 2017;6(5):1860-1865.

8. Deva S. Effect of tillage practices and nutrient management on fodder yield of oat, soil fertility and microbial population. The Bioscan: An International Quarterly Journal of Life Sciences. 2015;10(1):173-176.
9. 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.
10. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. John Wiley & Sons, New York; c1984.
11. Hossain A, Kumar D, Rana DS, Gangaiah B, Dwivedi BS, Sahoo RN. Productivity and profitability of Bt cotton (*Gossypium hirsutum*)-wheat (*Triticum aestivum*) cropping system as affected by nutrient omissions. Indian Journal of Agronomy. 2013;58(2):175-181.
12. Jadav VM, Patel PM, Chaudhary JB, Patel JM, Chaudhary PP. Effect of integrated management on growth and yield of rabi forage maize (*Zea mays* L.). International Journal of Chemical Studies. 2018;6(1):196-200.
13. Khandey BA, Samoon AR, Waseem R, Khandey J, Bahar FA. Integrated nutrient management for seed production of oat (*Avena sativa* L.) under temperate region. Not Available; c2009.
14. Mandal SR, Bidhan CK, Mohanpur V. Effect of biofertilizer (*Azotobacter*) inoculation on forage yield and quality of oats. Journal of Interacademicia. 2000;4(4):524-527.
15. Pandey *et al*. Effect of integrated nutrient management on productivity of oat (*Avena sativa* L.) and soil fertility. Annals of Plant and Soil Research. 2020;22(2):151-155.
16. Pandey M, Chauhan M. Effect of sulphur and zinc on yield, quality and uptake of nutrients in barley. Annals of Plant and Soil Research. 2016;18(1):74-78.
17. Pandey M, Rana N. Response of wheat to sulphur and zinc nutrition in alluvial soil. Annals of Plant and Soil Research. 2016;18(4):418-422.
18. Patel JR, Rajagopal S. Response of oats (*Avena sativa* L.) to nitrogen and phosphorus levels. Indian Journal of Agronomy. 2002;47(1):134-137.
19. 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.
20. 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.
21. Pathan SH, Damame SV, Sinare BT. Effect of different cutting management on growth, yield, quality and economics of dual-purpose oat, barley and wheat. Forage Research. 2020;46:182-186.
22. Rakshit R, Das A, Padbhushan R, Sharma RP, Kumar S. Assessment of soil quality and identification of parameters influencing system yield under long-term fertilizer trial. Journal of the Indian Society of Soil Science. 2018;66:166.
23. Ravankar HN, Gajbhiye NN, Sarap PA. Effect of organic manures and inorganic fertilizers on yield and availability of nutrients under sorghum-wheat sequence. Indian Journal of Agricultural Research. 2005;39(2):142-145.
24. Sharma A, Kumar A. Effect of organics and integrated nutrient management on productivity and economics of Rabi sorghum. Karnataka Journal of Agricultural Sciences. 2009;22(1):11-14.
25. 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.
26. Singh R. Role of livestock in India economy. Department of Veterinary Public Health and Epidemiology, Uttarakhand; c2020.
27. Singh V, Patra A. Effect of FYM and manganese on yield and uptake of nutrients in wheat (*Triticum aestivum*). Annals of Plant and Soil Research. 2017;19(4):381-384.
28. Tiwana US, Puri KP, Chaudhary DP. Fodder productivity and quality of multi-cut oat grown pure and in mixed with different seed rates of season. Forage Research. 2008;33(3):224-226.
29. Tripathi SB. Soil test-based phosphorus recommendation to fodder oat grown as sole and mixed with Indian clover (*Melilotus paniflora*). Range Management and Agroforestry. 2003;24(3):100.
30. Umadevi, Singh KP, Sehwag M, Kumar S. Effect of nitrogen levels, organic manures and *Azotobacter* inoculation on nutrient uptake of multicult oats. Forage Research. 2010;36(1):9-14.
31. Vikram Shiyal, HK Patel, CH Raval, MK Rathwa, PS Patel, Patel HK. Fodder yield and economics as influenced by integrated nutrient management on fodder dual-purpose oat (*Avena sativa*). International Journal of Current Microbiology and Applied Sciences. 2020;9(11):3752-3758.
32. Wortman SE, Davis AS, Schutte BJ, Lindquist JL. Integrating management of soil nitrogen and weeds. Weed Science. 2011;59:162-170.
33. Saha J, Barman B, Chouhan P. Lockdown for COVID-19 and its impact on community mobility in India: An analysis of the COVID-19 Community Mobility Reports, 2020. Children and youth services review. 2020 Sep 1;116:105160.