Int.J.Curr.Microbiol.App.Sci (2019) *8*(11): 333-340

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 11 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.811.042

Enhancing the Performance of Wheat (*Triticum aestivum* L.) through Fly Ash and Nitrogen Management

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Keywords

Fly ash, Growth, Grain yield, Nitrogen, Wheat

Article Info

Accepted:
04 October 2019
Available Online:
10 November 2019

A B S T R A C T

A field experiment entitled "Enhancing the performance of wheat (*Triticum aestivum* L.) through fly ash and nitrogen management" was conducted during the *rabi* season of 2018-19 at Research Farm of Guru Kashi University, Talwandi Sabo, Bathinda (Punjab). The trail was laid out in split plot design with two fly ash levels *viz.*, control (F_0), 10 t ha^{-1} (F_{10}) in main plot and five levels of nitrogen *viz.*, control (N_0), 90 kg N ha^{-1} (N_{90}), 120 kg N ha^{-1}(N_{120}), 150 kg N ha^{-1} (N_{150}) and 180 kg N ha^{-1} (N_{180}) in sub plot. Use of fly ash and nitrogen showed the significant impact on growth and yield attributes of wheat. Fly ash application 10 t ha^{-1} with nitrogen 180 kg ha^{-1} proved to be significant over rest of the treatments as it registered maximum growth expect N 150 kg ha^{-1}. Highest plant height, number of tillers, leaf area index, dry matter accumulation, straw yield and biological yield were found in fly ash @ 10 t ha^{-1} and 180 kg N ha^{-1}. Number of effective tillers, ear length, number of grains ear^{-1} and grain yield was found highest in fly ash @ 10 t ha^{-1} and 180 kg N ha^{-1} which was at par with Fly ash application fly ash @ 10 t ha^{-1} and 150 kg N ha^{-1}. Thus it can be concluded that fly ash application 10 t ha^{-1} and nitrogen 150 kg ha^{-1} more effective.

Introduction

Wheat (*Triticum aestivum* L.) is the most important food crop of the world. It is the major food of millions of people of our country. It is the second cereal crop after rice which is widely grown all over the India. China is leading wheat producing country followed by India and Russia. India's share in global wheat production was 15.4% in 2017-18. In India, wheat is cultivated on area of 29.08 million ha with a production level of 102.19 million tonnes and productivity of 3408 kg ha^{-1}(Anonymous 2019). Wheat is the major cereal crop of Punjab. It is grown on 34.80 lakh ha during 2017-18 with the production of 163.60 thousand tonnes and average yield of 4700 kg ha^{-1} (Anonymous 2019).

Nitrogen is often the most deficient of all the plant nutrients. Wheat crop is very responsive to nitrogen fertilization. The major role of the nitrogen in the plants is its existence in the structure of proteins, the most important building substances of the protoplasm of every cell. In addition, nitrogen is also present in chlorophyll, the green pigment present in the leaves, Chlorophyll helps the plant to convert energy and sunlight with the help of photosynthesis. Thus, the nitrogen affects the amount of protein, protoplasm and chlorophyll. Therefore, this influences cell size, leaf area and photosynthetic activity of the plant.

Fly ash is a by-product of thermal power plants and considered as environmental pollutant and hazardous to human health but, if proper management is done in agriculture sector it helps in improving soil properties as well as crop yield. Utilization of fly ash in agriculture as a soil amendments and fertilizer improve the soil properties *viz.*, structure, texture and bulk density and plant growth. Fly ash provides some essential elements i.e. K, Ca, Mg, S, Co, Fe, Zn, Mn, P and B etc. in minor quantities, which are beneficial for plant growth and development. The addition of fly ash improved the germination, tillering, plant height, biological and grain yield of wheat.

Materials and Methods

The present investigation entitled "Enhancing the performance of wheat (*Triticum aestivum* L.) through fly ash and nitrogen management" was conducted at Guru Kashi University, Talwandi Sabo (Bathinda). Talwandi Sabo is located at latitude of 29^{0}59' N and longitude of 75^{0}05' E with an altitude of 213 m above the sea level. The experimental site belongs to sub-tropical semi-arid climate having extreme winters and summers. The average temperature was 19-28^{0} C at the crop growth stages which was optimum for crop growth and development. The average annual rainfall is about 500-700 mm, most of which received during the monsoon period from July to September. However, a few showers received during winter season also. The temperature and rainfall both were found to be optimum for wheat crop.

The soil was slightly alkaline (pH 7.92) with normal electrical conductivity (0.32 dSm^{-1}). The soil was medium in organic carbon content (0.69%). The available nitrogen (238.8 kg ha^{-1}) was low, whereas the available phosphorus (16.4 kg ha^{-1}) and available potassium (214.7 kg/ha) were both medium. The experiment was laid out in split plot design with three replications. The treatments comprised of two level of fly ash (0, and 10 t ha^{-1}) and five levels of nitrogen (no nitrogen, 90, 120, 150 and 180 kg ha^{-1}).

The height of five randomly selected plants was measured at maturity. Total number of tillers was counted per metre of row length. Tillers bearing ears were counted and recorded as effective tillers. The observations were taken differently from every five randomly selected plants from each plot. The number of grains per ear counted from the best ears of the selected plants. Dry matter accumulation was recorded from each plot. The plant biomass harvested from individual plots was first sun dried and constant weight was obtained. Leaf area index (LAI) was recorded at 120 days after sowing (DAS). Five plants were selected randomly from each plot and the area of each leaf blade was calculated using the following formula (Gomek, 1972).The samples of 1000-grains were drawn from each plot after cleaning mean value was worked out after recording their weight. The weight of total production from the net plot was recorded after harvest with help of electronic balance. The weight of the grain per net plot was record in kilogram after threshing of the produce. Later on it was converted into grain yield (kg ha^{-1}). The straw yield was worked out from the weight of total biomass and expressed as kg ha^{-1}. The biological yield was calculated by the addition of grain yield and straw yield. Harvest index (HI) was calculated by using following formula;

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Fisher's ANOVA technique and least significant difference (LSD) test at 5% probability level was used to compare differences among treatment means (Steel *et al.*, 1997).

Results and Discussion

Growth parameters of wheat

The maximum plant height (101.1 cm) was observed at 10 t fly ash ha^{-1} and lowest plant height (98.6 cm) was observed at control (Table 1). The lowest plant height (94.5 cm) was observed at control (no nitrogen) and maximum plant height (103.3 cm) was observed 180 kg N ha^{-1}. Mattas *et al.,* (2011) observed that each increment in nitrogen levels up to 180 kg ha^{-1} significantly increased the plant height. Lowest plant height (94.0 cm) was observed at control and maximum plant height (105.1 cm) was observed with 10 t fly ash ha^{-1} + 180 kg N ha^{-1} treatment.

Higher number of tillers per metre of row length (179.5) was observed with 10 t fly ash ha^{-1} and lowest number of tillers (162.2) was observed at control (Table 1). Highest number of tillers (201.8) was observed with the 180 kg N ha^{-1} (201.8) and lowest number of tillers (142.2) were observed at control. Mattas *et al.,*.(2011), Waraich *et al.,*.(2012) observed that there was significant increase in the total number of tillers with increase in nitrogen levels up to 180 kg ha^{-1}. The maximum number of tillers (215.3) observed with 10 t fly ash ha^{-1} + 180 kg N ha^{-1} and lowest number of tillers were recorded at control (138). Total number of tillers of wheat with 10 t fly ash ha^{-1} was statistically at par with control 90 and 120 kg N ha^{-1}.

Leaf area of wheat crop showed a significant increase with the increase in the level of fly ash 10 t FA ha^{-1} recorded the maximum leaf area (2.9) and lowest leaf area index (2.6) was observed at control (Table 1).

The highest leaf area index (3.0) was observed with 180 kg N ha^{-1} and lowest leaf area index (2.5) was observed at control (no nitrogen). Waraich *et al.,*(2012) concluded that leaf area index of wheat increases with increase in nitrogen levels up to 180 kg ha^{-1}.

Mattee and Thakare (1995), Deshmukh (2000) concluded that application @10 t ha^{-1} is alone or incorporation of fly ash with the recommended dose of fertilizers was found useful in improving dry matter production of wheat (Table 1 & Fig. 1).

The highest dry matter (41.2 q ha^{-1}) was observed with 10 t fly ash ha^{-1} and lowest dry matter (37.3 q ha^{-1}) was observed at control. The highest dry matter (44.3 q ha^{-1}) was observed with 180 kg N ha^{-1} and lowest dry matter production (34.2 q ha^{-1}) was observed at control (no nitrogen). Mattas *et al.,* (2011) revealed that dry matter accumulation increased with increase in the nitrogen levels up to 180 kg ha^{-1}.The highest dry matter (46.5 q ha^{-1}) was recorded at 10 t fly ash ha^{-1} + 180 kg N ha^{-1} and lowest dry matter (32.1 q ha^{-1}) was observed at control.

Yield attributes of wheat

The highest number of effective tillers per metre row length was recorded with 10 t fly ash ha^{-1} (172.4) and lowest number of tillers was observed at control (152.3) (Table 2). Nitrogen also showed as significant increase in the effective number of tillers with the increase in the application rates of nitrogen. Lowest number of effective tillers (133) was observed at control (no nitrogen). Highest number of tillers (193.8) was observed at 180 kg N ha^{-1} which was at par to 150 kg N ha^{-1}.Interaction effect of fly ash and nitrogen showed a significant increase in the effective number of tillers in wheat. Interaction showed the lowest number of effective tillers (125) at control and highest number of effective tillers (202.3) with fly ash 10 t ha^{-1} and 180 kg N ha^{-1} which was at par to 10 t fly ash ha^{-1} + 150 kg N ha^{-1}.

Ear length increases with the fly ash application (Table 2). The maximum ear length (16.9 cm) was observed with (10 t fly ash ha^{-1}) and smallest ear length (15.4 cm) was observed with control (no fly ash).

The nitrogen showed significant influence on the ear length of wheat. The longest ear length (17.5 cm) was observed with 180 kg N ha^{-1} which was at par to 150 kg N ha^{-1} and smallest ear length (14.6 cm) was observed under control (no nitrogen). The interaction effect of fly ash incorporation and nitrogen also showed a significant increase in the ear length. The longest ear length (18.6 cm) was observed with 10 t fly ash ha^{-1} + 180 kg N ha^{-1} which was at par with 10 t fly ash ha^{-1} and 150 kg N ha^{-1} and smallest ear length (14.1 cm) was observed at control

Fly ash incorporation showed a significant result on test weight of wheat (Table 2). The 10 t fly ash ha^{-1} showed highest (40.8 g) of test weight which was higher than control (40.3 g).There was significant increase in the test weight of wheat with increasing the different levels of nitrogen application. The highest test weight (41.7 g) was observed with 180 kg N ha^{-1} which was at par with 150 kg N ha^{-1} and lowest test weight (39.6 g) was observed at control (no nitrogen). Interaction effect of fly ash and nitrogen showed non-significant effect on the test weight of wheat crop.

The fly ash incorporation showed significant increase in the number of grains ear^{-1} (Table 2 & Fig. 2). The highest number of grains ear^{-1} (63.9) was recorded at 10 t fly ash ha^{-1} and lowest number of grains ear^{-1} (50.3) was recorded in control (no fly ash).The nitrogen application showed a significant increase in the number of grains per ear with the increase in the levels of nitrogen.

The highest number of grains ear^{-1} (67.1) was recorded at 180 kg N ha^{-1} which was at par with 150 kg N ha^{-1} and lowest number of grains ear^{-1} (44.1) was recorded at control (no nitrogen). The interaction effect of fly ash incorporation and nitrogen application also showed a significant increase on the number of grains ear^{-1}. Highest number of grains (76.2) were recorded at 10 t fly ash ha^{-1} + 180 kg N ha^{-1} which was at par with 10 t fly ash ha^{-1} + 150 kg N $ha^{-1}$and lowest number of grains (40.2) were recorded at control (Fig. 3).

Productivity of wheat

The fly ash incorporation showed an increase in grain yield of wheat (Table 3). The highest grain yield (4347 kg ha^{-1}) was observed at 10 t fly ash ha^{-1} and lowest grain yield (4009 kg ha^{-1}) was at control. Agarwal *et al.,* (2009), Deshmukh and Matti (2000), Mattee and Thakare (1995) observed that fly ash 10 t ha^{-1} resulted in significantly higher grain yield with fly ash over control. The nitrogen application showed a significant increase in the grain yield of wheat.

Table.1 Effect of different levels of fly ash and nitrogen on growth parameters of wheat

Treatment	Plant height (cm)	Number of tillers m^{-1} row length	Dry matter accumulation (q ha^{-1})	Leaf area index
Fly ash levels (t ha^{-1})				
0	98.6	162.2	37.3	2.6
10	101.1	179.5	41.2	2.9
LSD (P=0.05)	2.3	14.1	1.0	0.1
Nitrogen levels (kg ha^{-1})				
Control	94.5	142.3	34.2	2.5
90	97.7	154.8	36.0	2.6
120	101.6	170.2	39.1	2.7
150	102.5	185.2	42.7	2.8
180	103.3	215.3	44.3	3.0
LSD (P=0.05)	0.9	11.3	1.4	0.1
Interaction	1.0	10.8	1.8	NS

Table.2 Effect of different levels of fly ash and nitrogen on yield attributes of wheat

Treatment	No. of effective tillers m^{-1} row length	Ear length (cm)	No. of grains ear^{-1}	Test weight (g)
Fly ash levels (t ha^{-1})				
0	152.3	15.4	50.3	40.3
10	172.4	16.9	63.9	40.8
LSD (P=0.05)	19.6	0.3	0.8	0.4
Nitrogen levels (kg ha^{-1})				
Control	133.0	14.6	44.1	39.6
90	148.2	15.9	50.8	40.0
120	160.8	16.0	57.3	40.3
150	180.3	17.2	66.0	41.1
180	193.8	17.5	67.1	41.7
LSD (P=0.05)	18.8	0.4	1.3	0.6
Interaction	26.1	0.5	1.6	NS

Table.3 Effect of different levels of fly ash and nitrogen level on productivity of wheat

Treatment	Grain yield (q/ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
Fly ash levels (t ha^{-1})				
0	4009	5305	93.1	42.3
10	4347	6182	105.3	41.7
LSD (P=0.05)	156.1	21.3	3.2	0.8
Nitrogen levels (kg ha^{-1})				
Control	3365	4148	75.1	44.8
90	3829	5029	88.6	40.9
120	4357	5706	100.6	43.3
150	4588	6546	111.4	41.3
180	4750	7289	120.6	39.6
LSD (P=0.05)	245	80	2.1	0.9
Interaction	291	113	3.9	1.1

Fig.1 Effect of different levels of fly ash and nitrogen on leaf area index of wheat

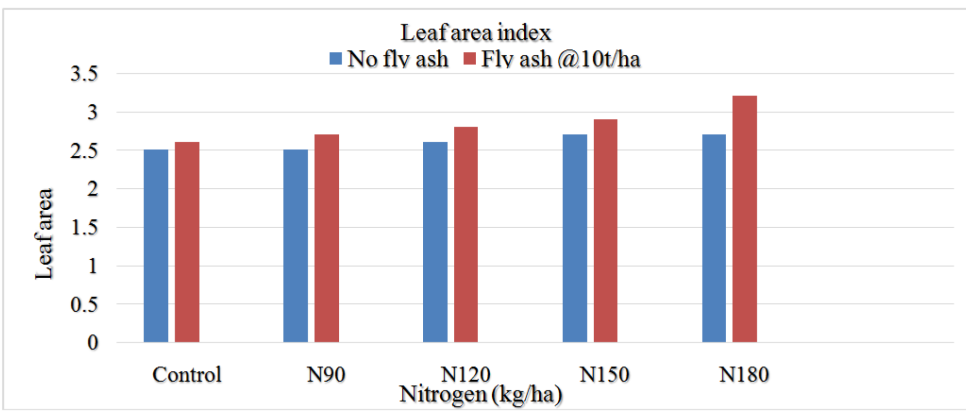


Fig.2 Effect of different levels of fly ash and nitrogen on test weight of wheat

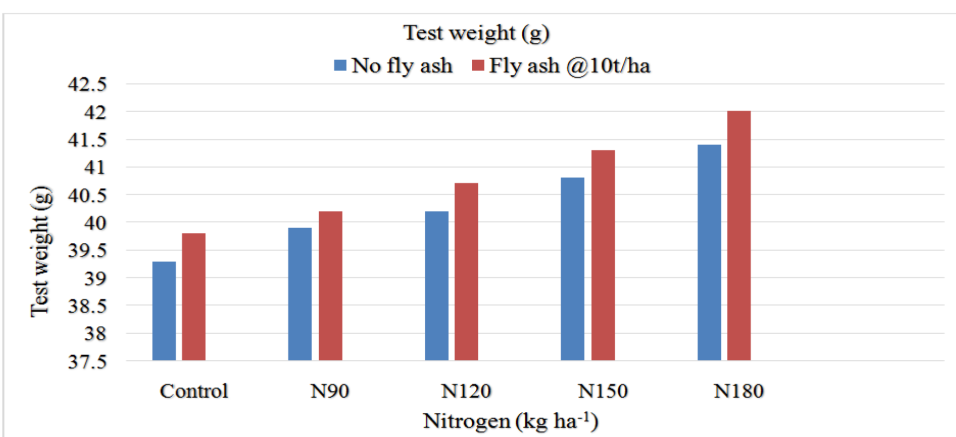
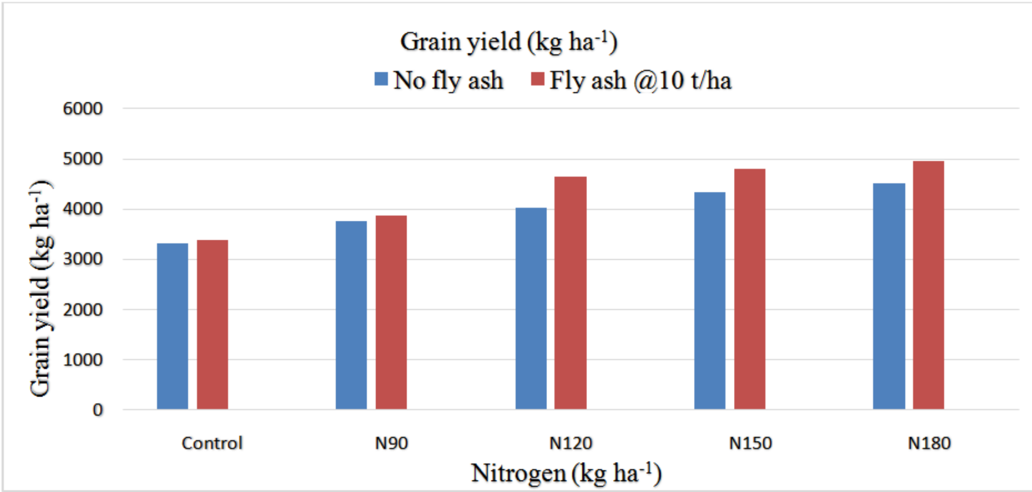


Fig.3 Effect of different levels of fly ash and nitrogen level on productivity of wheat



The highest grain yield (4750 kg ha^{-1}) was observed with 180 kg N ha^{-1} which was significantly better than 0, 90and 120 but was at par with 150 kg N ha^{-1} and lowest yield (3365 kg ha^{-1}) was observed at control. Hussain *et al.*, (2006) revealed that highest grain yield was observed at 150 kg N ha^{-1}.The interaction effect of fly ash and nitrogen application also increased the grain yield with the increase in levels of fly ash and nitrogen. Application of fly ash did not influence the grain yield of wheat at control and 90 kg N ha^{-1}treatments but significantly better yield with fly ash at 90, 120and 180levels. The highest grain yield (4967 kg ha^{-1}) was observed with10 t fly ash ha^{-1} + 180 kg N ha^{-1}which was at par with 10 t fly ash ha^{-1} + 150 kg N ha^{-1} and lowest grain yield (3340 kg ha^{-1}) was observed at control crop.

The fly ash incorporation increased the straw yield of wheat (Table 3). The highest straw yield (6182 kg ha^{-1}) was observed with 10 t fly ash $ha^{-1}$and lowest straw yield (5305 kg ha^{-1}) was observed at control.

Matte and Thakare (1995) revealed that highest straw yield of wheat was observed at fly ash 10 t ha^{-1}.The nitrogen application increased the straw yield of wheat crop. The highest straw yield (7289 kg ha^{-1}) was observed with 180 kg N ha^{-1} and lowest straw yield (4148 kg ha^{-1}) was observed at control (no nitrogen). Jakhar *et al.*, (2005), Mattas *et al.*, (2011) concluded that highest straw yield of wheat observed at 180 kg N ha^{-1}.The interaction effect of fly ash incorporation and nitrogen application showed a significant increase in straw yield of wheat crop. The highest straw yield (8178 kg ha^{-1}) was observed with 10 t fly ash ha^{-1} + 180 kg N ha^{-1} and lowest straw yield (4106 kg ha^{-1}) was observed at control.

Biological yield is the summation of grain yield and straw yield (Table 3). Therefore, increase in grain and straw yield resulted in increase in the biological yield of wheat. The highest biological yield (105.3 q ha^{-1}) was observed at 10 t fly ash ha^{-1} and lowest biological yield (93.1 q ha^{-1}) was observed and control. The biological yield of wheat crop increased with increases the level of nitrogen application.

The highest biological yield (120.6 q ha^{-1}) was observed at 180 kg N ha $^{-1}$ and lowest biological yield (75.1 q ha^{-1}) was observed at control. The interaction effect of fly ash and nitrogen application increased biological yield with increasing levels. The highest biological yield (131.4 q ha^{-1}) was observed with 10 t fly ash + 180 kg N ha^{-1} and lowest straw yield (74.4 q ha^{-1}) was observed at control.

The effect of fly ash incorporation showed no improvement in harvest index of wheat (Table 3). The data revealed that the highest harvest index (42.3%) is at control and lowest harvest index (41.7%) with 10 t fly ash ha^{-1}.The nitrogen application showed no improvement on the harvest index of wheat crop.

Highest harvest index (44.8%) was obtained with (control) and lowest harvest index (39.6%) was obtained with 180 kg N ha^{-1}.

The interaction effect of fly ash incorporation and nitrogen application showed no improvement on harvest index that highest harvest index (44.9%) was recorded at control and lowest harvest index (39.6%) is at 10 t fly ash ha^{-1} + 180 kg N ha^{-1}.

In conclusion, Fly ash 10 t ha^{-1} and nitrogen 180 kg ha^{-1} recorded the maximum growth parameters. The yield attributes (Ear length, grains ear^{-1}, effective tillers) and grain yield of wheat was higher in 10 t fly ash ha^{-1} + 180 kg N ha^{-1} which at par with 10 t fly ash ha^{-1} + 150 kg N ha^{-1}treatment.Thus, apply 10 t fly ash + 150 kg N $ha^{-1}$to get better yield of wheat.

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How to cite this article:

Gurlal Singh and Balwinder Singh Dhillon. 2019. Enhancing the Performance of Wheat (*Triticum aestivum* L.) through Fly Ash and Nitrogen Management. *Int.J.Curr.Microbiol.App.Sci.* 8(11): 333-340. doi: https://doi.org/10.20546/ijcmas.2019.811.042