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Response of Some Cultivars of Oat (*Avena Sativa* L.) To Sowing Dates and Nitrogen Fertilizer Rates on Its Growth and Yield Component's

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ABSTRACT

A field experiment was carried out at Experimental Farm of Faculty of Technology and Development, Zagazig University at Ghazalah Village, Zagazig District, Sharkia Governorate, Egypt during the two successive growing winter seasons of 2022/2023 and 2023/2024 to investigate the effect of three sowing dates, i.e. 30st October, 15th November and 30th November and four nitrogen fertilizer rates, i.e. without application, 30, 60 and 90 Kg. N/fed. on growth, yield and its attributes for two varieties of Oats, i.e. White Oat and Red Oat under middle Delta conditions in Sharkia Governorate. Results indicated that sowing date at 15th November produced a tallest plant height (cm), greatest no. of green leaves/plant, largest flag leaf area (cm^2), greatest no. of total tillers/plant, no. of productive tillers/ plant, no. of days to (50% heading), greatest no. of panicle /m^2, tallest panicle length (cm), greatest no. of spikelets/panicle, greatest no, of grains /panicle (g.), heaviest weight of grains/ panicle, heaviest 1000-grain weight(g.), greatest grain, straw and biological yield (ton/fed.) and harvest index %, followed by sowing date at 30st October. On the other hand, the sowing date of 30 November gave the lowest values in this concern. Moreover, the obtained results indicated that the two varieties significantly differed in all studied traits in the two growing seasons. White Oat variety superior Red Oat variety and gave the highest values in the all studied traits. Results also showed that significantly increased in all studied traits with increasing the application of nitrogen fertilizer rates from 0 up to 90 Kg. N/fed.

The interactions effect between sowing dates and Oats varieties significantly affected the grain yield (ton/fed.), between sowing dates and nitrogen fertilization on grain yield (ton/fed.) and the interactions between Oats varieties and nitrogen fertilization levels on grain yield ton/fed. were significant.

Positive and significant correlation coefficient between grain yield and most studied characters, while no. of grains/panicle, and no. of spikelets /panicle did not reach the 5% level of significance.

Conclusively: It be concluded that sowing date at 15 November, White Oat variety and 90 kg. N /fed. caused an increases in growth of Oat and yield and its components under Middle Delta conditions in Sharkia Governorate, Egypt.

Keywords: Growth- Yield-Nitrogen fertilizer- Varieties Oats-Planting dates.

INTRODUCTION

Oat (*Avena sativa* L.) is well dual – purpose (both fodder and grain) winter cereal crop grown in many parts of the world. Oat can provide quality fodder and feed for livestock and nutritious and healthy food for human consumption. Oats nutritional value sustains by its dietary fibers, which are an essential part of the human diet. Oat production for human consumption has been increased in resent decades' world because people recognized the health benefits of food products. Oat can be grown in acidic soils to saline soils and relatively low fertile soils compared to the other cereals. Oat thrives well in areas where winter temperatures range between 15 and 25^{o}C, and it requires a long winter season for growth and development.

Oat (*Avena sativa* L.) belongs to the family Gramineae is one of the most important winter grain crops in the world **(Bibi *et al.,* 2021).**

Also, Oat grains it is used in preparing many meals such as baked goods and sweets. Is easy to digest and contains a low percentage of sugar and salt. It contains a large proportion of protein more than other types of grains, as well as dietary fiber, fats, carbohydrates, folic acid and many minerals such as iron, manganese and zinc **(e3arabi.com, 2021)**. Oats contain 9.23% fat, 3.56% protein, 30.44% fiber, 0.82% calcium, and 0.27% phosphorous. **(Bibi *et al.,* 2021).**

The productivity of grain, its quality ,as well as nutrient content in grain and straw as animal feed largely depend upon proper management of sowing time careful selection of ideal sowing time is needed to take advantage of environmental conditions and enhance the green fodder and grain yield of Oat (**Kadam *et al.,* 2022).**

Time of sowing, which is regulated by temperature and moisture, is a major yield contributing factor for Oat production. Hence, the impact of early and delayed sowing on yield and quality of Oat need to be investigated in order to optimize the best sowing time for higher production. (**Samal *et al.,* 2023).**

Therefore, it is necessary to choose the best variety of Oats for cultivation to obtain the highest productivity and quality of grain and straw yield.

When Oat cultivars were introduced to new regions, adaptation to the new environment and production should be studied then introduced to the local farmers and highlight their importance in terms of high productivity and its nutritional and health benefits **(Addaheri *et al.*, 2021).**

Vegetative growth of any crop depends on the nutrient supply system and capacity of the soil to supply the nutrients to crop and capacity to take and use the nutrient is unit time. Among all the major and secondary nutrients, nitrogen plays a pivotal role in quantitative as well as qualitative improvement in the productivity of crop. It is an important constituent of proteins and chlorophyll. It imparts dark green color to the plants, promotes vegetative growth and rapid early growth. It improves the quality by increasing the protein content of crops and governs to a considerable degree, the utilization of potassium, phosphorus and other elements **(Kebede *et al.,* 2024).**

Nitrogen (N) is an essential plant mineral for cell division and elongation, formation of nucleotides and enzymes resulted in high photosynthesis activity which leads to more accumulation of photosynthetic and highest **(Kebede *et al.,* 2024).**

Considering the importance of N on the productivity of Oats, an investigation was carried out to find out the response of yield and yield components of Oat to different doses of N fertilizer. **(Islam *et al.,* 2020).**

Recent research in Oat has led to improved production practices providing growers with incentives to increase production. Currently, growers targeting high yields and high return have started to apply in excess of 90 kg ha-1 of nitrogen (N) fertilizer to their Oat crop. **(May *et al.,* 2020).**

The objectives of this study.

1- To identify a suitable time of sowing date and establish a relationship with climatic factors on productivity in Egypt.

2. To identify suitable variety of Egypt which produce higher grain yield.

3. To identify an optimum nitrogen fertilizer rates for production of higher grain yield.

MATERIALS AND METHODS

The field experiment was carried out at Experimental Farm of Faculty of Technology and Development, Zagazig University at Ghazalah Village, Zagazig District, Sharkia Governorate, Egypt during the two successive growing winter seasons of 2022/2023 and 2023/2024 to study the effect of three sowing dates, i.e. 30st October, 15th November and 30th November and four nitrogen fertilizer rates, i.e.: without application, 30, 60 and 90 Kg. N/fed., on growth, yield and its attributes for two Oats varieties, i.e., White Oat and Red Oat under middle Delta conditions at Sharkia Governorate.

Soil preparation:

The soil of the experimental site is clay in texture. The mechanical and chemical analysis of soil at the sowing depth in the two growing seasons are presorted in Table (1).

Table (1): Mechanical and chemical analysis of the experimental soil in the two growing seasons

Soil analysis	Season	
	2022/2023	2023/2024
1-Medical analysis		
Sand %	25	24
Silt %	30	32
Clay %	45	44
Organic matter (O M) g Kg^{-1}	15	16
Textured class	Clay loam	Clay loam
2- Chemical analysis		
Available N	28	25
Available P	16	15
Available K	309	311
pH	8.12	8.31
EC ($ds.m^{-1}$)	2.66	2.68

Soil sample was collected for physiochemical analysis before starting the experiment. Soil samples were analyzed using the method of **(AOAC 1990).**

Experimental design:

The split - split plot design as a form of the randomized complete block design with three replications was followed in two growing seasons. Since, three sowing dates were allotted in the main plots; while the two studied varieties were arranged at random in the sub plots, four nitrogen rates were randomly allotted in sub-sub plots. Each sub-sub plot area was 6 m^2 [3 x 2 m].

Cultural practices:

The preceding crop was maize in both growing seasons, Oats verities grains were drilled in rows, the distance between them is 20 cm. on specific sowing dates in both seasons. Seeding rate was 25 kg. / fed.

The four nitrogen fertilizer rates (ammonium nitrate 33.5 %) were added into two equal doses and applied after 25 and 60 days from sowing. Land irrigation method was used. The normal agricultural practices for Oats crop were carried out perfectly. The two varieties were obtained from Field Crops Department, Agricultural Research Center, Kafr El-Sheikh, Egypt

Data recorded:

A. Growth characters:

The following characteristics were measured on samples each of ten plants taken randomly from the inner four rows in each sub plot (After exiting panicles was complete).

1- Plant height (cm) **2- Number of green leaves / plant.**

3- Flag leaf area/cm^2. Flag leaf area = length ×maximum width × 0.72 cm^2

4- Number of total tillers / plant. 5-Number of productive tillers / plant.

6-Number of days to 50% heading.

B-Yield and yield attributes:

At harvest time after 161 days from sowing, approximately a random sample of ten plants from each plot were taken and the following characters were determined, as follows:

1- Number of panicles /m^2. **2- Panicle length (cm).**

3- Number of spikelet's/ panicle. **4- Number of grains/panicle.**

5- Weight of grains / panicle (g.). **6- 1000-grain weight (g.)**.

The grain and biological yields /fed., as well as harvest index were calculated using the yields obtained from 1meter length of 5 central rows (1 m^2).

7- Grain yield (ton/fed.): Average grain yield /m^2 (1m. length of 5 central rows) were estimated for each plot and the yield of grains ton/fed. was calculated.

8- Straw yield (ton/fed.): Average of straw yield/m^2 were estimated for each experimental and straw yield (ton/fed.) was calculated.

9- Biological yield (ton/fed.): Average above ground Oats plants (grain and straw) from 1 square meter were weighted for each plot and the total yield biological yield (ton/fed.) was calculated.

10- Harvest index (H.1.) % the harvest index was calculated according to the following equation:

$$\textbf{H. I (\%)} = \frac{\textbf{Grain yield}}{\textbf{Grain yield+Sraw yield}} \textbf{ x 100}$$

Statistical analysis:

The proper statistical analysis of split-split plot design was used and combined analysis was performed for the characters recorded in both growing seasons. The collected data were statistically analyzed using the Analysis of Variance (ANOVA). Differences among treatments were judged according to **Duncan (1955)**. Means followed by different letters were statistically significant. In the interaction tables, small letters were used to compare means in columns, whereas capital ones were used to compare means in rows, Using the COSTAT system for windows, version 6:311 **Costat, Cohort softwar (2005).**

Simple correlation coefficient:

For comparison study between yield and its components and measurements, as well as their relationship with field emergence results, the correlation coefficient among all possible test results and measurements were subjected to simple correlation and path coefficient analysis according to **Svab (1973)**.

RESULT'S AND DISCUSSION

Growth characteristics:

a-Effect of sowing dates:

Data in Tables (2 and 3) show the effects of sowing dates, Oat varieties and nitrogen fertilizer rates on growth of Oats:

Plant height (cm), number of green leaves/plant flag leaf area(cm^2), number of total tillers/ plant and number of days to 50% heading were significantly affected by sowing dates while number of productive tillers/ plant was not significant in the two growing seasons and their combined analysis. Sowing dates at 15th November (D2) was significantly superior at the first sowing date following by 30st October (D1) and the late sowing date at 30th November (D3) respectively. These results are true in both seasons and their combined analysis.

These results clearly indicate that there were a significantly differences due to the effect of sowing dates on growth characteristic viz plant height (cm), number of green leave/plant, flag leaf area(cm^2), number of total tillers/ plant and number of days to 50% heading. Mid and early sowing dates gave Oat plant a good chance in vegetative growth to achieve the optimum growth in Sharkia Governorate condition. This was reflected in significantly tallest plant height (cm), greatest green leaves/plant, largest flag leaf area (cm^2), greatest number of total tillers/plant and number of days to 50% heading. This high may be due to favourable weather occurred during October 30th to November15th. These results are similar with **Al-dulaimi *et al.* (2020).** These variations might have attributed to prevailing weather condition during Oat growth particularly, temperature, light, and humidity.

These results conformed to that of **Shaker *et al.* (2016), Bazzo *et al.* (2020), Mahajan and Chauhan (2021) and Park *et al.* (2022).**

b. Effect of Oat varieties:

The results in Tables (2 and 3) indicated clearly that there were significant differences among Oat varieties in all studied traits in both growing seasons. These results are true, in both growing seasons and their combined analysis. White Oat variety (V1) superior Red Oat variety (V2) in all studied traits in growth characteristics viz plant height (cm), number of green leaves/ plant, flag leaf area/plant (cm^2), number of total, number of productive tillers /plant and number of days to 50% heading in both growing seasons and their combined analysis, such results could be attributed to differences in the genetic constitution of the tested varieties. These results are in harmony with those obtained by **Ali et al. (2017), Al-Ajmi and AL-Refai (2020), Bibi et al. (2021), Park et al. (2022), Samal et al. (2023) and Kebede et al. (2024).**

Table (2): Plant height (cm), number of green leaves / plant and flag leaf area / cm^2 of Oat as affect by Sowing dates, varieties and nitrogen rates in two seasons and their combined

Main effects and interactions:	Plant height (cm)			Number of green leaves / plant			Flag leaf area / cm^2		
	1st season 2022/2023	2nd season 2023/2024	Combined Data	1st season 2022/2023	2nd season 2023/2024	Combined Data	1st season 2022/2023	2nd season 2023/2024	Combined Data
Sowing dates (D)									
D1 (30	158.9 b	164.6 b	161.7 b	38.50	41.05 a	39.78 b	59.39 a	61.37 b	60.38 a

October)									
D2 (15 November)	164.0 a	170.2 a	167.1 a	39.92	42.72 a	41.32 a	60.51 a	66.08 a	63.30 a
D3 (30 November)	153.6 c	158.7 c	156.1 c	37.04	39.36 b	38.20 b	50.36 b	59.28 b	54.82 b
F .test	**	**	**	**N.S**	*	*	**	**	**
Varieties (V)									
V1 (White Oat)	164.8 a	173.5 a	169.1 a	46.97 a	50.82 a	48.90 a	74.50 a	80.93 a	77.72 a
V2 (Red Oat)	152.9 b	155.5 b	154.2 b	30.00 b	31.27 b	30.63 b	39.00 b	43.56 b	41.28 b
F .test	**	**	**	**	**	**	**	**	**
Nitrogen rates (N)									
Control (N zero)	141.5 d	144.7 d	143.1 d	31.94 d	33.53 d	32.74 d	43.62 d	48.35 d	45.99 d
N1 (30 kg/fed.)	158.3 c	163.1 c	160.7 c	36.33 c	38.45 c	37.39 c	50.97 c	56.28 c	53.63 c
N2 (60 kg/fed.)	164.3 b	170.6 b	167.5 b	40.83 b	43.55 b	42.19 b	62.78 b	68.56 b	65.67 b
N3 (90 kg/fed.)	171.2 a	179.4 a	175.3 a	44.83 a	48.65 a	46.74 a	69.64 a	75.78 a	72.71 a
F .test	**	**	**	**	**	**	**	**	**
Interaction									
D*V	**	**	**	*	*	*	**	**	**
D*N	**	**	**	**	**	**	**	**	**
V*N	**	**	**	**	**	**	**	**	**
D*V*N	**	**	**	*	*	*	**	**	**

Treatment within a column followed by different letter are significantly with Duncan's multiple range test at 5 % level.

Table (3): Number of total tillers / plant, number of productive tillers / plant and number of days to 50% heading of Oat as affect by Sowing dates, varieties and nitrogen rates in two seasons and their combined

Main effects and interactions:	**Number of total tillers / plant**			**Number of productive tillers / plant**			**Number of days to 50% heading**		
	1st season 2022/2023	**2nd season 2023/2024**	**Combined Data**	**1st season 2022/2023**	**2nd season 2023/2024**	**Combined Data**	**1st season 2022/2023**	**2nd season 2023/2024**	**Combined Data**
Sowing dates (D)									

D1 (30 October)	14.83 a	15.87 a	15.35 a	8.166 a	8.866 a	8.516 a	94.17 b	97.15 b	95.66 b
D2 (15 November)	15.71 a	16.75 a	16.23 a	8.530 a	9.230 a	8.880 a	101.08 a	104.09 a	102.6 a
D3 (30 November)	13.83 b	14.87 b	14.35 b	7.745 a	8.445 a	8.095 a	89.92 c	92.90 c	91.41 c
F .test	*	*	*	**N.S**	**N.S**	**N.S**	**	**	**
Varieties (V)									
V1 (White Oat)	19.42 a	20.46 a	19.94 a	10.42 a	11.12 a	10.77 a	96.81 a	98.30 a	97.56 a
V2 (Red Oat)	10.15 b	11.19 b	10.67 b	5.881 b	6.58 b	6.228 b	93.32 b	96.31 b	94.82 b
F .test	**	**	**	**	**	**	**	**	**
Nitrogen rates (N)									
Control (N zero)	10.74 d	11.78 d	11.26 d	6.173 b	6.87 b	6.523 b	93.67 a	96.74 a	95.21 a
N1 (30 kg/fed.)	13.70 c	14.74 c	14.22 c	7.502 b	8.20 b	7.852 b	94.78 a	97.86 a	96.32 a
N2 (60 kg/fed.)	15.90 b	16.94 b	16.42 b	8.947 ab	9.65 ab	9.297 ab	95.33 a	98.21 a	96.77 a
N3 (90 kg/fed.)	18.81 a	19.85 a	19.33 a	9.967 a	10.67 a	10.32 a	96.44 a	99.32 a	97.88 a
F .test	*	*	*	*	*	*	**N.S**	**N.S**	**N.S**
Interaction									
D*V	*	*	*	N.S	N.S	N.S	**	**	**
D*N	*	*	*	*	*	*	*	*	*
V*N	*	*	*	*	*	*	N.S	N.S	N.S
D*V*N	*	*	*	*	*	*	*	*	*

Treatment within a column followed by different letter are significantly with Duncan's multiple range test at 5 % level.

C. Effect of nitrogen fertilization rates

Data presented in Tables (2 and 3) demonstrate clearly that highly significant effect of nitrogen fertilizer rates on the studied growth traits in this concern, expect number of days to 50%heading was not significant. These results are true in both growing seasons, as well as their combined analysis. Plant height (cm), number of green leaves/ plant, flag leaf area (cm^2), number of total tillers/plant and number of productive tillers/ plant were increased by increasing nitrogen rates from 0 up to 90 Kg. N/fed.. Nitrogen is the nutrient most likely

to be in short supply for plant growth and the effect of nitrogen rates during that period appeared to be more pronounced on Oat plant. Increases in plant height (cm) allied with increasing nitrogen fertilizer rates may be recognized to the role of nitrogen in protoplasm and chlorophyll formation, enhancement meristematic activity and cell division, consequently it increases cell size which caused increase in internodes length, accordingly increase in plant height (cm). Therefore, the final plant height (cm) was consequently increased by increasing the applied nitrogen (Table 2). The increases in plant height (cm) by increasing nitrogen rate might be attributed to the increase in internode lengthy, since the number of internodes is greatly influenced by genetic make up of the plant. Increasing nitrogen rates up to 90 kg. N/fed., significantly increased plant height (cm) and consequently number of total tillers / plant and number of productive tillers/plant which were reflected on greatest number of green leaves/ plant and largest leaf area (cm^2). These findings are also in a good agreement with those obtained by **Iqbal *et al.* (2013), Irfan *et al.* (2016), Ali *et al.* (2017), Devi *et al.* (2019), Alhilfi (2020), Islam *et al.* (2020), Krga *et al.* (2021), Samal *et al.* (2023) and Kebede *et al.* (2024).**

Yield and Yield components:

a- Effect of sowing dates:

The results are presented in Tables (4,5,6 and 7), show that the sowing date significantly affected the number of panicles(m^2), panicle length (cm), number of spikelets/ panicle, number of grains/panicle, weight of grains/panicle(g.), 1000-grain weight (g.), grain yield (ton/fed.), straw yield (ton/fed.), biological yield (ton/fed.) and harvest index% in the two growing seasons, as well as in the combined analysis. Sowing date at the mid sowing in 15th November (D2) was superior at the first sowing compared with 30st October (D1) and the late sowing date at 30 November (D3) respectively. This was true in both seasons and their combined analysis. The results revealed that yield and yield attributes of Oat grain yield / unit area was bigly depended on sowing dates. The superior grain yield observed with the November 15 sowing date is due to the optional environmental condition that promote balanced growth, effective tillering and efficient grain development, while late sowing November 30 limits vegetative and reproductive potential due to cold stress and shorter growing duration. These results are in harmony with this obtained by **Shaker *et al.* (2016), Bazzo *et al.* (2020), Mahajan and Chauhan (2021) and Park *et al.* (2022).**

b. Effect of Oat varieties:

Grain yield and yield component as mentioned before in both seasons are shown in Tables (4,5,6 and 7) were significantly affected by differences among Oat varieties in all studied traits in the two growing seasons, as well as in the combined analysis. White Oat variety gave the highest values in all studied traits in both growing seasons. These results are in accordance with those obtained by **Ali *et al.* (2017), Al-Ajmi and AL-Refai (2020), Bibi *et al.* (2021), Park *et al.* (2022), Samal *et al.* (2023) and Kebede *et al.* (2024).**

C-Effect of nitrogen fertilization:

Generally, there was a significant increase in all studied traits and yield of Oat crop with increasing the application of nitrogen fertilizer. The difference may be attributed to genetically differences between Oat varieties, which play an important role for make up the available nutrient and yield of Oat varieties.

It is clear found from data of these Tables (4,5,6 and 7) that nitrogen fertilizer rates affected all the studied traits in the present investigation**.**

Number of panicles/ (m^2) was significantly increased by each increment of nitrogen fertilization rates from 0,30,60 and 90 kg. N/ fed., gradually. The increment of (4.46, 6.92 and 9.38%) of number of panicle (m^2) compared to nitrogen rate without any addition in the combined analysis. Such increases in the number of panicles / (m^2) as a result of increasing nitrogen fertilizer rates may be due to the roles of nitrogen in encouragement meristem division which increases plant ability to produce more tillers which give more panicles **Kebede *et al.* (2024).** Results showed a highly significant increase in panicle length (cm) with the increases in the rate of nitrogen from 0 up to 90 kg. N/ fed. combated to the control treatment were (8.47, 13.38 and 23.02 %) in this concern. This increase in panicle length (cm) as a result of increasing nitrogen fertilizer rates may be recognized to the role of nitrogen in protoplasm and chlorophyll formation, enhancement meristematic activity

and cell division consequently increases cell size which caused increase in internodes length accordingly increases in panicle length. Nitrogen fertilizer rates had a favourable effect on number of spiklets / panicle was significantly increased by each increment of nitrogen fertilization rates from 0, 30, 60 and 90 kg. N/fed.. The increment of (9.2, 17.33 and 23.02 %) of number of spiklets/ panicle compared to nitrogen rate without any addition it the combined analysis. Such increase in number of spikelets/ panicle as a result of increasing nitrogen fertilizer rates may be inputted to its effective role in enhancement panicle length and nutritive status of Oat plants number of grain /panicle in the two growing seasons and their combined. The highest numbers of grain / panicle (49.56 grains/panicle) were induced due to mineral fertilized with 90 Kg. N/fed. in the combined analysis. The increment (3.74, 7.55 and 13.78%) of number of grains/panicle compered to nitrogen rate without any addition in the combined analysis. Such increase in number of grains/panicle as a result of increasing nitrogen fertilizer rates may be input to its effective role in enhancement panicle length, number of spikelets/ panicle and nutritive status of Oat plant in addition increasing flowers fertility. In the two seasons and their combined, grains weight panicle was significantly and gradually increased by each increment of nitrogen fertilization rates from without application up to 90 kg. N/fed. in the combined analysis. Regarding the effect of nitrogen fertilization rates on 1000-grain weight(g.), data showed a significant effect of nitrogen on that trait, since any increment in nitrogen rates was followed by a significant increase in 1000- grain weight (g.) The increases in 1000-grain (g.) weight due to applications of 90 kg. N/fed. amounted to 15.94, 27.57 and 57.66%) compared to N1, N2 and N3, respectively (combined data). The increment in grains weight / panicle (g.) due to increasing nitrogen fertilizer rates may be due to the role of nitrogen in increasing cells division, size, elongation and metabolic, as well as photosynthesis processes and consequently increased grains weight.

Data in Table (6) showed that in both seasons any addition of nitrogen application significantly increased the grain yield (ton/fed.) compared to the control treatment (without application). As an average, the increment of (20.29, 35.15 and 67.8%) in the combined data for Oat yield (ton/fed.) due to application of 30, 60 and 90 Kg. N/fed., respectively compared to nitrogen fertilization rate without any addition in the combined analysis. The increase in grain yield due to increasing nitrogen fertilizer rates can be easily ascribed to the nitrogen which consider as one of the major elements for plant nutrition and it increases the vegetative cover for plant and forms strong plant with long panicles. This might be due to the good influence of that major element (N) on the growth traits and the attributing characteristics of Oat grain yield (ton / fed.) **Kebede *et al.* (2024).** Data in Table (6) showed that nitrogen fertilization rate significantly increased straw yield in both growing seasons. These increases of straw yield/fed. due to increasing mineral nitrogen fertilizer rates might be due to the role of nitrogen fertilizer in improving vegetative growth, plant height (cm) and stem diameter accordingly increasing straw yield per unit area. Biological yield of Oat which included grain and straw yields (ton/fed.) (Total yield). In the two growing seasons there was a significantly increased by each increment of nitrogen fertilization rates from without application up to 90 kg. N/fed. this was valid in the combined analysis. In the two seasons, addition of nitrogen significantly increased the harvest index% as compared to the control increasing nitrogen fertilization rates gradually from 0.0, 30, 60 to 90 kg. N/fed. caused significantly increase in harvest index%. This might be due to the good influence of that major element (N) on the growth traits and the attributing characteristics of Oat grain yield Tables (4,5,6 and 7). These results are in agreement with those reported by **Iqbal *et al.* (2013), Irfan *et al.* (2016), Ali *et al.* (2017), Devi *et al.* (2019), Alhilfi (2020), Islam *et al.* (2020), Krga *et al.* (2021), Kumar *et al.* (2023) and Kebede *et al.* (2024).**

Effect of interaction:

The interaction studies in Fig. (1) have shown that grain yield (ton/fed.) was significantly influenced by the interaction between sowing dates and Oats varieties. The interaction studies have shown that White Oat recorded significantly increased in grain yield by delaying sowing date at 15 November (4.94 ton/fed.) followed by the early sowing date at 30 October (2.972 ton/fed.). The sowing date at 30 November gave the lowest values of grain yield (2.216 ton/fed.). Red Oat variety recorded the lowest values of grain yield (2.88, 1.958 and 1.411 ton/fed.) at the three sowing dates in D2, D1 and D3, respectively. Fig. (2) show the interaction effect between sowing dates and nitrogen rates on grain yield ton/fed. of Oat (combined data). Also, grain yield of Oat was significantly affected by the interaction of sowing dates X N fertilization rates as shown in Fig. (2). The greatest

yield (4.997 ton/fed.) was recorded at sowing date in 15 November when fertilized at the rate of 90 kg. N/fed. followed by the early sowing date at 30-October (3.251 ton/fed.), while late sowing date in 15 November gave the lowest values (2.244 ton / fed.).

The interaction studies Fig. (3) between varieties of Oat and nitrogen rates shown that White Oat recorded significantly increases in grain yield (4.472 ton/fed.) when fertilized at the rate of 90 kg. N/fed., followed by 60 kg. N/fed. (3.494 ton/fed.). Red Oat variety recorded the lowest values of grain yield (2.522 ton/ fed.) at the rate of 90 Kg. N/fed followed by kg. N/fed. (2.164 ton/fed.).

The simple correlation coefficient:

The association between grain yield (ton/fed.) and other characters are shown in Table (8) combined data revealed that the Oat grain yield/ fed. was positive and highly significant correlated with studied characters, number of panicles / (m^2), panicle length(cm), 1000-grian weight (g.), straw and biological yield (ton/fed.) and harvest index % but weight of grains/panicle (g.) showed significant, while number of grains/panicle and number of spikelets/panicle did not reach the 5% level of significance. Also, number of panicles / (m^2) showed positive and highly significant inter relationships with panicle length(cm), number of spikelets/panicle, straw yield (ton/fed.) and harvest index (%), while weight of grains/ panicle (g.), 1000-grain weight(g.) and biological yield (ton/fed.) showed significant but this inter relationships with number of grains/panicle did not reach the 5% level of significance. panicle length (cm) showed positive and highly significant with number of spikelets/ panicle, 1000 grain weight (g.) and harvest index % but showed significant in no. of grains/ panicle, weight of grains/panicle (g.) and biological yield (ton/fed.), while it was insignificantly correlated with straw yield (ton/fed.). Number of grains/panicle showed a positive and highly significant with number of spikelets/ panicle and harvest index % while showed significant in weight of grains/panicle(g.), 1000 grains weight (g.), straw yield (ton/fed.) and biological yield (ton/fed.). Also, number of spikelets/ panicle

Table (4): Number of panicles /m^2, panicle length (cm) and number of spikelets/ panicle of Oat as affect by sowing dates, varieties and nitrogen rates in two seasons and their combined

Main effects and interactions:	Number of panicles /m^2			Panicle length (cm)			Number of spikelet's/ panicle		
	1st season 2022/2023	2nd season 2023/2024	Combined Data	1st season 2022/2023	2nd season 2023/2024	Combined Data	1st season 2022/2023	2nd season 2023/2024	Combined Data
Sowing dates (D)									
D1 (30 October)	470 b	474 b	472 b	38.19 a	38.69 b	38.49 b	24.30 b	24.71 b	24.51 b
D2 (15 November)	474 a	478 a	476 a	39.73 a	40.23 a	40.03 a	25.10 a	25.51 a	25.31 a
D3 (30 November)	464 c	468 c	466 c	36.82 b	37.32 b	37.12 b	23.72 c	24.13 b	23.93 c
F .test	**	**	**	*	*	*	*	*	*
Varieties (V)									
V1 (White Oat)	488 a	492 a	490 a	42.14 a	42.64 a	42.44 a	27.86 a	28.27 a	28.07 a
V2 (Red Oat)	450 b	454 b	452 b	34.36 b	34.86 b	34.66 b	20.89 b	21.30 b	21.10 b

F .test	**	**	**	**	**	**	**	**	**
Nitrogen rates (N)									
Control (N zero)	446 d	450 d	448 d	34.34 d	34.84 d	34.64 d	21.54 d	21.95 d	21.75 d
N1 (30 kg/fed.)	466 c	470 c	468 c	37.29 c	37.79 c	37.59 c	23.5 c	23.95 c	23.75 c
N2 (60 kg/fed.)	477 b	481 b	479 b	39.00 b	39.50 b	39.30 b	25.31 b	25.72 b	25.52 b
N3 (90 kg/fed.)	488 a	492 a	490 a	42.36 a	42.86 a	42.66 a	27.10 a	27.50 a	27.30 a
F .test	**	**	**	**	**	**	**	**	**
Interaction									
D*V	**	**	**	*	*	*	*	*	*
D*N	**	**	**	**	**	**	*	*	*
V*N	**	**	**	**	**	**	*	*	*
D*V*N	**	**	**	*	*	*	*	*	*

Treatment within a column followed by different letter are significantly with Duncan's multiple range test at 5 % level.

Table (5): Number of grains/panicle, weight of grain / panicle (g.) and 1000-grain weight (g.) of Oat as affect by sowing dates, varieties and nitrogen rates in two seasons and their combined

Main effects and interactions:	**Number of grains / panicle**			**Weight of grain / panicle (g.)**			**1000-grain weight (g.)**		
	1st season 2022/2023	**2nd season 2023/2024**	**Combined Data**	**1st season 2022/2023**	**2nd season 2023/2024**	**Combined Data**	**1st season 2022/2023**	**2nd season 2023/2024**	**Combined Data**
Sowing dates (D)									
D1 (30 October)	40.49 b	44.79 b	42.68 b	24.86 b	31.61 b	28.23 b	1.024 b	1.433 b	1.228 b
D2 (15 November)	61.84 a	66.14 a	64.037 a	26.14 a	32.89 a	29.51 a	1.651 a	2.209 a	1.930 a
D3 (30 November)	30.08 c	34.37 c	32.28 c	24.41 b	31.16 b	27.78 b	0.745 c	1.082 c	0.914 c
F .test	**	**	**	*	*	*	*	*	*
Varieties (V)									
V1 (White Oat)	48.09 a	52.38 a	50.29 a	28.28 a	35.03 a	31.65 a	1.388 a	1.863 a	1.626 a

V2 (Red Oat)	40.18 b	44.480 b	42.38 b	21.99 b	28.74 b	25.37 b	0.892 b	1.286 b	1.089 b
F .test	**	**	**	**	**	**	*	*	*
Nitrogen rates (N)									
Control (N zero)	41.41 d	45.71 d	43.56 d	21.12 c	27.87 c	24.49 c	0.892 d	1.292 d	1.092 d
N1 (30 kg/fed.)	43.04 c	47.34 c	45.19 c	24.21 b	30.96 b	27.58 b	1.055 c	1.478 c	1.266 c
N2 (60 kg/fed.)	44.70 b	48.99 b	46.85 b	25.68 b	32.43 b	29.06 b	1.173 b	1.614 b	1.393 b
N3 (90 kg/fed.)	47.40 a	51.71 a	49.56 a	29.53 a	36.28 a	32.91 a	1.440 a	1.916 a	1.678 a
F .test	*	*	*	*	*	*	*	*	*
Interaction									
D*V	**	**	**	**	**	**	*	*	*
D*N	*	*	*	*	*	*	*	*	*
V*N	*	*	*	*	*	*	*	*	*
D*V*N	**	**	**	*	*	*	*	*	*

Treatment within a column followed by different letter are significantly with Duncan's multiple range test at 5 % level.

Table (6): Grain yield (ton/ fed.) and straw yield (ton / fed.) of Oat as affect by sowing dates, varieties and nitrogen rates in two seasons and their combined

Main effects and interactions:	Grain yield (ton/ fed.)			Straw yield (ton / fed.)		
	1st season 2022/2023	2nd season 2023/2024	Combined Data	1st season 2022/2023	2nd season 2023/2024	Combined Data
Sowing dates (D)						
D1 (30 October)	2.047 b	2.882 b	2.465 b	4.727 b	5.216 b	4.972 b
D2 (15 November)	3.332 a	4.487 a	3.910 a	6.980 a	7.470 a	7.226 a
D3 (30 November)	1.474 c	2.153 c	1.813 c	2.562 c	3.051 c	2.807 c
F .test	**	**	**	**	**	**
Varieties (V)						
V1 (White Oat)	2.871 a	3.880 a	3.376 a	5.332 a	5.821 a	5.577 a
V2 (Red Oat)	1.698 b	2.468 b	2.083 b	4.181 b	4.670 b	4.426 b
F .test	**	**	**	**	**	**
Nitrogen rates (N)						

Control (N zero)	1.697 d	2.472 d	2.084 d	4.286 d	4.775 d	4.531 d
N1 (30 kg/fed.)	2.078 c	2.935 c	2.507 c	4.582 c	5.071 c	4.827 c
N2 (60 kg/fed.)	2.372 b	3.286 b	2.829 b	4.932 b	5.421 b	5.177 b
N3 (90 kg/fed.)	2.991 a	4.004 a	3.497 a	5.227 a	5.716 a	5.472 a
F .test	**	**	**	**	**	**
Interaction						
D*V	**	**	**	**	**	**
D*N	**	**	**	**	**	**
V*N	**	**	**	**	**	**
D*V*N	**	**	**	**	**	**

Treatment within a column followed by different letter are significantly with Duncan's multiple range test at 5 % level.

Table (7): Biological yield (ton / fed.) and harvest index (%) of Oat as affect by sowing dates, varieties and nitrogen rates in two seasons and their combined

Main effects and interactions:	**Biological yield (ton / fed.)**			**Harvest index H.I (%)**		
	1st season 2022/2023	**2nd season 2023/2024**	**Combined Data**	**1st season 2022/2023**	**2nd season 2023/2024**	**Combined Data**
Sowing dates (D)						
D1 (30 October)	6.774 b	8.099 b	7.437 b	31.34 b	36.71 b	34.03 b
D2 (15 November)	10.31 a	11.96 a	11.14 a	36.09 a	41.03 a	38.56 a
D3 (30 November)	4.036 c	5.204 c	4.620 c	29.43 c	34.92 c	32.18 c
F .test	**	**	**	**	**	**
Varieties (V)						
V1 (White Oat)	8.203 a	9.702 a	8.952 a	34.73 a	39.78 a	37.26 a
V2 (Red Oat)	5.879 b	7.138 b	6.508 b	29.84 b	35.33 b	32.59 b
F .test	**	**	**	**	**	**
Nitrogen rates (N)						
Control (N zero)	5.982 d	7.247 d	6.614 d	28.74 c	34.38 c	31.56 c
N1 (30 kg/fed.)	6.660 c	8.006 c	7.333 c	31.95 b	37.22 b	34.60 b
N2 (60 kg/fed.)	7.304 b	8.708 b	8.006 b	32.46 b	37.73 b	35.10 b
N3 (90 kg/fed.)	8.217 a	9.720 a	8.968 a	36.00 a	40.86 a	38.43 a
F .test	**	**	**	**	**	**
Interaction						
D*V	**	**	**	**	**	**

D*N	**	**	**	**	**	**
V*N	**	**	**	**	**	**
D*V*N	**	**	**	**	**	**

Treatment within a column followed by different letter are significantly with Duncan's multiple range test at 5 % level.

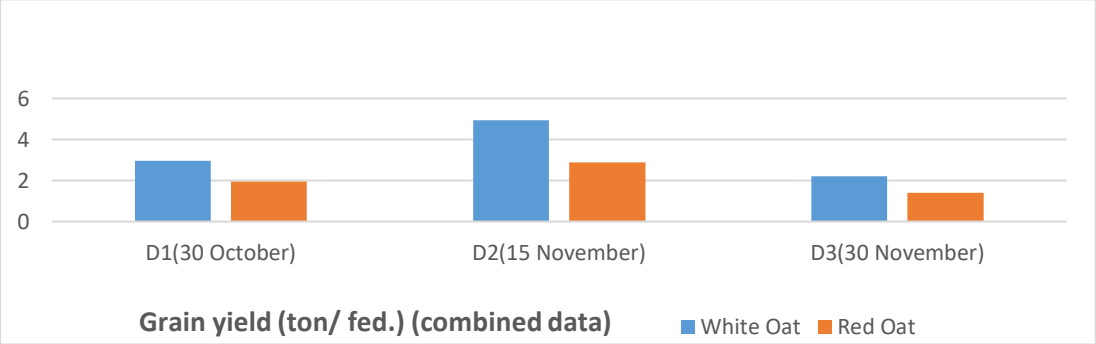

Fig. (1): Grain yield (ton/ fed.), as interaction effect between sowing dates and varieties of Oat in the combined.

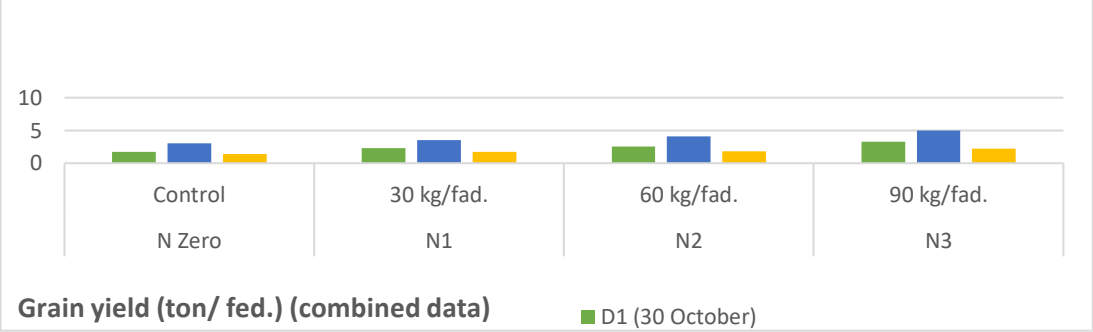

Fig. (2): Grain yield (ton/ fed.), as interaction effect between sowing dates and nitrogen rates in the combined.

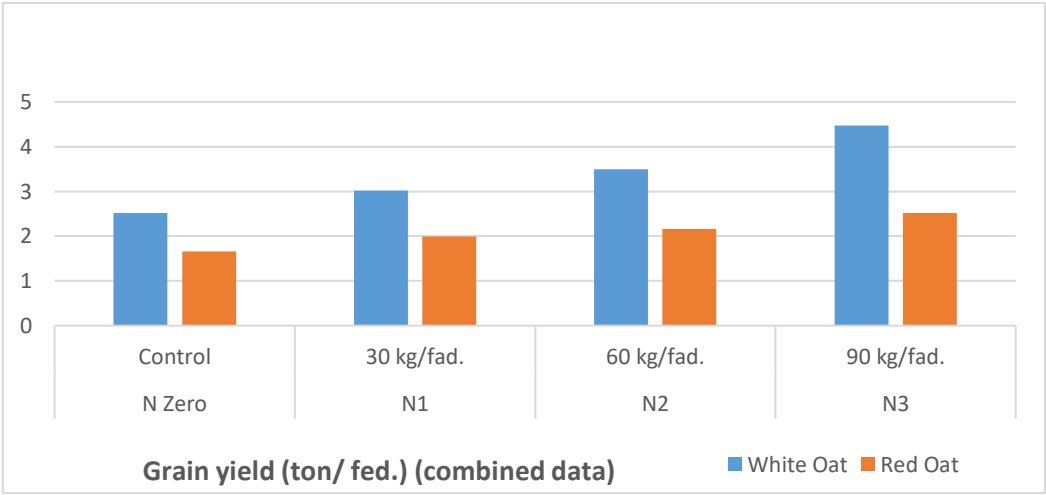

Fig. (3): Grain yield (ton/ fed.), as interaction effect between varieties of Oat and nitrogen rates in the combined.

showed positive and highly significant correlated with weight of grains/panicle(g.), 1000-grain weight(g.), biological yield (ton/fed.) and harvest index % while straw yield (ton/fed.) did not reach the 5% level of significance. Weight of grains/panicle (g.) showed highly significant correlated with straw yield (ton/fed.) and harvest index but showed significant in 1000 grain weight (g.) and biological yield (ton/fed.). 1000-grain weight (g.) showed highly significant correlated with both biological yield (ton/fed.) and harvest index %, while straw yield(ton/fed.) was un significant. Straw yield (ton/fed.) showed highly significant with biological yield (ton/fed.) and harvest index %. Also, Biological yield (ton/fed.) showed positive and highly significant with harvest index%. Similar results were obtained by **Tessema and Getinet (2020), Mahajan and Chauhan (2021) and Kebede *et al.* (2024).**

Conclusively. It be concluded that sowing date at 15th November, White Oat variety and 90 kg. N/fed. caused an increased in growth in Oat, yield and its components.

Table (8): Simple correlation coefficients among Oat grain yield and its components (combined analysis)

Characters	2	3	4	5	6	7	8	9	10
1- Grain yield (ton/ fed.)	.986(**)	.985(**)	.436	.441	.733(*)	.997(**)	.984(**)	.962(**)	.977(**)
2- Number of panicles /m^2		.983(**)	.438	.980(**)	.720(*)	.770(*)	.991(**)	.603(*)	.852(**)
3- Panicle length (cm)			.520(*)	.987(**)	.787(*)	.832(**)	.476	.673(*)	.897(**)
4- No. grains/panicle				.965(**)	.714(*)	.765(*)	.549(*)	.593(*)	.827(**)
5- No. spikelets/ panicle					.933(**)	.903(**)	.464	.976(**)	.811(**)
6- Weight of grains / panicle (g.)						.783(*)	.984(**)	.600(*)	.874(**)
7- 1000-grain weight (g.)							.464	.977(**)	.963(**)
8- Straw yield (ton/ fed.)								.985(**)	.813(**)
9- Biological yield (ton/ fed.)									.897(**)
10- Harvest index H.I (%)									

**** Correlation is significant at the 0.01 level (2-tailed).**

*** Correlation is significant at the 0.05 level (2-tailed).**

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