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Effect of Nano DAP on Growth and Yield Performance of *Triticum aestivum* (L.) East Nimar Region, Khandwa, Madhya Pradesh, India

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Authors' contributions

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

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ABSTRACT

The study was to evaluate the impact of Nano DAP on the growth and productivity of wheat (*Triticum aestivum* L.), specifically on the HI-1634 (Pusha Ahilya) variety, through foliar application. The experiment laid out in randomized block design (RBD) with three replications. The field experiment was carried out during the Rabi season of 2023/24 at the School of Agriculture, Research farm of DR. C.V. Raman University in Khandwa, Madhya Pradesh, India. There were seven treatments consisting of different doses of T1-100% NPK, T2-75% N and P and 100% K, T3-50% N and P and 100% K, T4- T2 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 2 ml/litter of water, T5-T3 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 4 ml/liter of

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water, T6- T2 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 4 ml/litter of water at and T7- Control. The findings revealed that treatmenT1 resulted in the highest number of tillers and yield, followed by T6, which significantly higher performance with the application of 100% NPK. The foliar sprays of Nano-DAP in T1 treatment showed promising outcomes in terms of tillers, grains earhead^{-1}, spikelet earhead^{-1}, earhead^{-1} length, and yield ha^{-1}. It is evident that utilizing Nano DAP in place of half of traditional DAP, as well as treating seeds with Nano DAP, leads to superior root growth and overall crop development.

Keywords: Foliar application; Nano-DAP; wheat; yield.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is a cereal grain that originated in the Levant region but is now grown all over the world [1]. Wheat is a grain crop that provides a significant amount of carbohydrate [2]. It is the most common source of vegetable protein in human meals, with a protein level of around 13%, which is reasonably high when compared to other main cereals but low in protein quality for delivering important amino acids. Wheat is grown on 223.40 million hectares, yielding 778.6 million metric tonnes globally. It is cultivated on 31.62 million hectares in India, with a total yield of 3420 kg per hectare and a total production of 109.2 million metric tonnes (USDA, 2021). Madhya Pradesh produces wheat on 10.02 million hectares, yielding 16.52 million metric tonnes with a productivity of 3298 kg per hectare (Department of Agriculture, M.P., 2021).

The Indian population was 683 million in 1981, but it is expected to increase to 1475 million by 2030. To feed the predicted 1.48 billion people by 2030, India would need to produce 350 million tonnes of food grains. This growing trend indicates that the creation and application of new forms of fertilizers is one of the few viable alternatives for feeding the predicted world population of 9.6 billion in 2050 or more without adversely endangering ecosystems and the environment. The recent surge in global population has compelled the agricultural industry to enhance crop yield in order to feed billions of people, particularly in underdeveloped and emerging nations [3].

2. MATERIALS AND METHODS

2.1 Study Area

The field experiment on wheat crop was conducted in the research farm of DR. C.V. Raman University Khandwa M.P. The study location comes under tropical and subtropical climate zone and is located at 21°50'N, latitude and 76°13'E longitude and the maximum and minimum height above mean sea level is 905.56 m and 180.00 m respectively.

2.2 Experimental Details

Seven Treatments with 3 Replication of Wheat variety- (HI-1634) with Fertilizer dose (RDF) N: P_2O_5: K_2O: 120:60:40 and Statistical design Randomized Block Design (RBD). Plant spacing was used 22.5 cm (Row to Row), Seed rate of wheat seed were used 100 kg ha^{-1}, Gross plot Size was used 5 m × 5 m and Net Plot Size was 4 m × 4.10 m

2.3 Details of Treatments

The seven (7) treatments were used T1-100% NPK (120:60:40 kg ha-1 Recommended dose), T2-75% N & P and 100% K (90:45:40 kg ha-1), T3- 50% N & P and 100% K (60:30:40 kg ha-1), T4- T2 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 2 ml/litter of water at 30 DAG , T5-T3 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 4 ml/liter of water at 30 DAG, T6- T2 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 4 ml/litter of water at 30 DAG and T7- Control.
Note: - ST - Seed treatment FS – Foliar spray DAG – Days after germination

2.4 Data Recorded on Wheat Crop

2.4.1 Growth parameters

under the growth parameters data was recorded on Plant population 20 DAS and at harvest, Plant height (cm) at 30, 60, 90 DAS and at harvest, Fresh weight at 30,60,90 DAS and at harvest, Dry weight at 30,60,90 DAS and at harvest., No. of tillers at 30,60,90 DAS and at harvest and Post-harvest parameters were recorded**,** effective tillers (m^{-1}), No. of Grains Earhead-1,

Test weight (g), Grains yield (kg ha^{-1}), Straw yield (kg ha^{-1}), Harvest index (%).

2.5 Statistical Analysis

Data analysis was done from numerous observations were collated and then statistically analyzed using analysis of variance (ANOVA) procedures, with the treatment being evaluated using the F test. To examine the differences between treatment means, a critical difference (CD) was calculated for each character at a 5% level of significance. Before doing analysis of variance, the data on weed count and weed biomass were square root converted, i.e., x+0.5, and only transformed values were compared.

2.6 Economic Analysis: Cost of Cultivation (Rs ha^{-1})

The cost of cultivation for each treatment is calculated using various inputs used to raise the crop under various treatments on a one-hectare basis. Gross monetary returns (Rs ha^{-1}): The value achieved from the crop received under each treatment was calculated as gross monetary returns (GMR) per hectare based on the current market price of the output (both grain and straw).

2.6.1 Net monetary returns

The net monetary returns (NMR) per hectare for each treatment were calculated by deducting the cost of cultivation from the GMR for that same treatment.

Net monetary returns (Rs.) = Gross monetary return – total cost of cultivation

2.6.2 Benefit-cost ratio

The benefit-cost ratio, often known as profitability, is a statistic that shows monetary gains over each rupee invested under various treatments.

Benefit cost ratio = Gross monetary return (Rs ha^{-1}) / Total cost of cultivation (Rs ha^{-1})

3. RESULTS AND DISCUSSION

Growth performance data were recorded among treatments as given below:

3.1 Plant Height and Plant Population

Plant height differed significantly (p = 0.05) among the various treatments. After 30 days of growth, Plant height ranged from 20.33 cm to 22.67 cm with an average value of 21.57 cm. The maximum plant height (22.67 cm) was recorded in the T1 which is 100% NPK (120:60:40 kg ha-1 Recommended dose) followed by T6 (22.33 cm) and minimum (20.33 cm) was noticed in T7 which is absolute control followed by T4 (22.00 cm) and T3 (20.67 cm). The variation in Plant height in different treatments can be attributed to its peculiarity to increase height of plant by cell enlargement and the influence of environment during the period of growth Plant population data were recorded non-significantly (p = 0.05) among the various treatments. Plant population data was recorded after 20 days. Highest plant population was recorded T1 treatment 38.93, which is closely followed by T6 98.92 and lowest was recorded T7 37.40. Plant height maximum recorded after 60DAS, 90DAS, at the time of harvest which was 57.00 cm, 84.00 cm, and 83.80 cm respectively which was followed by 55.67 cm, 81.67 cm and 81.17. Plant height minimum recorded after 60 days, 90 days, and at the time of harvest which was 44.33cm 64.33 cm and 63.83 cm. it shown on Fig. 1. Plants were able to avail the most of their available growth resources, resulting in increased plant height owing to the weed-free environment. Similar results were reported by Poudel et.al.,[4].

List 1. Result showing plant height and population (m^{-1} of wheat)

Statistical Analysis	Plant population m^{-1} 20 DAS	Plant height (cm) 30 DAS	Plant height (cm) 60 DAS	Plan height (cm) 90 Days	At harvest plant height (cm)
Mean	38.16	21.57	52.61	76.47	75.97
SE(m) (+)	0.538	0.527	0.851	0.851	0.851
SE(d)	0.761	0.745	1.204	1.204	1.204
CD (P=0.05)	1.657	1.624	2.623	2.623	2.623
CV %	2.441	4.232	2.803	1.928	1.941

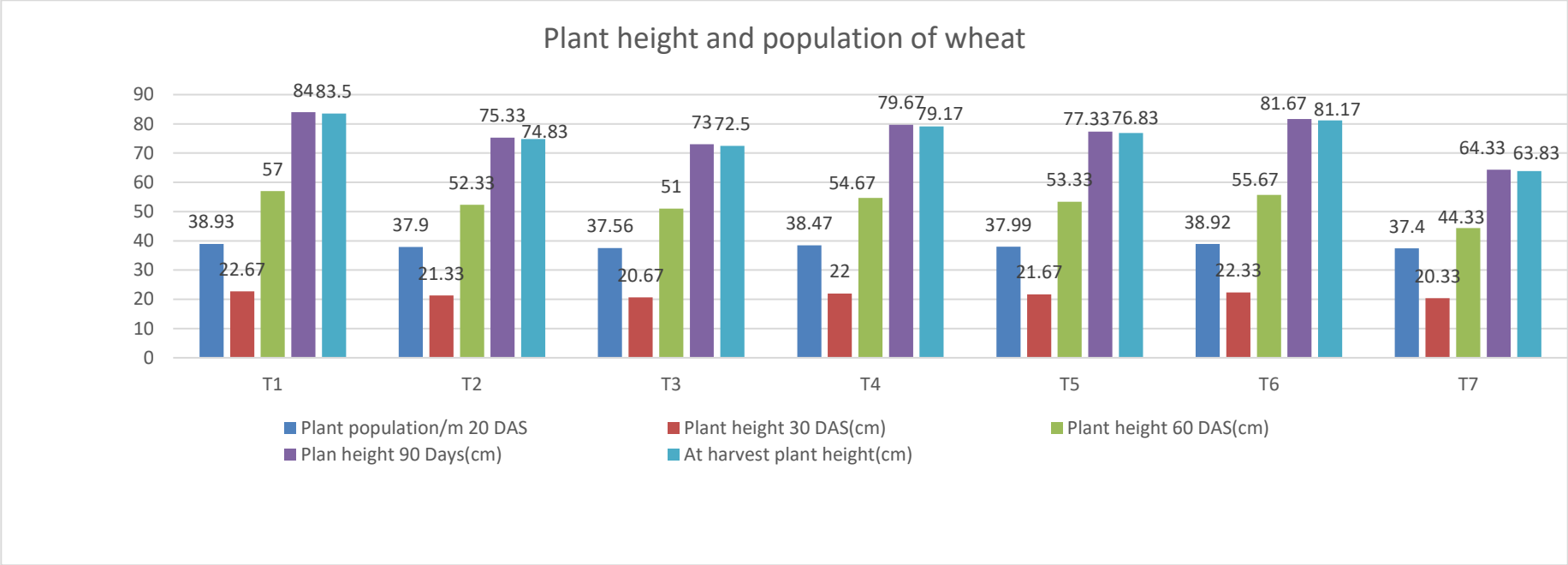

Fig. 1. Plant height and population m^{-1} of wheat

3.2 Fresh Weight m $^{-1}$ and Dry Weight m $^{-1}$

in Fig. 2 Show Fresh weight differed significantly (p = 0.05) variation in among the various treatments. After 30 days, 60 days, 90 days of growth, fresh weight ranged after 30 days that is 117.75 g to 124.46 g with an average value of 120.96g. The maximum fresh weight is recorded after 30 days, 60 days and 90 days, T1 treatment recorded highest fresh weight is 124.46 g, 364.48 g and 409.28 g followed by T6 treatment which is 123.83 g, 362.66 g, 406.55 g respectively. Lowest fresh weight recorded after 30 days, 60 days and 90 days which is T7 117.75 g, 198.40 g and 199.07 g. Dry weight differed significantly (p = 0.05) variation in among the various treatments. After 30 days, 60 days, 90 days of growth, dry weight ranged after 30 days that is 29.44 g to 31.44 g with an average value of 30.24 g. The maximum dry weight is recorded after 30 days, 60 days and 90 days, T1 treatment recorded highest dry weight is 31.11 g, 127.57 g and 245.57 g followed by T6 treatment which is 30.96 g, 126.93 g, 243.93 g respectively. Lowest dry weight recorded after 30 days, 60 days and 90 days which is T7 29.44 g, 69.44 g and 119.44 g. The study is in line with the findings of Kumari et al. [5].

3.3 Number of Tillers m^{-1}

Number of tillers differed significantly (p = 0.05) variation in among the various treatments. After 30 days, 60 days, 90 days of growth, number of tillers ranged after 30 days are 48.00 to 50.11 with an average value of 48.51 tillers. The maximum tillers are recorded after 30 days, 60 days and 90 days, Fig. 3 show, T1 treatment recorded highest number of tillers 50.11, 75.11 and 75.11 followed by T6 treatment which is 49.03, 73.13 and 73.13 tillers respectively. The smaller number of tillers was recorded after 30 days, 60 days and 90 days from T7 i.e. 48.00, 63.00 and 63.00 tillers respectively. Crop growth, leading in the efficient use of growth resources, resulting in these treatments having the higher number of tillers. These results were confirmed by Rajput et.al. [6] and Maloth et.al. [7].

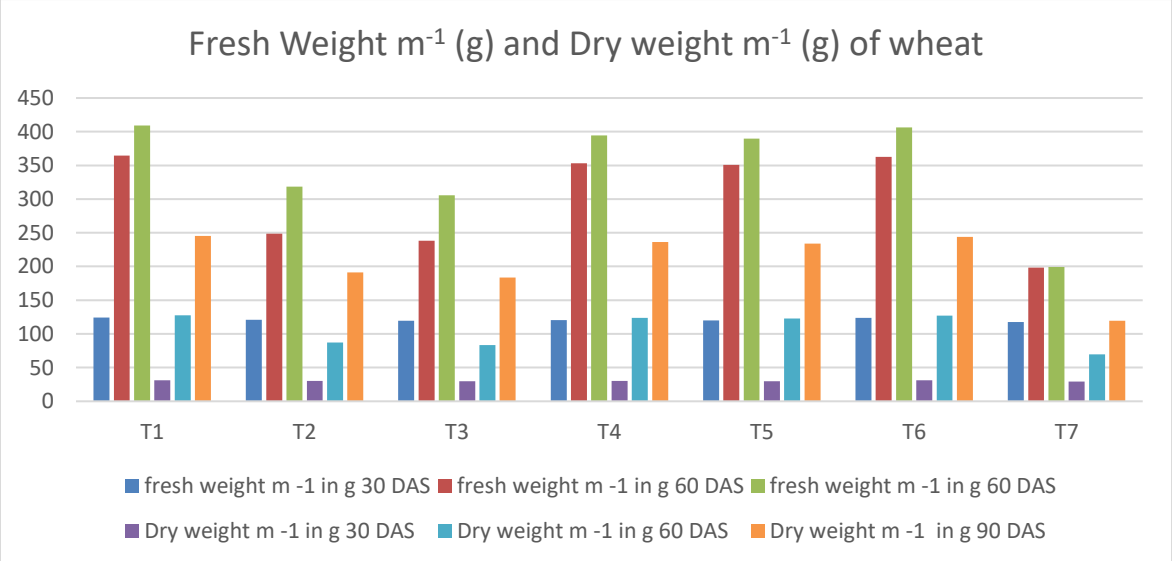

Fig. 2. Fresh weight and dry weight of wheat

List 2. Result showing statistical analysis of fresh weight and dry weight of wheat

Statistical Analysis	fresh weight m $^{-1}$ in g 30 DAS	fresh weight m $^{-1}$ in g 60 DAS	fresh weight m $^{-1}$ in g 60 DAS	Dry weight m $^{-1}$ in g 30 DAS	Dry weight m $^{-1}$ in g 60 DAS	Dry weight m $^{-1}$ in g 90 DAS
Mean	120.96	302.35	346.14	30.24	105.82	207.68
SE(m) (+)	2.591	7.589	4.427	0.648	2.656	2.656
SE(d)	3.665	10.732	6.260	0.916	3.756	3.756
CD (P=0.05)	7.984	23.383	13.640	1.996	8.184	8.184
CV %	3.710	4.347	2.215	3.710	4.347	2.215

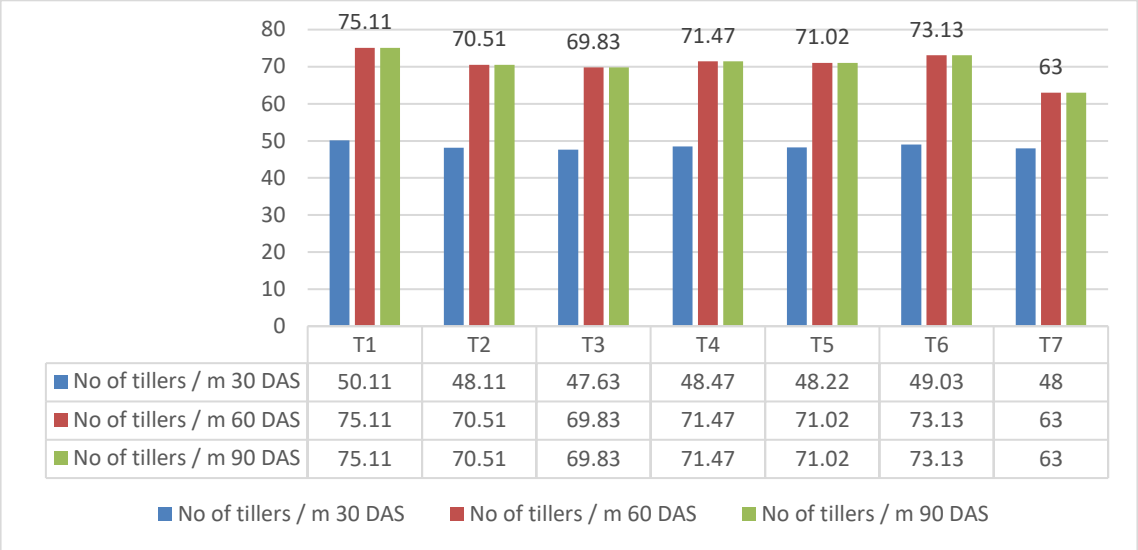

Fig. 3. Number of tillers m $^{-1}$

List 3. Result showing statistical analysis of number of tillers m $^{-1}$

Statistical Analysis	No of tillersm^{-1} 30 DAS	No of tillers m^{-1} 60 DAS	No of tillers m^{-1} 90 DAS
Mean	48.510	70.581	70.5814
SE(m) (+)	0.709	0.709	0.709
SE(d)	1.003	1.003	1.003
CD (P=0.05)	2.185	2.185	2.185
CV %	2.531	1.740	1.740

List 4. Result showing statistical analysis grains, spikelet and earhead

Statistical Analysis	Grains earhead^{-1} (cm)	Spikelet earhead^{-1} (cm)	Earhead^{-1}Length (cm)
Mean	34.30	11.43	8.45
SE(m) (+)	0.957	0.319	0.125
SE(d)	1.354	0.451	0.177
CD (P=0.05)	2.950	0.983	0.385
CV %	4.834	4.834	2.562

3.4 Grains Earhead^{-1}

In the Fig. 4, Grains earhead^{-1} recorded differed significantly (p = 0.05) variation in among the various treatments, Grains earhead^{-1} highest recorded T1 38.20 followed by T6 35.20 and lowest 31.6 was recorded from T7 which is followed by T3 32.60. Grains earhead^{-1} ranged between 31.60 to 38.20 and average of among treatments is recorded 34.31. Spikelet per ear head recorded differed significantly (p = 0.05) variation in among the various treatments, Spikelet earhead^{-1} highest recorded T1 12.73 followed by T6 11.73 and lowest was recorded 10.53 which is followed by 10.87 Spikelet earhead^{-1} ranged between 10.53 to 12.73 and average of among treatments is recorded 11.43.

3.5 Earhead^{-1}Length (cm)

Earhead^{-1}length was recorded significantly (p = 0.05) variation in among the various treatments, earhead^{-1} length highest recorded T1 8.95 cm closely followed by T6 8.90 cm and lowest was recorded T7 7.45 cm. Earhead^{-1}length ranged between 7.45cm to 8.95cm and average of among treatments is recorded 8.45cm. This study is in line with the findings of Mahachandramuki et al. [8].

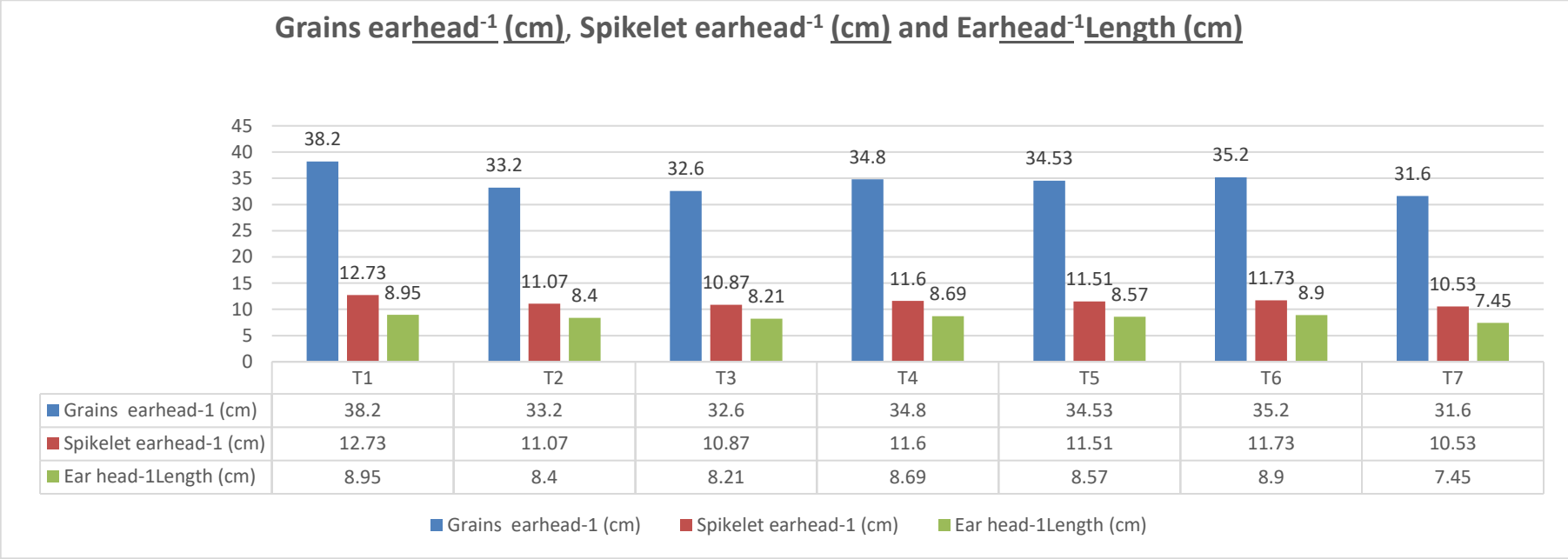

Fig. 4. Grains in per ear head^{-}, spikelet earhead^{-1} and ear head^{-1}length (cm)

3.6 Test Weight

Test weight and net plot yield was recorded significantly (p = 0.05) variation in among the various treatments, Test weight was highest recorded T1 93.60 g closely followed by T6 39.42 g and lowest was recorded T7 35.42 g. Test weight ranged between 35.42 g to 39.60 g and average of among treatments is recorded 37.85 g. Net plot yield was highest recorded T1 6.93 kg closely followed by T6 6.83 kg and lowest was recorded T7 3.25 kg. Net plot yield ranged between 3.25 kg to 6.93 kg and average of among treatments was recorded 5.77 kg. it was show on Fig. 5. Similar findings were also reported by Kumar et al. [9].

3.7 Yield and Straw Yield

In the Fig. 6., Yield and straw yield was recorded significantly (p = 0.05) variation in among the various treatments, the highest wheat yield was recorded in T1 of 4226.33 kg ha^{-1}which was closely followed by T6 4164.67 kg $ha^{-1}$and lowest yield was recorded in control T7 1984.33 kg ha^{-1}. Yield of wheat ranged between 1984.33 kg $ha^{-1}$to 4226.33 kg $ha^{-1}$and average of among treatments was recorded 3520.94 kg ha^{-1}. The highest Straw yield was recorded at T1 6339.5 kg ha^{-1}closely followed by T6 6330.25 kg $ha^{-1}$and the lowest straw yield 3174 kg $ha^{-1}$was recorded from T7. Similar findings were also reported by Singh et.al. [10].

3.8 Harvest Index (%)

Harvest index was recorded significantly (p = 0.05) variation in among the various treatments, Fig. 7. Show Harvest index of wheat was highest recorded in T1 40.03% which was closely followed by T6 39.69% and lowest was recorded in control T7 37.89%. average of Harvest index was recorded 39.28%. Higher value of harvest index T1 (40.03 %) because of higher amount of photosynthate assimilation as compared to other the treatments. Similar findings were also reported by Kumar e.al. [11] and Jaidev et al. [12,13].

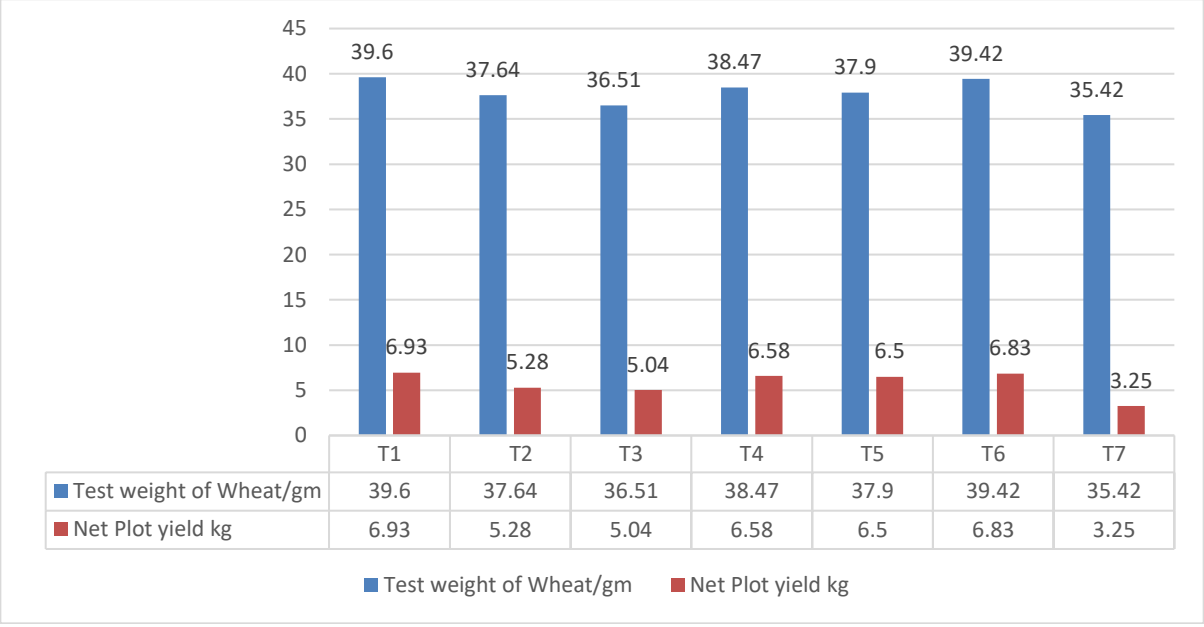

Fig. 5. Test weight g and net plot yield in kg

List 5. Result showing statistical analysis of Net plot yield and Test weight of wheat

Statistical Analysis	Net plot yield (kg)	Test weight of wheat (g)
Mean	5.77	37.85
SE(m) (+)	0.072	0.500
SE(d)	0.102	0.707
CD (P=0.05)	0.223	1.541
CV %	2.169	2.289

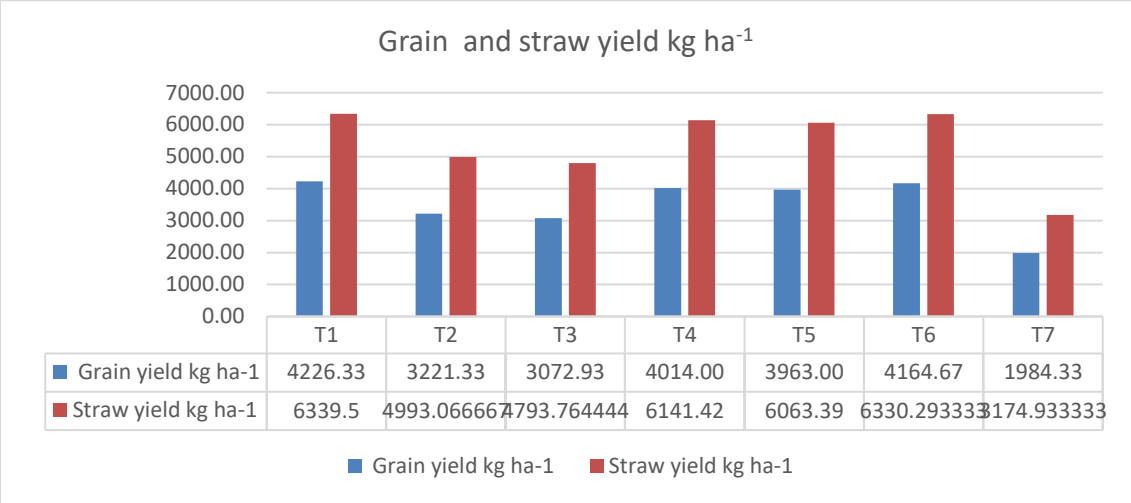

Fig. 6. Yield kg ha^{-1} and straw yield kg ha^{-1}

List 6. Result showing statistical analysis of grain and straw yield

Statistical Analysis	Straw Yield (kg ha^{-1})	Grain yield (kg kg ha^{-1})
Mean	5405.20	3520.94
SE(m) (+)	67.470	44.084
SE(d)	95.417	62.344
CD (P=0.05)	207.896	135.837
CV %	2.162	2.169

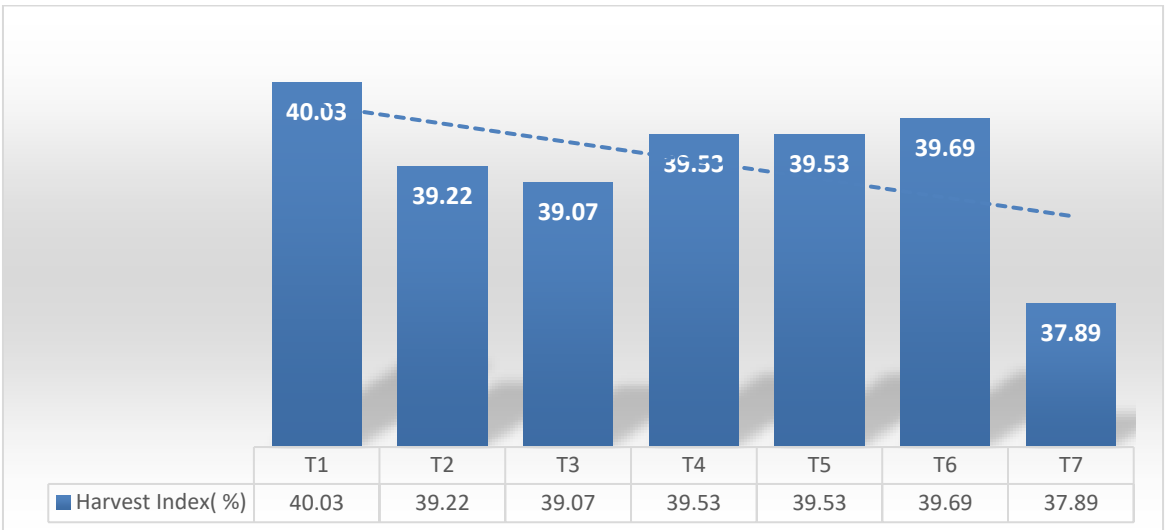

Fig. 7. Harvest index (%)

List 7. Results showing statistical analysis of harvest index

Statistical Analysis	Harvest Index (%)
Mean	39.28
SE(m) (+)	0.302
SE(d)	0.659
CD (P=0.05)	0.943
CV %	0.214

Table 1. Effects of Nano DAP on economics of various treatments

Treatment	Cost of cultivation (Rs.ha-^{1})	Gross Monitoring returns (Rs.ha-^{1})	Net Monitoring returns (Rs.ha-^{1})	B-C Ratio
T1	46,430	116,630	70,200	2.51
T2	43,659	87,346	43,687	2.00
T3	42,358	83,509	41,151	1.97
T4	45,519	110,766	65,248	2.43
T5	43,578	109,918	66,340	2.52
T6	45,879	111,752	65,874	2.44
T7	38,453	56,185	17,732	1.46

3.9 Partial Budget Analysis

The partial budget of the experiment is show that in Table 1. The maximum Cost of cultivation (Rs.ha-1) was recorded in T1 treatment followed by T6, T2 and T4 and the minimum cost of cultivation was recorded under the treatment T7. In point of view Gross Monitoring returns (GMR) and Net Monitoring returns (NMR), The highest GMR and NMR were recorded in T1 and minimum was recorded T7. In case of B-C ratio, the maximum was observed in the T5 treatment it is followed by T1, T6 and T4. However, the minimum B-C ratio was found under T7.

4. CONCLUSION

Based on experimental results, with respect to growth parameters, yield attributing characters and yield, it can be concluded that wheat variety HI-1634 (Pusha Ahilya) the result of the experiment show that the RDF treatment (T1) is better as compared to rest of the treatments such like Growth parameters, yield attributes and yield but, in prospect of economically the treatment T5 (T3 + ST with Nano DAP @ 5 ml/kg seed + FS with Nano DAP @ 4 ml/liter of water at 30 DAG) is best for farmers because in this treatment can save 50% N and P cost in rupees.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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