Vol. 5 No. 1 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

https://doi.org/10.5281/zenodo.19414772

Effect of Moringa Oleifera Leaf Powder as a Bio-Stimulant and Fertilizer on Nutrient Uptake and Growth Efficiency of Wheat

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Abstract

The present study focuses on the use of Moringa Oleifera Leaf (MDL) powder as a natural bio-stimulant and organic fertilizer to enhance plant growth, nutrient uptake, and crop efficiency under normal and stress conditions. Experimental findings revealed that MDL application significantly improved nitrogen (N), phosphorus (P), and potassium (K) uptake in wheat grains and straw, particularly when applied at critical growth stages such as jointing and booting. Treatments with 50% MDL showed the highest nutrient uptake and growth performance compared to control treatments. The use of MDL also enhanced shoot and grain yield by improving nutrient efficiency and overall crop health. Additionally, MDL contributed to increased resistance against insect and disease attacks. It is concluded that incorporating Moringa oleifera powder as a fertilizer source, along with conventional N-P-K fertilizers, can substantially improve crop yield, nutritional value, and sustainability in agricultural systems.

Author Details

Keywords: Moringa Oleifera Leaf Powder, Bio-Stimulant and Fertilizer and Growth Efficiency of Wheat

Received on 21 Feb 2026
Accepted on 24 Mar 2026
Published on 31 Mar 2026

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Introduction

Wheat (T. aestivum) is an important food crop and ranked as an important staple food in North Africa, Europe and West Asia for as far back as 8000 years (Sattar *et al*., 2015). 765 million tons wheat has been produced all over the world (Hyles, J., Bloomfield *et al*., 2020). Wheat is very essential due to its attributes and approximately 33% population consumed it as a staple food (Wang *et al*., 2016). Moreover, its straw is also used in making paper and consumed as a feed of livestock (Milad *et al*., 2013). Nutrients consider being one of the important parts of plant (Ready *et al.,* 2015). In different countries like Pakistan, there is more deficiency of Zn has been reported (Ladha *et al*., 2016 ; (Masood, 2015). Scientists predicted zinc deficiency in wheat in Pakistan (Chattha *et al*., 2017; Rafique *et al*., 2006). In addition to major elements, wheat is most sensitive to micronutrients like boron, Zn, Fe, Mg, MN etc. (Fariha *et al.,* 2025). Moringa oleifera is a perennial tree, still not fully utilized plant and represent Moringaceae family. Another name of Moringa plant is drumstick or sohanjana in Pakistan (Hazarat Bilal *et al.,* 2025). All parts of the plants having extraordinary nutritional and useful properties which make this plant manifold biomaterials for food uses (Abbas *et al.,* 20205). The leaves of this plant are valuable source of natural antioxidant due to presence of antioxidant compounds (Anwar *et al*., 2007). Five plant growth promoters are responsible for the growth and yield of plants including, Auxin, Corrosive, gibberellins, abscisic, Ethylene and cytokines (Prosecus, 2006). Cytokine has another type name Zeatin present in Moringa leaves (Maishanu *et al.,* 201). Wet concentration of Moringa along with high temperature and salt application show a reaction which increase yield and efficiency by changing the metabolic activities in plants (Yasmeen *et al*. 2013) Moringa dry leaves have been applied as a fertilizer in the soil of wheat and other cereal crops for raising their yield and expected advantages of small agricultural land holder (Aqsa Naseem *et al.,* 2025). Moringa dry leaves usage is beneficial as they create resistance against climatic cordial and involved less cost (Noaman *et al*., 2010). Moreover if Moringa dry leaf powder is used as a fertilizer in crops, it may bring great revolution in agriculture field and our need of synthetic fertilizers may be cut down (Muhammad Nabeel Sharif *et al*., 20205).Our input output ratio improve which reduce our expenses (Ali *et al.,* 2018). This will be great financial support for farming community especially small land holder farmers (Javaid *et al.,* 2025).

METHODOLOGY

Soil Analysis

The pot size having depth x width (14 x 10) inches filled with maximum 11-12 kg soil in each pot. Soil which was used in experiment has a character with the mixture of 1:1:1 (weight basis) sand, clay and silt filled in the pot. The sample took into tarpaulin bag and next sent to the testing laboratory for more checking. After upcoming of results observed that soil has 0.7% OM (Organic matter), Nitrogen(N) 0.93%, potassium(K) 360 ppm, phosphorus(P) 8.43 ppm with prismatic and loamy character. Maximum water retention capacity of soil was 14.5% on mass basis. Sample soil having loamy characters which have Ece 2.40 ds/m and hydrogen ion concentration was 9 and belonged to fertile soil (Farooq *et al*., 2014).

Observation

Emergence percentage

Numbers of emerged seeds were recorded on daily basis for about 10 days until accomplishment of seed germination. Emergence percentage of seedling was obtained by using the following formula;

Emergence % = (No. Of emerged seed/ Total No. seeds) ×100

Germination Index

Germination index was calculated described by the accordance Official Association of Seeds Analyst (Anonymous, 1983) by using following formula.

$$\text{Germination Index} = \frac{\text{Number of emerged seeds}}{\text{Days to first count}} + \frac{\text{Number of emerged seeds}}{\text{Days to finalcount}}$$

Time to 50 percent Emergence

Time taken to 50% emergence (T_{50}) was calculated described by Farooq *et al*. (2005).

$$T_{50} = t_i + \left[\frac{N+1/2-n_i}{(n_j - n_i)} \right] \times (tj - t_i)$$

Leaf area ratio

For leaf area ratio measurement we need length and width of the leaf of selected plants. Leaf area of leaf was measured by using measuring scale in unit of "cm". Risk of variations in parameter was decreased by taking averages of the leaves from each single factor.

Leaf Area Index

LAI of selected plant is measured by dividing crop growth rate to the Net assimilation rate by using formula given below.

$$LAI = \frac{CGR}{NAR}$$

Crop growth rate

Growth rate of plant from each pot was measured by taking average of given date from each treatment. Following formula is used for measuring this parameter.

$$CGR = W_2 - W_1 / t_2 - t_1$$

Mean emergence time (MET)

Data related to emergence and seedling vigor or seedling health parameters were calculated by following ISTA protocols (ISTA, 2020). Mean Emergence Time calculated by using formula given below.

$$\text{Mean Emergence Time} = \frac{\sum Dn}{\sum n}$$

Shoot length

Shoot length of selected plant was measured in unit of "cm" by selecting three plants randomly from each treatment. Shoot length of selected plant was measured with scale and finally average was taken from given data.

Root length

Root length of plant measured in "cm" by selecting three plants randomly from every treatment.

Fresh weight

Fresh weight of plant was determined at booting stage by taking 3 plants from each treatment and their weight was measured on digital weight measuring balance and then average was calculated from the data

Leaf area

Area of leaf for plants selected by a researcher was taken by using measuring scale in "cm". Variation in the area of leaf which was measured is declined by measuring leaf area from each treatment.

Chlorophyll content

Extract of selected plant's leaf which was obtained by grinding leaf into fine powder. The extracted paste content of that leaf was dissolved in water and then centrifuged. Supernatant should remove and remained material then filtered through filter paper. That final filtrate material is used for chlorophyll content measurement using following formula given below.

$$\text{Chlorophyll content} = C_t \times V \times R/M \times 1000 \text{ (mg/g)}$$

Final plant height

Final Plant height of wheat crop in trial area was measured in "cm" by randomized selection of only three plants. Final length/height of wheat plant was measured by a scale. Average data was used from available data for each treatment.

No. grains per spike

Numbers of grain per spike were recorded by taking three spikes from each treatment. At the end, average was taken from given data. The grains which were counted from each spike considered to be actual yield.

Weight of 100 grains

Weight of grains was taken by taking 100 grains from each treatment and weight was done by digital weight balance. Weight of seed represents directly or indirectly health vigor of seed.

Economic output/yield

Average of data of that crop which is considered as (A) was considered as final data. In next steps, 10 spikes should take from individual pots in one treatment and then average of data which is considered as B recorded. Finally weight of grains was taken and final harvest yield calculated by using given formula.

$$\text{Yield} = (A \times B \times C) / 10{,}000 = \text{unit is (t/ha)}$$

Grain color

Grain color of different treatments observed after harvesting procedure. Grain color show the seed health and it is mirror of seed nutrient profile.

Statistical investigation

Calculated data was statistical analyzed regarding all above described parameters using computer software which is Statistic 8.1. Statistically Analysis of variables data and results of given data was done by Statistic 8.1. Finally data was analyzed and compared accordingly.

RESULTS AND DISCUSSION

Wheat is an important food source of food in our country Pakistan and it growth occur on large area. With the passage of time, Pesticide sector creating many plant health issues which cause an alarming situation for our economy in form of output and capital losses. Wheat is very valuable and important food source which has potential to resist against

those risks which arise when natural control measures took like use of Moringa leaf dry powder. Many parameters are given below to check effect of Moringa leaf powder on plant growth and yield.

Emergence %age

A priority was observed among those treatments which were treated with great amount of MDL 50% and NPk 50%.The comparative results for all treatments considered to be sign of crop growth is at higher rate when MDL applied with proper quantity. At maturity stage of wheat, growth rate was more improved in T_2 in compare with other treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa. So, overall effect of fertilizer along with Moringa powder on growth rate has positively co-relation with insect pest control. Phyto-chemicals also found in Moringa. More growth rate in T_2 than control and all others treatments in experiment was observed. This variation in emergence % during research was due to nutritional, antifungal and insect resistance properties of Moringa. Same results observed in cotton. So, if we use Moringa as a bio stimulant on crop then there are more chances of improvement in growth and yield of crop. One of the major problems is quantifying Moringa for recommended doze. If we enable ourselves to overcome this problem we can bring revolution in agriculture

Table 1- LSD All Pair wise Comparisons Test of Emergence %

Treatment	Mean
100% NPK application	83.333
100% MDL application	66.667
75% NPK + 25% MDL application	63.333
50% NPK + 50% MDL application	60.000
25% NPK + 75% MDL application	56.667

Emergence index (GI)

Basically GI calculated on the behalf of given data. A priority was observed among those treatments which were treated with MDL 50% and N-P-k 50%. The effect of Moringa dry leaf powder in $T_1$and T_5 was significant. Later, it was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. At fully mature stage of wheat, growth rate of crop was more in T_3 than all other given treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa. So, overall effect of fertilizer along with Moringa powder on growth rate of crop has positive correlation with insect pest control.

Table 2- LSD All Pair wise Comparisons Test of Germination Index

Treatment	Mean
50% NPK + 50% MDL application	10.927
100% MDL application	9.8667
25% NPK + 75% MDL application	9.5467
100% NPK application	9.2500
75% NPK + 25% MDL application	7.3867

Leaf area

The effect of Moringa dry leaf powder in $T_4$and T_5 was significant. The comparative results for all treatments show that crop is stable at higher application rate of MDL. At fully mature stage of wheat, growth rate was more improved in T_3 in compare with all

those treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa. So, overall effect of fertilizer along with MDL on growth rate has positive relation with insect pest resistance. Phytochemical also found in Moringa. More growth rate of crop observed in T_3 than control and all other given treatments in experiment. MDL improved crop by all over aspects.

Table 3- LSD All Pair wise Comparisons Test for Leaf area

Treatment	Mean
50% NPK + 50% MDL application	48.067
T2 100% NPK application	46.200
75% NPK + 25% MDL application	41.833
100% MDL application	36.267
25% NPK + 75% MDL application	34.133

Leaf area index (LAI)

The effect of Moringa dry leaf powder in $T_4$and T_5 was significant. Later, it was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results for all treatments were considered that crop is stable at higher rate of MDL application. At fully mature stage of wheat growth rate was more in T_3 than all other treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa so overall effect of fertilizer along with Moringa powder on growth rate has positive relation with insect pest control. Phytochemical also found in Moringa. More growth rate was observed in T_3 than control treatment and all other treatments in experiment. This variation in growth and yield during research was due to nourishment, antifungal & insect resistance characters of Moringa. MDL improved crop by all over aspects. Similar situation was observed in cotton and they relate Moringa with character of insect control. So, if we use Moringa as a bio stimulant on crop then there are more chances of improvement in growth and yield of crop.

Table 4- LSD All Pair wise Comparisons Test for Leaf area Index

Treatment	Mean
50% NPK + 50% MDL application	717.27
100% MDL	659.46
100% NPK application	626.05
75% NPK + 25% MDL application	591.95
25% NPK + 75% MDL application	590.50

Crop growth rate

It was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results for all treatments were considered that crop is very stable when more powder is being applied. At fully mature stage of wheat, growth rate was more prominent in T_3 in comparison with those treatments which are fully treated with synthetic fertilizers. Effect of MDL powder on growth rate has positive relation with insect pest control. Phytochemicals also present in Moringa. More growth rate was observing in T_3 than control and all other given treatments in experiment. Variation in growth rate during research was due to nutritional, antifungal & insect resistance properties of the Moringa. MDL improved crop by all over

view. Same trends observed in cotton and they show relation of Moringa with property of insect control.

Table 5- LSD All Pair wise Comparisons Test for CGR

Treatment	Mean
50% NPK + 50% MDL application	12.378
25% NPK + 75% MDL	10.621
100% NPK	9.4567
75% NPK + 25% MDL application	9.2509
100% MDL application	8.6888

Mean Emergence time (MET)

It was estimating that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results of all treatments show that crop is in stable condition when MDL powder applied. At fully mature stage of wheat, growth rate was higher in T_3 than all other treatments which are fully treated with synthetic fertilizers. So, all over experiment, effect of Moringa dry leaf powder on growth has positive relation with insect pest control. More growth rate observes in T_3 experiment. Variations in mean emergence time during research due to nutritional, antifungal and insect resistance character of the Moringa.

Table 6- LSD All Pair wise Comparisons Test for MET

Treatment	Mean
50% NPK + 50% MDL application	26.557
100% NPK	24.000
25% NPK + 75% MDL	23.617
75% NPK + 25% MDL application	22.746
100% MDL application	22.663

Root length

The effect of Moringa dry leaf powder in $T_3$and T_4 was significant. Later, it was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results for all treatments show that crop is in stabile form at higher rate of powder application. At full mature stage of wheat, growth rate was more in T_2 than all other treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa. So, overall impacts of fertilizers along with Moringa powder on growth rate show positive relation with insect pest control. Phytochemicals also present in Moringa. More growth rate observes in T_3 in given experiment. This variation in emergence % during research was due to nutritional, antifungal and insect resistance property of Moringa. MDL improve crop by all aspects.

Table 7- LSD all pair wise comparisons test for Root length

Treatment	Mean
50% NPK + 50% MDL application	12.133
75% NPK + 25% MDL	10.333
25% NPK + 75% MDL	9.1667
100% NPK	8.9667
100% MDL	83.8675

Fresh weight

For T3 final Value was 3.7393.While for that treatment where 100% MDL apply has value2.1259. The effect of Moringa dry leaf powder in $T_3$and T_4 was significant. Later, it was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results of all treatments show that crop is in stable form when high rate of powder applied. At fully mature stage of wheat, growth rate was higher in T_2 than other treatments where crop treated with synthetic fertilizers or along with small quantity of Moringa. So all over the impacts of fertilizer along with MDL on growth rate has positive relation with the insect pest control. Many phyto-chemicals are also present in Moringa. More growth rate observes in T_3 than other treatments in experiment. This variation in fresh weight during research was due to nutritional, antifungal & insect resistance character of the Moringa. MDL improve crop by all aspects.

Table 8- LSD All Pair wise Comparisons Test for Fresh weight

Treatment	Mean
50% NPK + 50% MDL application	3.7393
100% NPK	3.1116
25% NPK + 75% MDL	2.6038
75% NPK + 25% MDL	2.1682
100% MDL	2.1259

Dry weight

It is estimating effect of MDL powder on growth rate was more effective for T_3 during early research stage which was taking during growth period and value was 5.9431. While, on other side treatment where 100% MDL apply has value 4.1752. The effect of Moringa dry leaf powder for all other treatments was significant. Later, it was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results for all treatments show that crop is in stable condition at higher rate of powder application. At fully mature stage of wheat, growth rate was more effective for T_3 than other treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa. So, overall effect of fertilizer along with Moringa powder on crop growth rate has positive relation with insect pest control. Phytochemicals also found in Moringa. More growth rate observes in T_2 in given experiment. This variation in Dry weight during research was due to antifungal and insect resistance character of the Moringa.

Table 9- LSD All Pair wise Comparisons Test for Dry weight

Treatment	Mean
50% NPK + 50% MDL application	5.9431
100% NPK	4.3623
100% MDL	4.1752
75% NPK + 25% MDL	4.0084
25% NPK + 75% MDL	3.9047

Leaf area

The effect of Moringa dry leaf powder in all T1, T3, T4 and T5 was significant. Later, it was estimated that with the passage of time values showing that it brings more improvement in physiological characteristics of crop. The comparative results for all treatments were considering that crop is in stable condition at higher rate of dry powder application. At fully mature stage of wheat, growth rate was more in T_3 than other treatments which are fully treated with synthetic fertilizers or along with small quantity of Moringa. So, overall impact of fertilizers along with MDL on growth rate has positive relation with the insect pest control. Phyto chemicals are also present in Moringa. More growth rate observes in T_3 than control and other treatments in given experiment.

Table 10- LSD All Pair wise Comparisons Test for Leaf area

Treatment	Mean
50% NPK + 50% MDL application	48.067
100% NPK	46.200
75% NPK + 25% MDL	41.833
100 % MDL	36.267
25% NPK + 75% MDL	34.133

Chlorophyll at booting and milking

Treatments in which 100% MDL apply improved chlorophyll content to great extents in compare with control treatment. In experiment, we analyze that Chlorophyll was 49mg in T1 when crop was at booting stage. While on other side, in controlled value show 41mg chlorophyll content which show positive correlation between Moringa powder and chlorophyll. Value was also high in third treatment during booting stage. With time period crop growing toward maturity, chlorophyll start to decrease and during peak maturity stage, chlorophyll content remain 39.5mg in T1. In controlled condition, value was `32mg but value also high in T2 and T4 as 42 and 41. Many researchers conducted research on insect management strategies of crop. Study from Rashid *et al*., 2018 indicate that MDL Powder on quinoa also reduce heat tolerance capacity and improve chlorophyll part of plant. Another research conducted by Ahmad *et al*., (2019) indicates Moringa Dry leaf powder improve yield of crop by improving the chlorophyll contents. Thus, increasing chlorophyll contents in wheat enhance nutrition profile of Moringa.

Table 11- LSD All Pair wise Comparisons Test for Chlorophyll Content

Treatment	Mean
100 % NPK	42.067
50% NPK + 50% MDL application	39.200
75% NPK + 25% MDL	41.833
100 % MDL	48.267
25% NPK + 75% MDL	35.133

Final Height of Plant

Height of plant in the month of December was 16.45 cm in T_1. At same day in control (T_4) height of plant was 15.2 cm. In T_3 height was 16.2 cm. Variation in plant height observed from graphical representation on dated 30th January. The difference in height of plant was less prominent among T_3 and T_5. These changing in height indicates Moringa prevent plant from harm full insects. Hence it may promote plant health. Same situation observe by Madiha Nisar *et al.,* 2021 who use MDL as an insect control and yield promoter in cotton crop. Moringa used as a fertilizer due to valuable nutrients presence like zeatin, antioxidants, minerals and other health conscious regulators which ultimately promote growth of crop. Other research by Yasmeen *et al*., 2013 show MDL as a fertilizer enhance yield of wheat and consider an important practice for insect pest management. Shah *et al*., 2017 worked on moringa related fertilizer. He also uses Moringa as an aphid control agent in his research.

Table 12- LSD all pair wise comparisons test for plant height.

Treatment	Mean
50% NPK + 50% MDL	57.223
100% MDL	54.220
100% NPK	52.997
25% NPK + 75% MDL	52.333
75% NPK + 25% MDL	51.01

Grains count / spike

It is estimating there is positive relation exists between treatments and Grains per spike. Number of grain in each spikes were different from each other in every treatment.

Effect of Moringa leaf extract on grains per spike

Different parameters like grains per spike are highly affected by use of bio-regulators like present in MDL. It is because of preventive action and anti-fungal properties of plant. Abusuwar & Abo Hassan in 2017 studied show that application of MDL promotes grains per spike. Other study conducted by Khan *et al*., in 2021 proved application of MDL also improve grain quality and number of grains in spikes in wheat. Same situation observe in research conducted by Madiha Nisar*et al*., 2021. Other studies by Yasmeen *et al*., in 2013 realize that MDL fertilizer enhances final yield of wheat and act as an important management practice for insect pest management. Shah *et al*., 2017 expressed that Moringa fertilizer worked as an aphid controller in crop region enhance crop yield and improve physiological character of plant.

Table 13- LSD all pair wise comparisons test for grain per spike

Treatment	Mean
25% NPK + 75% MDL	41.333
75% NPK + 25% MDL	38.333
T2 100% NPK	36.667
50% NPK + 50% MDL	36.000
100% MDL	48.447

Impact of MDL on 1000 grain's weight

It is estimating clearly that there is strongly link exist with application of MDL on wheat. There is a positive correlation exist between application of MDL and weight of 1000 grains. Final weights increase when MDL use as an insect controller. In first treatment, MDL application gives more effective result on over all look, health and also on grain weight.

Table 14- LSD all pair wise comparisons test for grain per spike

Treatment	Mean
25% NPK + 75% MDL	40.333
75% NPK + 25% MDL	39.333
100% NPK	38.667
50% NPK + 50% MDL	35.000
100% MDL	33.447

Net Assimilation rate

From given analysis of variable table regarding net assimilation rate of wheat. It is concluding that impact of treatments has non-significant result on weight for NAR. Wheat has positive correlation between given treatments and Net Assimilation Rate.

Effect of MLD on Net Assimilation rate

When moisture condition lower than 13% while NAR in other treatments like T2, T3 and T4 have values 45.4, 43.6, 39.333,40.333 respectively. It shows their relation with MDL fertilizer in wheat. There is also positive relation exists between application of Moringa dry leaf and NAR. When 100% MDL use as an antifungal and insect control agent in T5 show more effective result on physical look and spike health of grains.

Table 15- LSD All Pair wise Comparisons Test for NAR

Treatment	Mean
50% NPK + 50% MDL	0.8667
100% MDL	0.7333
100% NPK	0.7333
25% NPK + 75% MDL	0.6667
75% NPK + 25% MDL	0.6000

CONCLUSION

It is concluded that if Moringa powder is used as a fertilizer source along with Nitrogen, Phosphorous and potassium source. Over all effects on crop growth, productivity and yield will be positive. Moringa not only act as fertilizer source, it also enhances plant resistance against insect and disease attack. So we concluded that MDL has positive correlation with plant health and yield.

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