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Effect of Organic Manure and Inorganic Fertilizer on the Quality of Eggplant Cultivars

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Abstract
Eggplant being a long summer vegetable crop, needs a continuous amount of nutrients for the production of higher yield and quality. Therefore, a field experiment was undertaken to study the qualitative attributes of eggplant cultivars as affected by organic manure and inorganic fertilization. A Randomized Complete Block Design (RCBD) with split plot arrangement was adopted having eight treatments and replicated thrice. Organic manure (Farm Yard Manure, Poultry Manure, Spent Mushroom Compost at 25:5:10 tons ha^{-1}) and Inorganic fertilizers (NPK at 100:50:50 kg ha^{-1}) were subjected to the main plots while cultivars (Namli-F1, Black Boy-F1, BSS-513 and Meiyinqienquan) were assigned to the subplots. Obtained results revealed that the quality of all the cultivars were significantly ($p \leq 0.05$) affected by the growing regimes. Cultivar Namli-F1 produced early fruiting, maximum yield $plot^{-1}$, fruit firmness and percent titratable acidity. Highest fruit length and pH were observed in cultivar Black boy F1. BSS-513 had maximum fruit length. While cultivar Meiyinqienquan had maximum days to 50 % fruiting, fruit diameter and volume. Between the growing condition, early fruiting, maximum fruit length, diameter, volume and yield $plot^{-1}$ were detected in plants grown under organic regime. No significant differences were observed in fruit firmness, pH and percent titratable acidity of eggplant fruits under fertilization regimes. Present studies concluded that cultivar Namli-F1 and Meiyinqienquan produced better quality under the organic fertilization, but to reduce cost of production Namli-F1 is recommended to grow.
Keywords: Eggplant cultivars, growing conditions, fruit firmness, pH, percent titratable acidity, Quality.

1. INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the most important herb among vegetable crops belongs to Solanaceae family; usually have a semi-spreading habit. There is a wide variation in the fruit shape and color among the various varieties of eggplant. Eggplant is thought to be originated from India (Kashyap *et al.*, 2014) considerably most popular and commercially important crop of Asia (Sihachkr *et al*.,1993). In Pakistan, eggplant is grown over 9044 hectares area with the estimated production of about 91126 tones (MINFAL, 2013). Fruits of eggplant are supplemented with sufficient amount of starches, proteins, minerals, vitamins, dietary fibers and low-fat content (Zenia and Halina, 2008) high phenolic compounds (Cao *et al*. 1996). Fruits are mainly used for cooking and pickling which aids in digestion, lowering high blood pressure, prevents constipation while its green leaves are the good aphrodisiac, laxative and effective tonic for liver problems (Kashyap *et al.*, 2014). Eggplant is a summer vegetable crop which grows throughout the year under the optimum temperature of 22-30ºC, while at 17°C its growth is inhibited (Adamczewska-Sowinska and Krygier, 2013). Its performance is successful on well drained and wide range of soil types having 5.5-6.5 pH (Abbas *et al*., 2011). Fertility of the soil declines with soil erosion, insufficient fertilizer inputs, leaching, continuous cropping and nutrients losses during harvest. Therefore, application of both artificial and natural fertilizers in appropriate amount, proportion, at correct time and available form are required for the optimum production of eggplant due to their positive impact on the phyto-nutritional attributes of a crop (Dumas *et al.*, 2003). Appropriate amount of inorganic fertilizers containing Nitrogen, Phosphorus and Potassium are necessary for the plants vegetative and reproductive growth (Rao and Subramanian, 1994). Inadequate proportion of agro-chemicals including synthetic fertilizer adversely affected plants physiological process (Cooke, 1972) whereas excess of which have some negative impacts on human health, secondly chemical fertilizers are cost effective therefore eco-friendly agriculture products should be used which are reliable and easily assessable. Many investigators (Kashyap *et al*., 2014; Moraditochaee *et al*., 2011; Suge *et al*., 2011) have studied the effect of organic and inorganic fertilizers on the vegetative growth, yield and quality of eggplant. Organic farming strictly excludes the use of inorganic fertilizers and growth regulators and largely depends on natural resources. Organic manures play a direct role in soil fertility, microbial population, improves plant growth by providing micro and macro nutrients in available form, which eventually increased productivity (Shahein *et al*., 2015). Concerning the organic manure, many researchers have found that addition of organic manure had a positive impact on the growth, quantitative and qualitative attributes of eggplant (Agbo *et al*., 2012; Sarhan *et al*., 2011; Christo *et al*., 2011). Vegetables are consumed both fresh and cooked; in order to avoid them from the residual effects of chemical fertilizers. Organic nutrition should be preferred for improving food quality and provide health security to the people. Organic manures like FYM, Poultry manure and spent mushroom compost improve growth, yield and quality of eggplant (Rehman *et al*, 2015). In light of the

above facts, a thorough study was therefore carried out in the field with the objective to evaluate the qualitative attributes of eggplant cultivars under both the organic and inorganic regime.

2. MATERIALS AND METHODS

Field experiment was held at the Ornamental Horticulture Nursery, The University of Agriculture, Peshawar, during the long rainy season of 2015.

2.1 Experimental design

Experiment was arranged in Randomized Complete Block Design (RCBD) with split-plots arrangement which was replicated thrice and each was assigned with eight treatments. Eight experimental plots (each having area of 3×4 m^2) were made for the farming of eggplant cultivars.

2.2 Application of treatments

Eight treatments were presumed, viz; **r**egimes (Organic regimes (O) = Farm yard manure (25 tons ha^{-1}) + Poultry manure (5 tons ha^{-1}) + spent mushroom compost (10 tons ha^{-1}) and Inorganic regimes (I) = NPK (100:50:50 kg ha^{-1}) incorporated in main plots while cultivars (Namli-F1, Black Boy-F1, BSS-513 and Meiyinqienquan) were grown in Subplots.

2.3 Seedlings raising and transplantation

Seedlings of four different eggplant cultivars were raised in pots containing leaf molds and garden soil which were irrigated frequently till germination. Seedlings after attaining a height of 15 cm were transplanted into the well-prepared field beds after 40 days with plant and row spacing of 50cm and 75cm, respectively. All the agronomic practices were retained throughout the experiment.

2.4 Analysis of Soil and organic materials

Table a and b shows properties of experimental soil and organic materials, tested in the Soil Science Laboratory, Department of Soil & Environmental Sciences at The University of Agriculture, Peshawar.

Table a: Physico-chemical properties of soil at the experimental site before transplantation

Depth	15-30 cm	Soil texture	Silty loam
Clay (%)	9.60	EC (ms cm^{-1})	0.16
Silt (%)	73.2	O.M (%)	0.21
Sand (%)	17.2	Total N (%)	0.32
Ph	7.65	P (mg kg^{-1})	2.80
Lime (%)	9.26	K+ (mg kg^{-1})	950

Table b: Nutrients composition of used manures, under organic regime.

Organic regime	**N%**	**P_2O_5%**	**K_2O%**
Farm yard manure	0.66	0.32	0.93
Poultry manure	0.62	0.31	0.83
Spent mushroom compost	0.47	0.23	0.85

2.5 Measurement of crop variables

On the following variables data were recorded by selecting five plants randomly from each subplot and their average was calculated.

Days to fruiting were calculated from the transplantation date to the fifty percent fruiting in every tagged plant. Fruit length was measured without pedicel with a help of measuring (Hasan, 2012). Fruit diameter was measured by using Vernier caliper, according to Waseem *et al*. (2013).

Fruit volume was determined by water displacement method (Bozokalfa and Kilic, 2010). Fruits samples were dipped separately in graduated cylinder with known volume, noted as initial reading. The amount of water displaced after dipping of fruit were collected in a beaker and then reading from the cylinder were noted as final reading.

Fruit volume (ml) = Initial reading --- final reading

Fruit yield per plot of eggplant was calculated from average fruit weight per plot and their mean was calculated (Kashyap *et al*., 2014). Fruit yield $plot^{-1}$ (kg) was calculated by using the following formula;

$$\text{Fruit yield plot}^{-1}\text{ (kg)} = \frac{Production\ per\ plot}{Area\ per\ plot}$$

Hand Penetrometer (Effigi, 8mm probe) was used to record fruit firmness. Eggplant fruit was held in hand firmly. A small section of fruit was peeled with a razor to expose the flesh of the fruit. Penetrometer was reset to zero held in one hand between forefinger and thumb, pressed gradually into the peeled portion. The probe was penetrated gradually with increasing force and readings from the dial were noted as the probe notch touched fruit flesh (Pocharski *et al*., 2000).

Data pertaining to fruit pH was observed by using electronic pH meter (Model no INOLAB, pH-720) which was standardized with Buffer solution before determination. pH meter electrode was dipped into the juice of eggplant fruit for a while (2-3 mins). Readings of five fruits samples collected from each treatment were noted after the digital dial stopped at one-digit value on the meter screen and mean was recorded (Jan *et al*., 2012). Total titratable acidity (%) was determined by titration with a standard solution of NaOH as described by (Kandoliya *et al*., 2015). **Procedure:** Fruit sample was first blended to extract juice, filtered in a beaker, 10 ml from which was taken and poured in another beaker which was then filled with distal water upto the mark of 100 ml. 10 ml from this 10% juice sample was taken in a beaker, 1-2 drops phenolphthalein indicator were added and titrated it against 0.1 N solution of NaOH which was taken in the burrete. After titration, a light pink color was appeared in the juice sample which was the end point of the reaction. Burrete readings were noted and titratable acidity in percent was calculated by using the following formula;

$$\text{Percent titratable acidity (\%)} = \frac{N \times T \times F \times 1_0}{D \times S} \times 100$$

Where, N = Normality of NaOH
T = ml of 0.1 N NaOH used
F = constant acid factor 10.0064
D = ml of sample taken of eggplant juice
S = ml of diluted sample taken for titration

2.6 Statistical Analysis

Data regarding qualitative variables of eggplant was subjected to ANOVA to find out significant variation among eggplant cultivars, fertilizers regimes and their interactions. Experiment was run in Randomized complete block design with split plot arrangements and replicated thrice. Eggplant fruit samples were taken for laboratory analysis as they were laid-out in the field into the laboratory and analyzed as such. Statistical software Statistix-8 was used for data analysis while the means of the treatments were compared by applying LSD test at $p \leq 0.05$ (Ali *et al*., 2014).

3. RESULTS AND DISSCUSIONS

3.1 Days to 50 % fruiting

Days to 50 % fruiting of eggplant cultivars is given in table 1. Its statistical analysis showed that there was a significant variation found in both regimes and among cultivars at ($p \leq 0.05$), however their interaction was non-significant. Maximum days to 50 % fruiting (46.00) were recorded for all the cultivars grown under inorganic regime, while minimum days to 50 % fruiting (44.65) were taken by the cultivars grown under organic growing regime (Table 1).

Table (1) also showed significant variations among all the studied cultivars of eggplant. Cultivar Meiyinqienquan took maximum days to 50 % fruiting (49.08), followed by BSS-513 (45.71) which was statistically identical with cultivar Black boy-F1 (45.54), while cultivar Namli-F1 took minimum (40.96) days to 50 % fruiting. Early fruit setting by cultivar Namli-F1 might be due to minimum number of days to 50 % flowering, or its efficient utilization of the available resources due to its adoptability with the local environment. Whereas the increase in the number of days to 50 % fruiting under the inorganic regime could be the increased amount of nitrogen that delayed flowering in eggplant which significantly increased number of days to fruit setting (Sat and Saimbhi, 2003). Similarly, Rahman *et al*. (2015) also stated that early fruit setting in eggplant under the organic regime could have been the availability of increased microbial action which promotes soil P, N and also increased the uptake of N by plant, leading to enhance chlorophyll and carbohydrate synthesis that fasten the fruit development process. Moreover, Shashidhara, (2000) in eggplant and Sutagundi, (2000) in chilli also observed early fruit setting under the organic condition.

3.2 Fruit length plant^{-1} (cm)

Fruit length plant^{-1} of eggplant cultivars is depicted in Table no 1. The Statistical analysis for fruit length clearly revealed that there was significant variation in both regimes and also among cultivars at ($p \leq 0.05$), however their interaction was non-significant. Maximum fruit length (24.87cm) was recorded in all the cultivars grown under organic regime, while minimum fruit length (23.00cm) was noted under inorganic regime (Table 1). Significant variations observed among the studied cultivars of eggplant showed that Black boy-F1 have maximum fruit length (27.58cm) which was statistically identical with cultivar BSS-513 (26.79cm), while least response was

observed in cultivar Namli-F1and Meiyinqienquan with 21.09cm and 20.29cm fruit length accordingly which were statistically alike. Increase in the fruit length of cultivar Black boy-F1and BSS-513 might be due to their genetic makeup or more nutrient uptake. The increment in fruit length under organic condition by all the cultivars may be due to more nutrients availability that helped in improving optimum vegetative growth that resulted in production of more photosynthates, more cell elongation and thus increased length of fruits. Results of present investigation are in analogy with Ullah *et al.* (2008) who reported that the increase in fruit length of eggplant could be due to combined application of organic manures. Moraditochaee *et al*. (2011) found that the use of vermicompost significantly amplified fruit length by supplementation of optimum nutrients that helped in improving growth and yield attributes of eggplant. Federico *et al*. (2007) in tomato and Sarhan *et al.* (2008) in potato also recorded the same reports.

3.3 Fruit diameter (cm)

The Statistical analysis of fruit diameter in table 1 clearly revealed that there was significant variation in both regimes and among cultivars at ($p \leq 0.05$), however their interaction was non-significant. A similar trend of results was also obtained in fruit diameter (cm) as was recorded in fruit length (cm). Maximum fruit diameter (4.18cm) was recorded for all the cultivars grown under organic regime, while minimum fruit diameter (4.06cm) was noted under inorganic growing regime. Similarly, among all the studied cultivars of eggplant, Meiyinqienquan have maximum fruit diameter (6.89 cm), followed by cultivar Black boy-F1 (3.70 cm) which was statistically alike with cultivar BSS-513 (3.31cm), while least response (2.58 cm) fruit diameter was observed in cultivar Namli-F1(table 1). Increased fruit diameter of cultivar Meiyinqienquan might be due to its maximum fruit volume, fruit weight or its genetic makeup. While the maximum fruit diameter recorded for cultivars grown under organic regime could possibly be the profound effect of organic manure on the eggplant fruit growth and development. The data obtained by Ghasem *et al*. (2014) regarding fruit diameter in cucumber is supported by the recent result who studied the effect of organic fertilizers on cucumber yield. Present results are also in conformity with the early findings of Ullah *et al*, (2008) who reported a positive impact of the combined form of organic fertilization on the fruit diameter of brinjal. Similarly, Suge *et al*. (2011) found a significant effect on the fruit diameter of eggplant under the organic condition.

3.4 Fruit volume (ml)

Fruit volume of eggplant was significantly ($p \leq 0.05$) influenced by the combined effect of different cultivars and growing conditions, however their interaction was non-significant. Maximum fruit volume (285.14 ml) was recorded for all the cultivars grown under organic regime, while minimum fruit volume (277.06 ml) was noted under inorganic growing regime (Table 1). Fruit volume varied significantly among the different cultivars of eggplant. Meiyinqienquan have maximum fruit volume (556.35 ml), followed by cultivar BSS-513 and Black boy-F1with 239.03 ml and 188.73 ml, respectively. while minimum fruit volume was recorded in cultivar Namli-F1and with 140.29 ml. Highest fruit volume found in cultivar Meiyinqienquan might have been due to its maximum diameter and fruit weight or more nutrients uptake. Similarly, the increased in the fruit volume under the organic regime could be the fact that organic manure is a rich source of both micro and some secondary nutrients (S, Mg, Fe, Cu) and is an important substitute for chemical fertilizers in term of nutrients availability, thus plants receiving more nutrients would have fruits with increased volume (Delate and Camberdella, 2004). Our results also resemble with the previous finding of Waseem et *al*. (2013) who reported that application of poultry manure + FYM resulted in increased volume in brinjal fruit. Results of previous investigators such as (Aujla *et al*., 2007; Aminifard *et al*., 2010) are in good accordance with the data obtained here who reported that higher rates of nutrients increased fruit volume in eggplant.

3.5 Yield plot^{-1} (kg)

The statistical analysis of yield plot^{-1} of eggplant showed highly significant differences ($p \leq 0.05$) among cultivars, growing conditions as well as in their interaction (table 2). The interaction (fig 01) between cultivars and growing regimes both organic and inorganic stated that under organic regime highest fruit yield plot^{-1} (8.51 kg) was observed in cultivar Namli-F1, whereas minimum fruit yield plot^{-1} was observed in Meiyinqienquan (5.39 kg) under inorganic regime. Highest fruit yield plot^{-1} found in cultivar Namli-F1 might have been due to more number of fruits per plant or could be its better compatibility with the existence environment. Whereas, the reason for highest yield obtained under organic regime condition by various cultivars could be attributed to better biological and physical properties of the organic manure resulting in improved supply of nutrients to the plants (Ekwu and Nwokwu, 2012). This result is supported by the early observations of Devi *et al*. (2002) in eggplant, Jablonska (1990) and Hosmani (1993) in tomato, chilli and pepper who reported that the combined form of organic manure resulted in highest yield. Moreover, Ojeniyi *et al*. (2007) also quoted that crop residues when amended with poultry manure increased fruit yield in tomato.

3.6 Fruit firmness (kg cm^{-2})

Data about mean values of fruit firmness for both the factors i.e. regimes (organic, inorganic) and different cultivars are indicated in Table-2. Mean values stated that there was a highly significant variation among various cultivars of eggplant, while a non-significant variation for regimes and interaction at $p \leq 0.05$. Maximum fruit firmness (kg cm^{-2}) was recorded for Namli-F1 (2.09 kg cm^{-2}), followed by Black boy-F1 (1.38 kg cm^{-2}), while minimum was recorded for cultivar BSS-513(0.88 kg cm^{-2}) and Meiyinqienquan (0.74 kg cm^{-2}) which were not significantly different from each other. The variation in firmness of different eggplant cultivars is attributed to the differences in their pectin composition. This trend is comparable with the results of previous researchers (Billy *et al*., 2008; Jan *et al*., 2013) in apple. Maximum fruit firmness of cultivar Namli-F1 might be due to the low surface area of the fruit, slow rate of respiration and evapo-transpiration that ultimately reduce losses of water and solutes (Ghafir *et al*., 2009) or it could be depended on the genotype of the cultivar. Comparable results of the present study were also found by Shahein *et al*. (2015) who reported that fruit firmness of bell pepper was not significantly affected by various organic fertilizers treatments.

3.7 Fruit pH

Mean Data on fruit pH in relation to the effect of regimes on eggplant cultivars is indicated in Table-2. The analysis of variance table of the data pertaining fruit pH showed that different cultivars had a highly significant effect on fruit pH, while non-significant differences were recorded for regimes and their interaction ($p \leq 0.05$). Keeping in view the mean data for cultivars a significant variation was recorded, highest fruit pH value (5.87) was noted in cultivar Black boy-F1, followed by cultivar BSS-513 and Meiyinqienquan with pH of 5.77 and 5.55, while lowest fruit pH value was observed in cultivar Namli-F1 (5.47). Maximum pH of the fruits of cultivar Black boy-F1 could be due to its low percent acidity and also a considerable range of genetic diversity in the composition of the eggplant fruits among its cultivars (Hanson *et al*., 2006). Findings of Raigo *et al*. (2010) are also similar with the results of current study who found significant differences in the fruit pH among eggplant cultivars. Whereas, fruit pH of eggplant did not show significant variations under the fertilizer treatment, which suggests that the Nitrogen translocation ability of the plants and qualitative attributes of fruits were not influenced by the fertilizer type (Leogrande *et al*., 2014).

3.8 Percent titratable acidity (%)

Once again, a similar trend of result (table 2) was obtained for percent titratable acidity (TA) as was recorded in fruit pH of eggplant cultivars depicted in table 2. There was only significant variation in percent titratable acidity among the fruits of different cultivars of eggplant at ($p \leq 0.05$). The highly significant result showed differences among all the cultivars of eggplant. Namli-F1 contained highest percent titratable acidity with the value 1.07 % that may be due to its low fruit pH, or high fruit firmness, followed by BSS-513 (0.78 %), Black boy F1 and Meiyinqienquan with 0.66 and 0.61 % titratable acidity accordingly which were statistically alike. The changes in the TA among various cultivars is due to differences in their metabolic rates (respiration), taking more organic acid and decline acidity (Rivera, 2005; Jan *et al*., 2012). Moreover, Kandoliya *et al*., 2015 also studied significant differences in titratable acidity among various eggplant varieties. Whereas, TA of eggplant fruits were non-significant under the fertilizer treatment, which suggests that the Nitrogen translocation ability of the plants and qualitative attributes of fruits were not influenced by the fertilizer type (Leogrande *et al*., 2014).

4. CONCLUSION

The qualitative variables of the present study are purely depended on the cultivars of eggplant. The analysis of principal components of the eggplant illustrated that its variability was influenced more by cultivar differences than by growing regimes. Cultivar Namli-F1 produced maximum yield $plot^{-1}$, fruit firmness, percent titratable acidity and early fruiting. Meiyinqienquan recorded maximum fruit diameter and volume while highest fruit length and pH were observed in Black boy F1. Under organic condition, early fruiting, maximum fruit length, diameter, volume and yield $plot^{-1}$ were detected. Therefore, Namli-F1 followed by Meiyinqienquan should be cultivated under organic condition, due to its superiority for better quality over other cultivars. But to reduce production cost Namli-F1 is recommended.

Table 1:- Days to 50% fruiting, Fruit length, Fruit diameter and Fruit volume of eggplant cultivars under organic and inorganic regime.

Characters	Days to 50% fruiting	Fruit length(cm)	Fruit diameter(cm)	Fruit volume(ml)
Treatments		**Cultivars(C)**		
Namli-F1	40.96 c	21.09 b	2.58 c	140.29 d
Black boy-F1	45.54 b	27.58 a	3.70 b	188.73 c
BSS-513	45.71 b	26.79 a	3.31 b	239.03 b
Meiyinqienquan	49.08 a	20.29 b	6.89 a	556.35 a
LSD	1.86	1.69	0.44	36.98
		Regimes(R)		
Organic	44.65	24.87	4.18	285.14
Inorganic	46	23	4.06	277.06
		Interaction		
C×R	NS	NS	NS	NS
LSD	NS	NS	NS	NS

Table 2:- Fruit yield plot^{-1}, Fruit firmness (kg cm^{-1}), Fruit pH and Titratable acidity (%) of eggplant cultivars under organic and inorganic regime.

Characters	Yield plot^{-1} (kg)	Fruit firmness (kg cm^{-2})	Fruit pH	Titratable acidity (%)
Treatments		**Cultivars(C)**		
Namli-F1	22.05 a	2.09 a	5.47 d	1.07 a
Black boy-F1	19.41 b	1.38 b	5.87 a	0.66 b
BSS-513	18.16 bc	0.88 c	5.77 b	0.78 b
Meiyinqienquan	17.62 c	0.74 c	5.55 c	0.61 b
LSD	1.93	0.27	0.05	0.26
		Regimes(R)		
Organic	21.22	1.25	5.67	0.77
Inorganic	17.41	1.29	5.65	0.79
		Interaction		
C×R	**	NS	NS	NS
LSD	2.44	NS	NS	NS

Mean values followed by different letters are not significantly the same at ($p \leq 0.05$) according to LSD test. NS: Non-significant, ** highly significant.

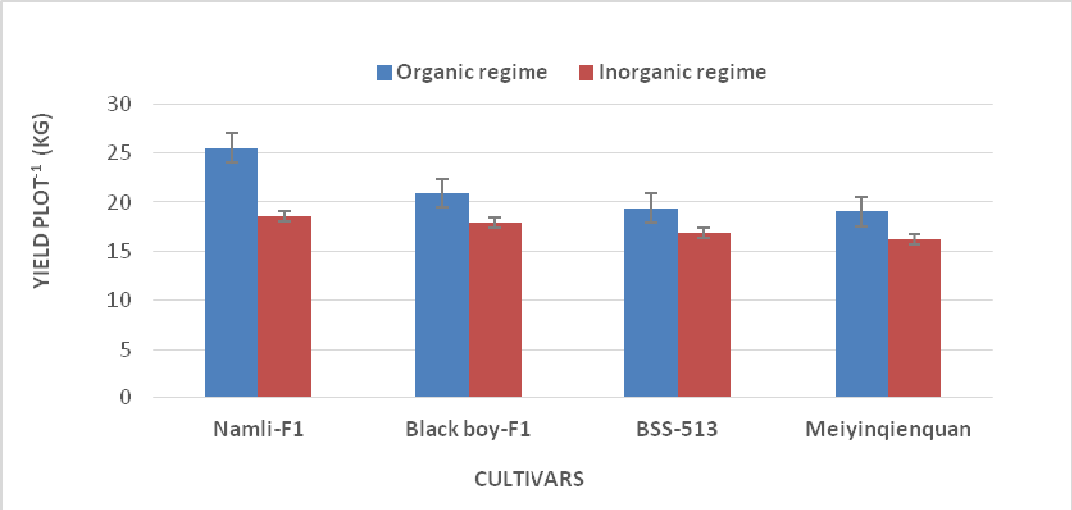

Figure 01: Interaction effect of cultivars and regimes on yield plot^{-1}.

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