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Study on Production and Productivity of Oat (*Avena sativa* L.) Crop as Influenced by Different Organic and Inorganic Nutrient Managements under Mid – Hill Region of Himachal Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author Rakhi conducted field study in India with the assistance of their advisor, collected all data, and employed laboratory methodologies. Author MSA advisor, oversawed all technical and laboratory work completed by the author while conducting the experiment and writing the literature. He also provided the author with the necessary instruments to conduct their inquiry. Author JNP has invaluable counsel and member of the advisory board. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To study on production and productivity of oat (*Avena sativa* L.) crop as influenced by different organic and inorganic nutrient managements under mid – hill region of Himachal Pradesh.
Study design: The field experiment was conducted in randomized block design (RBD).
Place and duration of study: A field experiment was carried out during 2022-2023 with the concept of integrated nutrient management at Abhilashi University Chail chowk Mandi (H.P.).
Methodology: Seven treatments were evaluated in randomized block design with three replications. T_1 – Control, T_2 -50% NPK (N_{40} P_{20} K_{20}), T_3- 75% NPK (N_{60} P_{30} K_{30}), T_4-100% NPK (N_{80} P_{40} K_{40}), T_5- 50% NPK + FYM 10 t/ha, T_6-75% NPK + FYM 5 t/ha, T_7-75% NPK + FYM 10 t/ha.
Results: The higher growth of oat crop could be achieved by adopting integrated nutrient management (T_7 -75% NPK + FYM 10 t/ha) proved significantly superior to other treatments. The minimum value of growth parameters was recorded under control. Results revealed that higher yield attributes *viz.* No. of effective tillers, Spike length, No. of spikes, Grains per spike, test weight, were recorded under T_7-75% NPK + FYM 10 t/h and lowest were recorded under T_1-control. Yield parameters *viz.* grain yield, straw yield, biological yield was highest recorded under T_7- (75% NPK + FYM 10 t/ha) and lowest were recorded under T_1- control.
Conclusion: On the basis of one season study, it can be safely concluded that the application of 75% NPK + FYM 10 t/ha superior in terms of growth and yield.

Keywords: Dry matter; INM; oat; yield; growth attributes.

1. INTRODUCTION

“Oat (*Avena sativa* L.) is one of the most important cereal forage crops of *Rabi* season and can be cultivated successfully in fallow lands along with proper nutrient management for obtaining maximum yield from the available area. Oats is a crop of Mediterranean origin not as old as wheat and barley, but their domestication dates back to ancient times. Oats is one of the most important cereal fodder crops grown in winter season requires a greater attention on a part of grower to improve the fodder production and its quality. Oats is very large and diverse genus and includes diploid, tetraploid and hexaploide species” [1]. “It is a good source of fibre, protein and minerals. Green fodder supply abundant quantity of vitamin A and contains about 10-12 per cent protein and important minerals like Ca & Fe in addition to energy for the animals. Oats, content 30-35% dry matter” [2]. “A well- distributed rainfall of 400mm and an optimum temperature range 16-32° C during the four months duration is sufficient to meet its requirement as a fodder crop. Oat forage can be used as green fodder, straw, hay or silage. It is a favorite food source for all types of animals, and its straw is superior to that of wheat and barley in both quality and pliability. Oat grain is also a good source of food for dairy, cows, pigs, chickens, and other young animals that are used for breeding. Oat being a fast growing and high yielding fodder crop, it requires a large quantity of nitrogenous fertilizers for enhancing production of quality herbage and the growth of fodder oat is directly related to the nutrient supply” [3-8]. “Oats are an annual plant that can be sown in the spring or the fall for harvest in the late summer (for early autumn harvest). It grows well in environments with temperatures between 15 and 25°C, 80 to 100 mm of rain is ideal for oat. The ideal sowing temperature range is 20 to 40 °C. Temperatures for harvesting should range from 25 to 30°C. Oat is one such fodder crop, grown in winter season with the advantage of highly nutritious, bulk amount of fodder as rations for poultry, cattle, sheep and other animals” [9-11]. However, applications of high dose of nitrogenous fertilizers leads to soil and water pollution in the long run and can also raise the possibilities of nitrate hazards to soil and water pollution in the long run and can also raise the possibilities of nitrate hazards to livestock. Oat flour is used in the formulation of a skin care baby powder and as a preservative in medicines. Oat is given as nerve simulates, tonic, soporific emollient refrigerant. It exerts a very beneficial action up on the heart muscles and on urinary organs. The oats can provide green fodder after 60-70 days in emergency to tide over the scarcity period but after 90-100 days to get large quantity of fodder [12,13].

“India, is basically an agriculture country, and about 20.5 million people depend on livestock for their livelihood” [14]. “Livestock contributes 4.11 percent of gross domestic product (GDP) and 25.6 percent of total agriculture gross domestic product" [15]. "India has the largest livestock population of 535.78 in the world" [16]. "India has the largest livestock population of 535.78 in the world" [16]. "But the country is heaving only 9.13 million hectares of the cultivated area (4.4% of the gross cropped area) under fodder crops and 10.26 million hectares of pasture and grazing land, which fulfil only a sizeable demand for fodder from the existing livestock population. There is currently a net deficiency of 35.6% green fodder, 10.95% dry fodder, and 44% concentrate feed materials in the country" [17]. In Himachal Pradesh, 9,451 ha of cultivated fodder crops and 1508 thousand hectares of pastures and grassland are able to meet the partial requirements of the large livestock population of 4.41 million. The total annual requirement of green and dry fodder in Himachal Pradesh is about 62 and 198 lakhs, respectively, whereas the total availability of green and dry fodder in the state is 31 and 52 lakhs, respectively. The shortages amount to 26.57 and 66.95 percent, respectively, for green and dry fodder [5-7].

INM in oat cultivation is very much limited due to lack of research works, awareness and technology transfusion. Proper fertilization management in oats increases the herbage yield per unit time along with improvement in quality parameters to take care of two biological systems 'soil-plant' and 'plant animals. Waheed et al. [18] found that "inorganic fertilizers provided sufficient nutrients for growth and resulted in maximum plant height, number of leaves per plant, number of tillers per plant, leaf area per plant, fresh weight per tiller, dry weight per tiller, and green fodder yield. Chemical fertilizers being crucial input for improving soil fertility have become an integral part of modern technology for crop production". Kumar and Ramavat [19] found that "applying 100% of the recommended NPK resulted in more plant height and shoot number per unit area of oat over the course of all years than applying 75% of the recommended NPK dose". "The application of nitrogen to fodder oats substantially increased growth and yields", according to Rawat and Agarwal [20].

2. MATERIALS AND METHODS

2.1 Study Area

The current study was carried out at the Agriculture Farm, School of Agriculture, Abhilashi University Mandi, Himachal Pradesh, India, which is situated at 77° East longitude and 31°North longitude and has an altitude of 1500 meters, during the *rabi* season of 2022-23. The soil of the experimental field was slightly acidic in reaction, high in EC, high in organic carbon.

2.2 Experiment Details

These treatments were replicated three times following randomized block design. The field experiment was carried out seven treatments of organic source and inorganic fertilizer as T_1 – Control, T_2 -50% NPK (N_{40} P_{20} K_{20}), T_3- 75% NPK (N_{60} P_{30} K_{30}), T_4- 100% NPK (N_{80} P_{40} K_{40}), T_5- 50% NPK + FYM 10 t/ha, T_6- 75% NPK + FYM 5 t/ha, T_7- 75% NPK + FYM 10 t/ha. Recommended dose of N, P and K for oat was 80:40:40 kg ha^{-1} respectively. Full quantities of P and K fertilizers were given at the time of sowing. Nitrogen was applied as basal and two splits at first and second irrigation.

2.3 Observations Recorded

Observations include plant height(cm), no. of tillers(m^{-2}), dry matter accumulation (g m^{-2}), no. of effective tillers(m^{-2}), spike length (cm), no. of spikes (m^{-2}), grains per $spike^{-1}$, test weight(g), Grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) of oat a periodic interval of 30 days.

2.4 Statistical Analysis

The data recorded from the field was statistically analysed through the analysis of variance method and treatment means were compared following critical differences (CD) suggested by Gomez and Gomez [21] for significance at 5%. The seed of oat was sown in each plot in second week of November using 100 kg ha^{-1}. Equal amount of water was supplied to every plot at the time of irrigation.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

The data pertaining to plant height of fodder oat as affected by different treatments were recorded at 30, 60 and 90 DAS and at harvest are presented in Table 1 and graphically shown in Fig. 1. The rate at which plant height increased varied depending on the treatment at 30 DAS, different nutrient management strategies had no significant effect on plant height in the early stage, but did have a substantial impact on it later in the growth cycle. Plant height was comparable to all treatments except the control plot and significantly higher than control. The lowest plant height was recorded under T_1(Control) (10.06) (36.27) (65.21) (75.28) and the maximum plant height was recorded under T_7 75% NPK + FYM 10 t/ha. It may be due to better proliferation of roots resulting to more absorption of water and minerals. Similar, results were also reported by Singh and Pathan [22] Choudhary [23], Patel et al. [24] and Yadav et al. [18].

Table 1. Effect of integrated nutrient management on plant height(cm) in oat crop

Sr. No.	Treatments	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
T_1	Control	10.06	36.27	65.21	75.28
T_2	50% NPK (N_{40} P_{20} K_{20})	12.13	41.89	67.43	77.34
T_3	75% NPK (N_{60} P_{30} K_{30})	13.75	46.58	69.54	78.21
T_4	100% NPK (N_{80} P_{40} K_{40})	16.25	52.25	71.55	80.37
T_5	50% NPK + FYM 10 t/ha	17.66	57.44	72.14	82.57
T_6	75% NPK + FYM 5 t/ha	18.46	62.11	74.26	84.74
T_7	75% NPK + FYM 10 t/ha	19.60	65.54	75.27	86.54
SEm±		2.14	1.52	0.91	0.97
C.D.		NS	4.74	2.84	3.02

Table 2. Effect of integrated nutrient management on no. of tillers(m^{-2}) in oat plants

Sr. No.	Treatments	30DAS	60DAS	90DAS	At harvest
T_1	Control	79.43	167.30	153.77	146.70
T_2	50% NPK (N_{40} P_{20} K_{20})	128.33	253.87	233.63	201.23
T_3	75% NPK (N_{60} P_{30} K_{30})	131.43	269.20	249.43	230.07
T_4	100% NPK (N_{80} P_{40} K_{40})	135.10	301.17	291.67	285.60
T_5	50% NPK + FYM 10 t/ha	141.73	341.60	337.27	333.43
T_6	75% NPK + FYM 5 t/ha	145.90	431.87	404.13	387.93
T_7	75% NPK + FYM 10 t/ha	149.43	451.90	430.77	402.40
SEm±		13.99	6.528	9.14	5.74
C.D.		NS	20.33	28.50	17.89

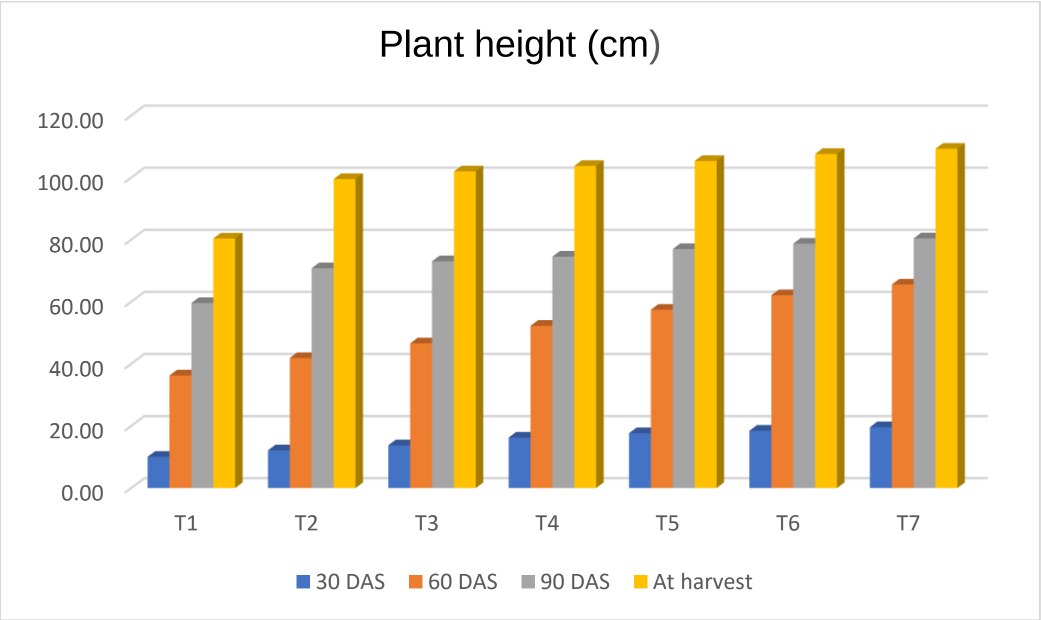

Fig. 1. Effect of integrated nutrient management on plant height(cm) in oat crop

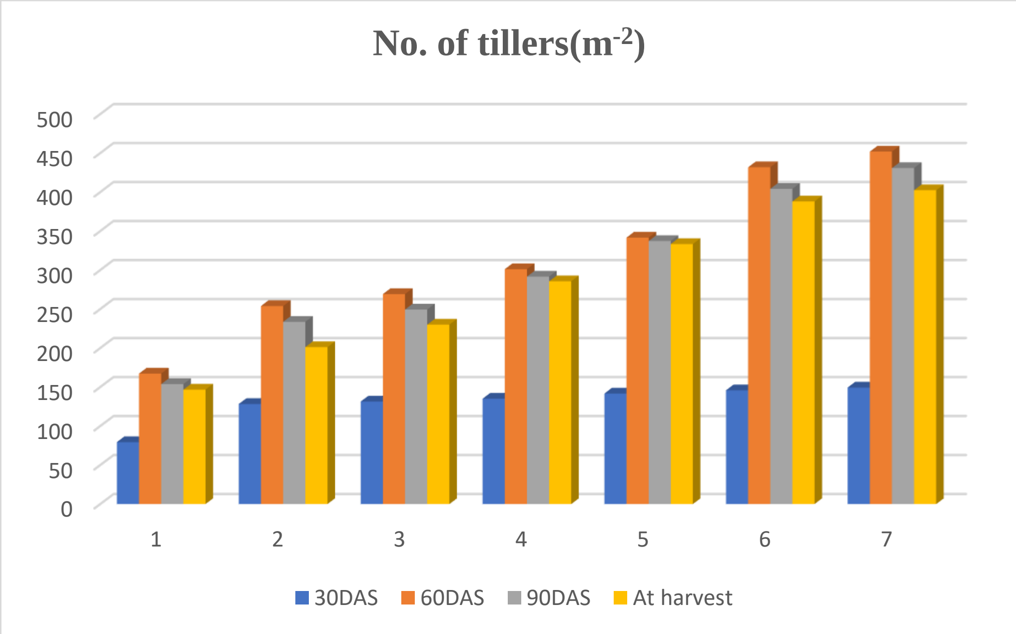

Fig. 2. Effect of integrated nutrient management on no. of tillers(m^{-2}) in oat plants

Table 3. Effect of integrated nutrient management on dry matter accumulation (g m^{-2}) in oat crop

Sr. No.	Treatments	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
T_1	Control	50.90	286.07	420.99	474.41
T_2	50% NPK (N_{40} P_{20} K_{20})	62.33	317.77	452.16	578.17
T_3	75% NPK (N_{60} P_{30} K_{30})	70.07	332.40	461.67	604.31
T_4	100% NPK (N_{80} P_{40} K_{40})	77.90	347.07	500.17	636.45
T_5	50% NPK + FYM 10 t/ha	85.70	379.03	535.53	687.06
T_6	75% NPK + FYM 5 t/ha	98.97	418.13	560.83	759.44
T_7	75% NPK + FYM 10 t/ha	105.23	450.70	600.04	799.61
SEm±		11.75	10.71	14.54	13.62
C.D.		NS	33.37	45.32	42.46

3.2 No. of Tillers (m^{-2})

Data presented under Table-2 and Fig. -2 show the number of oat tillers recorded at 30, 60, and 90 DAS, as well as during harvest. The results showed that integrated nutrition approaches had a substantial effect on the number of tillers at 60, 90 DAS and at harvest stage of crop growth. The maximum number of tillers was recorded in treatment T_7 (75% NPK + FYM 10t/ha), which was comparable to treatment T_6 (75% NPK + FYM 5 t/ha). While the lowest number (167.30) were seen under (T_1), i.e. Control at 60 DAS. It was due to more availability of nutrient by main Culm initially and nominal availability at the time of tillering which led to positive effect on tillers production. Similar results were recorded by Kumar et al. [25].

3.3 Dry Matter Accumulation (gm^{-2})

The data on dry matter accumulation at the 30, 60, 90 DAS and at harvest stages of the crop are reported in Table 3 and visually shown in Fig. 3. Different nitrogen management strategies did not significantly affect crop plant dry matter accumulation at 30 days post-sowing. The highest dry matter accumulation (105.23) (450.70) (600.04) (799.61) was seen at T_7-75% NPK + FYM 10 t/ha which were at par with T_6-75% NPK + FYM 5 t/ha. The T_1-control plot showed the lowest plant dry matter accumulation (50.90) (286.07) (420.99) (474.41). From these results it may be inferred that the beneficial effect of FYM is due to its contribution in supplying additional plant nutrients, improvement of soil physical conditions and biological processes in soil. Metabolites root activities increased resulting absorption of moisture and other nutrients enhanced resulting into higher dry matter production. Similar, results were observed by Patel et al. [24]. In general, the dry-matter accumulation by plant continued to increase at successive growth stages and the highest dry-matter accumulation was recorded at maturity Alam et al. [26].

3.4 Yield Studies

3.4.1 No. of effective tillers (m^{-2})

The data related to number of effective tillers(m^{-2}) is significantly influenced by different integrated nutrient management treatments and have been reported in table-4 and shown in Fig - 4. The highest no. of effective tillers was recorded under treatment T_7 - 75% NPK + FYM 10 t/ha (430.10) which were at par with T_6-75% NPK + FYM 5 t/ha and lowest was recorded under treatment T_1 -control (142.83). The reason for attaining maximum yield attributes might be due to the reason that FYM when combined with fertilizers released the nutrients probably at faster rate which enriched the soil to provide sufficient amount of nutrients that are essential for various metabolic activities which resulted in the better mobilization of synthesized carbohydrates. Better nutrient availability resulted in higher values of yield attributes which improved the translocation of photosynthates from source to sink. These results are in accordance with the findings of Ingle et al. (2014) [14].

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

The findings for the number of spikes m^{-2} were recorded and given in Table-4, as shown in Fig-4. The results indicated that the integrated nutrient techniques had a considerable effect on the number of spikes m^{-2}. The largest number of spikes per square meter was recorded with treatment T_7-75% NPK + FYM 10t/ha (428.76) which were at par with T_6-75% NPK + FYM 5t/ha and lowest number of spikes was recorded under treatment T_1- Control (140.24).

3.4.3 Length of spike (cm)

The data on spike length were recorded and reported in Table-4, as shown in Fig-4. The results indicated that the integrated nutrient techniques had no significant effect on spike length. The maximum spike length (39.57) is seen in treatment T_7 (75% NPK + FYM 10t/ha) which were at par with T_6 (75% NPK + FYM 5t/ha) and the minimum (25.21) in T_1(control). This might be due to that organic source enabled the plant to absorb largest amount of NPK through their well develop root system. Secondly, the chemical fertilizer not only increase the photosynthesis production but also translocation of source to sink which resulted in increase spike length and it has a positive relationship with grain and straw yield. The similar findings have been also reported by Prakash et al. (2019) [23] and Maurya et al. [27].

3.4.4 No. of grains spike^{-1}

The data related to number of grains spike^{-1} have been summarized in Table-4 and depicted in Fig -4 revealed that there was significant effect on number of grains spike^{-1} with various integrated nutrient management practices. However, the maximum number grains spike^{-1} (48.96) observed with T_7-75% NPK + FYM 10t/ha and minimum number of grain spike^{-1} (33.64) in T_1-control. It might be due to higher length of spike under such treatments. The similar finding has been also reported by Prakash et al. (2019) [25].

3.4.5 Test weight (g)

The weight of individual grain calculated from 1000 grain weight (test weight) is an important yield attribute which provides information regarding the efficiency with grain filling process took place. Data pertaining to the 1000 grain weight are presented in Table-4 revealed that effect of varieties had not significantly influenced on test weight. However, the higher test weight (43.11 g) recorded with application of T_7- 75% NPK + FYM 10t/ha. This might be due to maximum test weight under such treatments. The similar finding has been also reported by Prakash et al. (2019) [25] and Fazily et al. [28].

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

The data reported to grain yield (q ha^{-1}) as influenced by different organic and inorganic treatments have been presented in table-5 and depicted in Fig.-5. Among integrated nutrient management practices, T_7(75% NPK + FYM 10 t/ha) recorded significantly highest grain yield (23.65) and it was at par with T_6 (75% NPK + FYM 5 t/ha) respectively. The lowest grain yield was recorded under T_1-control (11.87). Increased seed yield may be attributed to the improvement in growth attributes due to nitrogen application. The results were in agreement with those of Sheoran et al. [29], Ashok et al. [30] Singh et al. [2], Patel and Rajagopal (2002) [24].

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

The data reported to straw yield (q ha^{-1}) as influenced by different treatment have been presented in table-5 and depicted in Fig.-5. The highest straw yield was recorded under treatment T_7-75% NPK + FYM 10 t/ha (60.18) which were at par with T_6-75% NPK + FYM 5 t/ha and lowest was recorded under treatment T_1- Control (31.76). The maximum straw yield of wheat might be due to sufficient nutrient availability in soil enhanced the yield attributes of wheat which ultimately increased straw yield. The similar finding has been also reported by Singh et al. [5] and [31] and Akhtar et al. [32]. These findings are in conformity with the results of Agarwal et al .[33,1], Deva, S. [34], Sheoran et al. [29], Sharma [35,36].

3.4.8 Biological yield (q ha^{-1})

The data pertaining to biological yield q ha^{-1} as influenced by integrated nutrient management practices are presented in Table-5 and depicted in Fig.-5. Among integrated nutrient management practices, T_7-75% NPK + FYM 10 t/ha recorded significantly highest biological yield (83.83) and it was at par with T_6-75% NPK + FYM 5 t/ha respectively. The lowest biological yield was recorded under T_1-control (43.63). This might be due to maximum number of tillers, plant height, leaf area index and crop dry matter accumulation at different crop growth stages recorded more grain and straw yield under these treatments. The similar finding has been also reported by Choudhary et al. [23].

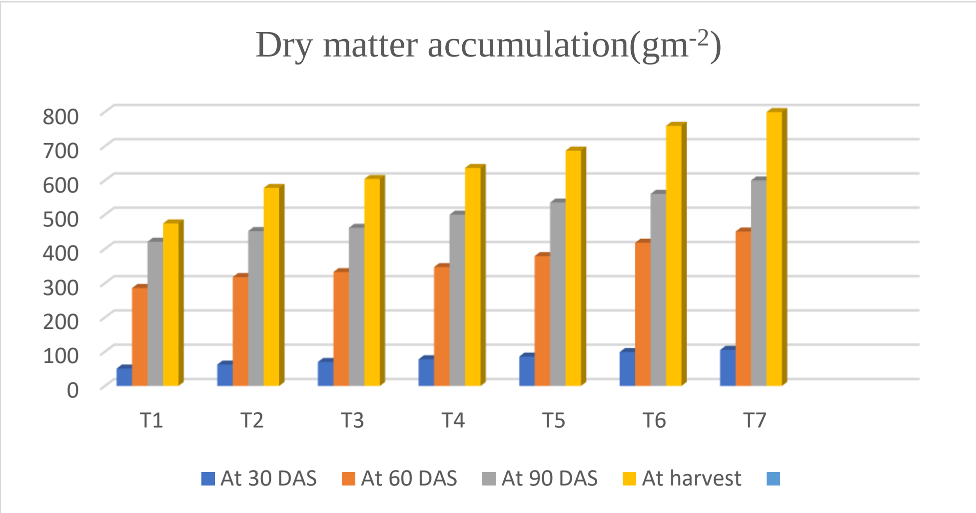

Fig. 3. Effect of integrated nutrient management on dry matter accumulation (g m^{-2}) in oat crop

Table 4. Effect of integrated nutrient management on yield attributes of oat crop

Sr. No.	Treatments	No. of effective tillers (m^{-2})	No. of spikes (m^{-2})	Spike length (cm)	Grains per spike	Test weight (g)
T_1	Control	142.83	140.24	25.21	33.64	35.26
T_2	50% NPK (N_{40} P_{20} K_{20})	229.90	228.48	27.43	35.54	38.29
T_3	75% NPK (N_{60} P_{30} K_{30})	245.40	244.40	28.42	37.21	39.99
T_4	100% NPK (N_{80} P_{40} K_{40})	278.07	275.12	31.12	40.47	40.09
T_5	50% NPK + FYM 10t/ha	318.90	315.56	33.65	43.86	42.06
T_6	75% NPK + FYM 5t/ha	417.15	416.30	38.73	46.43	42.37
T_7	75% NPK + FYM 10t/ha	430.10	428.76	39.57	48.96	43.11
SEm±		4.75	5.65	0.41	1.28	1.68
C.D.		14.81	17.61	1.30	3.98	NS

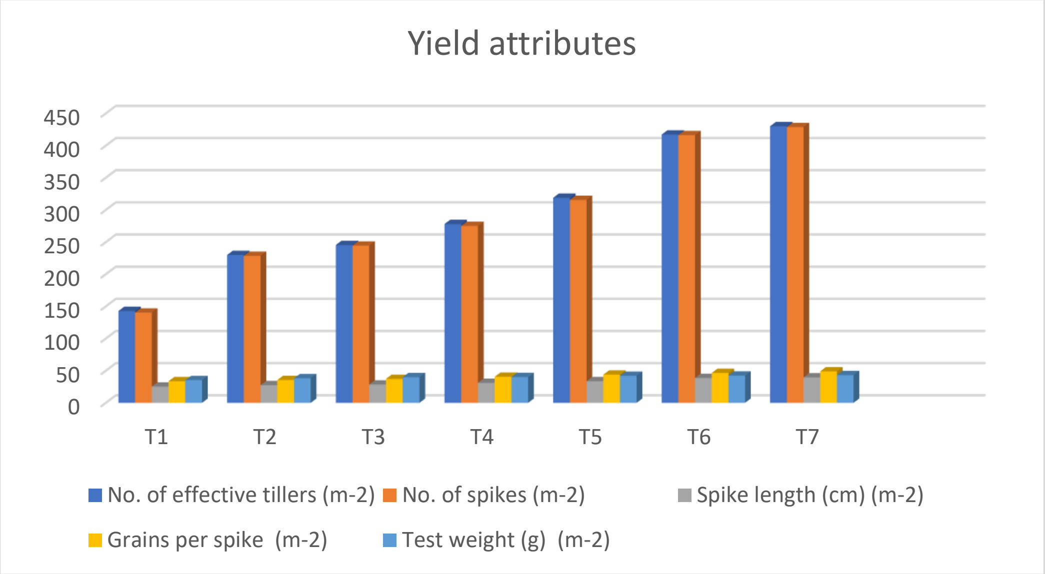

Fig. 4. Effect of integrated nutrient management on yield attributes of oat crop

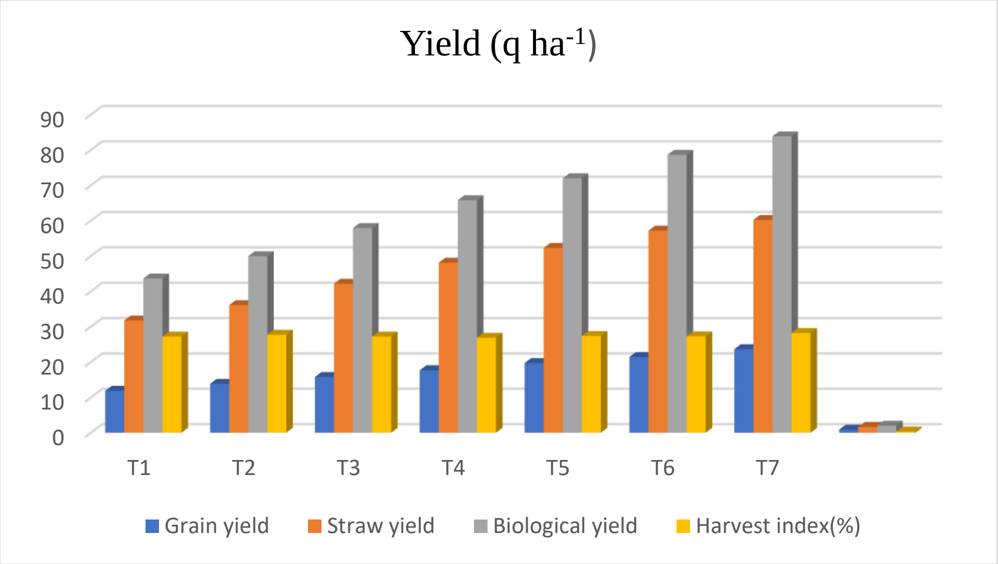

Fig. 5. Effect of integrated nutrient management on yield of oat crop

Table 5. Effect of integrated nutrient management on yield of oat crop

Sr. No.	Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
T_1	Control	11.87	31.76	43.63	27.20
T_2	50% NPK (N_{40} P_{20} K_{20})	13.85	36.09	49.95	27.72
T_3	75% NPK (N_{60} P_{30} K_{30})	15.76	42.15	57.91	27.21
T_4	100% NPK (N_{80} P_{40} K_{40})	17.69	48.11	65.80	26.88
T_5	50% NPK + FYM 10 t/ha	19.71	52.28	71.99	27.37
T_6	75% NPK + FYM 5 t/ha	21.45	57.17	78.62	27.28
T_7	75% NPK + FYM 10 t/ha	23.65	60.18	83.83	28.21
SEm±		0.86	1.64	1.98	0.34
C.D.		2.68	5.11	6.18	NS

3.4.9 Harvest index (%)

Table 5 displays data on the harvest index. The data showed that the maximum harvest index was achieved with T_7-75% NPK + FYM 10 t/ha which were at par with T_6-75% NPK + FYM 5 t/ha The harvest index for all treatments ranged from 27 to 28%. The similar finding has been also reported by Fazily et al. (2021) [19] and Maurya et al. (2018) [18].

4. CONCLUSION

The following conclusions are drawn from the above stated summary: the integrated use of inorganic fertilizer along with organic source positively affected the growth and yield of oat crop. The higher yield of oat could be achieved by adopting integrated nutrient management treatment as 75% NPK + FYM 10 t/ha.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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