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Effect of green manuring and fly ash on the growth and grain yield of rice (*Oryza sativa* L.)

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Abstract
A field experiment was planned and carried out with entitled "Effect of soil moisture and agrochemical A field experiment entitled "Effect of green manuring and fly ash on the growth and grain yield of rice (*Oryza sativa* L.)" was conducted during *kharif* 2018 at Research Farm, Guru Kashi University, Talwandi Sabo, Bathinda (Punjab). The experiment was laid out in split plot design comprising two green manuring levels *viz.*, control (0 t/ha), and 25 t/ha incorporation in main plots and three fly ash doses *viz.*, control (0 t/ha), 10 and 20 t/ha in sub plot plots. It is clearly concluded that there is a good scope of increasing crop yields through the use of green manuring and fly ash. It is extremely important for sustaining production and improving the fertility of soils. Green manuring significantly increased the plant growth *viz.*, plant height, dry matter and number of tillers/plant and yield attributing characters *viz.*, number of grains/panicle and test weight and seed cotton yield, straw yield and harvest index in rice. Incorporation of green manuring @ 25 t/ha recorded 8.70% more grain yield than control. Fly ash @ 10 t ha^{-1} and 20 t ha^{-1} resulted in the statistically similar plant growth, yield attributes and grain yield in rice. Fly ash @ 10 t ha^{-1} and 20 t ha^{-1} recorded 9.40 and 6.75%, respectively higher grain yield than control.

Keywords: Fly ash, grain yield, green manuring, rice, straw yield and test weight

Introduction
Rice (*Oryza sativa* L.) is one of the most important staple food grain crop of India as well as Asia. Rice is good supplement for nutritional requirement of human body and contains 6-7-per cent protein and 70-75 per cent carbohydrates. India stands in second position next to china in the world with regard to production of rice. In India Rice is grown on 44 m ha with total production of 112 million tonnes with average productivity of 2540 kg ha^{-1}. Punjab is not only a leading wheat producer, but also among the highest rice producing states in India. Rice is an important crop in Punjab and grown for Basmati, the best quality of rice known for its great taste and aroma is grown widely in Punjab. Punjab accounts for about 10% of total rice production in the country. The production of rice was 11.38 million tonnes harvested from 2.84 million ha (Anonymous 2019) [2].

Nutrient is most important input for crop production after water, application of inorganic fertilizers give quick response and provide nutrient to plant immediately continuous use of these inorganic fertilizers alone have increased the crop yield but cause many environment problems including soil, air and water pollution and human health hazards. It also caused depleted soil organic matter results into inherent loss of native soil available P and available K (Mehta *et al.* 2007) [4]. Moreover in low land rice ecosystem, the nitrogen use efficiency 25-35 per cent of applied nitrogen because of nitrogen is rapidly lost by ammonia volatilization and dentirification.

Crops are grown for the purpose of restoring or improving the organic matter content, soil properties and N-content in the soil are called green manure crops and their use in cropping system is called green manuring. Green manure crops are belonging to family Febaceae, are wonderful gift of nature to mankind. The inclusion of green manures before sowing of rice significantly improve the yield of rice by providing the essential nutrients to the soil. Among the green manure crops, *Sesbania rostrata* produced the highest grain yield of transplanting aman rice compared to other green manure crops. The *Sesbania rostrata* may be add about 60-80 kg N ha^{-1} in soil and also improve the physical, chemical, and biological conditions of soil (Pramanik *et al.* 2004) [7]. It increased the activity of heterotrophic bacteria, fungi in soil, responsible for conversion of unavailable form of nutrient to available from and mitigates the micro nutrient deficiencies.

It is a quick- growing succulent green manure crops. It adapts itself of varying conditions of soil and climate. It can be grown even under adverse conditions of drought, water logging and salinity etc.

Bacterial nodules are formed in plenty on the roots and plants have a soft stem which can be decomposed easily. Besides nitrogen, green manure contain sufficient amount of other essential elements for better performance of crop plants.

Fly ash is a coal combustion residue generated from thermal power plants during burning of coal. It is the finely dispersed solid waste consisting of partially or completely burnt or un-burnt particles of carbon. When coal is burnt to generate heat, the residue contains fly ash and bottom ash in about 80% and 20% respectively. Fly ash, the organic and the inorganic residues from the combustion of powdered coal is waste material produced in large quantity has already recognized as a potential sources for increasing the availability of mineral nutrients for plant growth, presences of essential plant nutrients such as macronutrients and micronutrients make it a source of plant nutrients and increases yield of several crops after application.

Physically fly ash occurs as very fine particles, having an average diameter of <10 mm, low to medium bulk density, high surface area and very light texture.

Chemically the composition of fly ash varies depending on the quality of coal has used and operating conditions of thermal power stations. Approximately, on an average 95 to 99 percent of fly ash consists of oxides of Si, Al, Fe and Ca and about 0.5 to 3.5 per cent consists of Na, P, K and S and the remainder of the ash composed of trace elements In combination with various organic manure, fly ash can enhance soil microbial activities, nutrient availability and plant productivity. Finding local outlets for sufficient quantities of fly ash often create problem of disposal. One of the ways of effective utilization of fly ash could be used as a soil amendment and as a source of plant nutrients. Hence the present investigation was undertaken to explore the feasibility of using fly ash as component of Integrated Plant Nutrient System for sustaining soil productivity and crop. There is need to adopt other sources of nutrient for achieving the objectives of environmentally and economically sustainable agriculture.

Materials and Methods

The field experiment study entitled, "Effect of green manuring and fly ash on the growth and yield of rice (*Oryza sativa* L.)" was conducted at research farm of Guru Kashi University, Talwandi Sabo (Bathinda) during kharif season 2018. The farm is located at 29º 33' N latitude and 75º 38' E longitude with an altitude of 252 meters above the mean sea level as per are extreme. The mean weekly maximum and minimum temperatures during the crop season ranged from 27.2 to 39.7 ºC and 11.5 to 26.1ºC, respectively. A maximum of 39.7ºC and minimum of 11.5ºC were recorded during months of May and November, respectively. The field experiment was conducted at experimental area of agriculture research farm of Guru Kashi University, Talwandi Sabo (Bathinda) during Kharif 2018.The monsoon generally starts in the first week of July. The total rainfall received during the crop season was 339.4 mm. The maximum mean weekly rainfall of 147.4 mm was observed during month of July. A maximum of 6.0 number of rainy days were recorded during months of June and July The trail was laid out in split plot design with two Green manuring levels *viz*., control (0 t/ha) and Green manuring (25 t/ha) in main plot and three Fly ash levels *viz*.,control, 10 and 20 t/ha in sub plot.

The collected data were statistically analyzed by using Fisher's ANOVA technique and Critical difference (CD) test at 5% probability level was used to compare differences among treatment.

Results and Discussion

Growth parameters of rice

The maximum plant height (101.1 cm) was recorded with green manuring (25 t/ha) as compare to control which was significantly higher than control (Table 1). Application of fly ash resulted in increased plant height. The maximum plant height (101.2 cm) was recorded with 20 t/ha of fly ash application which was significantly higher as compared to other fly ash levels. Similar results were also reported by Saraswat and Chaudhry (2014) [10].

Table 1: Effect of green manuring and fly ash levels on growth attributing characters of rice.

Treatment	Plant height (cm)	Number of tillers/plant	Dry matter accumulation (q/ha)
Green manuring			
Control	96.1	12.20	104.1
Green manuring (25 t/ha)	101.1	15.23	109.1
LSD (P=0.05%)	1.2	1.81	1.0
Fly ash levels (t/ha)			
0	95.2	11.93	103.2
10	99.4	14.10	107.4
20	101.2	15.20	109.2
LSD (P=0.05%)	1.3	1.00	1.3

Similarly, green manuring showed significant effect on other growth parameters of plant (Table 1). The maximum number of tillers/plant (15.23) was recorded with green manuring (25 t/ha) as compare to control (0 t/ha green manuring). The maximum number of tillers/plant (15.20) was recorded with 20 t/ha of fly ash application which was significantly higher than the other fly ash levels. Similar, results were also recorded by Kumar *et al.* (2011) [3] and Padhey *et al.* (2016) [5].

The maximum dry matter accumulation (109.1 g) was recorded with green manuring (25 t/ha) as compare to control (0 t/ha green manuring). The maximum dry matter accumulation (109.2 g) was recorded with the fly ash application of 20 t/ha which was significantly higher than the other fly ash levels. Similar, results were recorded by Ravi *et al.* (2007) [9].

Yield attributes of rice

The green manuring showed significant effect on various yield attributes of rice (Table 2). The increase in number of effective tillers/plant (14.28) was recorded with green manuring (25 t/ha) as compare to control (0 t/ha green manuring) which was significantly higher than the control. Panicle length (25.16 cm) attained with green manuring (25 t/ha) was highest and significantly higher than control. Number of grains/panicle (215.1) recorded with green manure (25t/ha) recorded the higher number of grains per panicle (215.1), being significantly higher than G_0 (control).However,

test weight was non-significant. Similarly, the fly ash application significantly increased the yield attributing parameters and fly ash application of 20 t/ha resulted in significantly higher number of effective tillers/plant (13.80), panicle length (25.38 cm), number of grains/panicle (218.0) and test weight (28.02 g) as compare to the other fly ash levels. Similar, results were also reported by the Sharma and Das (1994) [11], Padhey *et al.* (2016) [5], Ramesh and Rathika (2017) [8], and Anitha and Mathew (2010) [1].

Table 2: Effect of green manuring and fly ash levels on yield attributing characters of rice

Treatment	Number of effective tillers/plant	Panical length (cm)	Number of grains/panicle	Test weight (g)
Green manuring				
Control	11.30	23.02	206.4	27.40
Green manuring (25 t/ha)	14.28	25.16	215.1	27.38
LSD (P=0.05%)	1.54	0.57	7.7	NS
Fly ash levels (t/ha)				
0	10.98	22.62	203.0	26.78
10	13.57	24.27	211.3	27.37
20	13.80	25.38	218.0	28.02
LSD (P=0.05%)	0.95	0.49	4.9	0.45

Productivity of rice

The G_1 (green manure 25 t/ha) recorded the highest grain yield (71.09 q/ha), being significantly higher than G_0 (control). The minimum grain yield (65.40 q/ha) was recorded from G_0 (control) as in Table 3. In case of fly ash, significantly higher grain yield (70.85q/ha) was recorded at 20t/ha of fly ash application, which was significantly higher than control (0 t/ha) but at par with 10t/ha fly ash application. The percent increase in grain yield with incorporation of green manuring @ 25 t/ha recorded 8.70% and 10 t/ha and 20 t/ha of fly ash application was 9.40 and 6.75% over control. The interaction effect between green manuring and fly ash levels was The highest grain yield (74.1 q/ha) obtained in interaction G_1F_2 (Green manure 25 t/ha and fly ash 20 t/ha) which significantly higher over all the treatment but at par with G_1F_1.The lowest grain yield (63.24 q/ha) recorded in interaction G_0F_0 (control).

Table 3: Effect of green manuring and different fly ash levels on productivity of rice.

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
Green manuring				
Control	65.40	87.48	152.76	42.81
Green manuring (25 t/ha)	71.09	95.14	162.72	43.90
LSD (P=0.05%)	1.05	2.22	2.69	0.2
Fly ash levels (t/ha)				
0	64.76	86.00	149.83	43.21
10	69.13	91.92	158.47	43.50
20	70.85	96.00	164.00	43.35
LSD (P=0.05%)	1.88	2.27	2.85	0.1

Similar, trend was observed in straw yield, biological yield and harvest index (Table 3). The straw yield (95.14 q/ha), biological yield (162.72 q/ha) and harvest index (43.90%) was significantly increased with application of 25t/ha green manuring. Application of fly ash resulted in higher straw yield and biological yield. The maximum straw yield (96.00 q/ha) and biological yield (164.00 q/ha) was recorded with 20 t/ha of fly ash application. However, the maximum harvest index (43.50%) was recorded with 10 t/ha of fly ash application but at par with 20 t/ha of fly ash application. There was significant interaction between sowing dates and mulching levels on stover yield, biological yield and harvest index. Similar, results was reported by Kumar *et al.* (2011) [3] and Prakash *et al.* (2014) [6], In conclusion, It is clearly concluded that there is a good scope of increasing crop yields through the green manuring. It is extremely important for sustaining production and improving the fertility of soils. Green manuring significantly increased the plant growth *viz.*, plant height, dry matter and number of tillers/plant and yield attributing characters *viz.*, number of grains/panicle and test weight and seed cotton yield, straw yield and harvest index in rice. Incorporation of green manuring @ 25 t/ha recorded 8.70% more grain yield than control. Fly ash @ 10 t ha^{-1} and 20 t ha^{-1} resulted in the statistically similar plant growth, yield attributes and grain yield in rice. Fly ash @ 10 t ha^{-1} and 20 t ha^{-1} recorded 9.40 and 6.75%, respectively higher grain yield than control. These findings can be useful for improving the production of rice in south-west Punjab.

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