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Effect of Integrated Nutrient Management on Green Pod Yield of Chilli (*Capsicum annuum L.*) *cv* MIPC-01

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Abstract

A field experiment was conducted to study the effect of combined application of organic manures with recommended inorganic fertilizers (RIF) and to find out the best combination of applications on green pod yield of chilli *cv.* MIPC-01 (Mahailluppallama Kaludawali Selection). The following five treatment combinations *viz.* T_1- No fertilizer (control plot), T_2- 100% RIF, T_3- 50% RIF + 15 t ha^{-1} cattle manure, T_4- 50% RIF + 15 t ha^{-1} cattle manure + 250 kg ha^{-1} partially burnt paddy husk, T_5- 50% RIF + 15 t ha^{-1} cattle manure + 500 kg ha^{-1} partially burnt paddy husk were laid out in a Randomised Completely Block Design and replicated four times. The measurements related to growth and yield parameters were taken using destructive random sampling method. The results revealed that among the tested fertilizer combinations, there were significant differences ($p<0.05$) in plant height, root length, number of flowers, average numbers of pod per plant and pod length compared to the control treatment. The application of 50% RIF, 15 t ha^{-1} cattle manure along with 500 kg ha^{-1} partially burnt paddy husk produced higher number of pods per plant (10.50 and 24.50) and average pod weight per plant (40.42 g cm and 90.16 g) over the control treatment at 120 and 150 DAT (days after transplanting) respectively. It is concluded that application of 50% RIF with 15 t ha^{-1} cattle manure and 500 kg ha^{-1} partially burnt paddy husk is the best combination to obtain higher green pod yield of chilli.

Key words: Cattle manure, chilli, green pod yield, inorganic fertilizer, partially burnt paddy husk

Introduction

During the past few decades, intensive farming has been practiced to increase crop yield per unit area. Excessive amounts of inorganic fertilizers are generally applied to vegetable crops to obtain higher yield. Continuous cultivation of soil using inorganic fertilizers has been implicated in reduction of soil organic carbon and organic matter, nutrient imbalance, deficiency of secondary macronutrients and micronutrients [Osundare, 2004]. Therefore, the use of organic manures is beneficial to the soil in terms of alleviating soil acidity, enhancement of soil physical properties and nutrient status [Ano & Agwu, 2005]. Conversely, the application of organic manures only cannot fulfil the requirement of crop nutrients. Integrated nutrient management incorporates the use of various sources of plant nutrients. Productivity and nutrient status of crop product increases efficiently without sacrificing soil productivity of future generations [Javaria & Khan, 2010].

Chilli (*Capsicum annuum* L.) is one of the important cash and condiment crop widely grown in Sri Lanka for dry chilli production and also a part of the chilli crop is harvested as green pods. The average extent under green chilli was around 8,218 ha and the annual production of chilli in Sri Lanka was 50,717 Mt in 2015/2016 *Maha* season [Department of Census and Statistics, 2016]. Currently in Sri Lanka, chilli production is generally depending on the inorganic fertilizer however chilli production using organic manures is also timely required due to the problems associated with inorganic fertilizer [Dahanayake *et al.*, 2012]. Appropriate quantities of the available organic and inorganic sources should be integrated to develop the best combination of the both fertilizers for accomplishing quantity and quality in chilli [Rani *et al.*, 2015].

It is therefore necessary to obtain locally available, cheap and environmentally good materials that can be applied with integration for chilli production. Cattle manure is commonly used organic manure for crop cultivation and it consists of macronutrients mainly nitrogen (N) 20.7%, potassium (K) 0.15% and phosphorus (P) 0.42% [Omogoye, 2015] with other micronutrients that can be utilized by the chilli plants to overcome nutrition deficiencies. Partially burnt paddy husk has the ameliorative properties due to high content of potassium and additional nutrients which have immense potential for amending soil while those with relatively higher carbon content [Milla, 2013]. Biochar produced from rice husk is very porous in its structure, non-hazardous and having a large internal surface area [Ahiduzzaman & Islam, 2016]. Hence, an investigation was undertaken to study the effect of combined application of cattle manure and partially burnt paddy husk with inorganic fertilizers on growth and green pod yield

Table 1: Mean root length of chilli plants grown under different fertilizer combinations.

Treatments	Root length (cm)		
	At 30 DAT	At 60 DAT	At 90 DAT
T_1	6.23d	8.38c	8.93c
T_2	7.13cd	8.83c	12.98b
T_3	8.05bc	10.43b	14.35ab
T_4	9.48ab	11.68a	15.80a
T_5	9.58a	12.25a	15.70a
F test	$P < 0.01$	$P < 0.01$	$P < 0.01$

The data represents means of four replicates.
Mean values in a same column having the similar letter/letters indicate not significant differences at 1% level of significance by DMRT. T_1- No fertilizer (Control plot), T_2- 100% Inorganic fertilizers, T_3- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}), T_4- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (250 kg ha^{-1}), T_5- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (500 kg ha^{-1}).

of chilli.

Methods

Location and experimental details

The experiment was carried out at In-Service Training Institute, Karadiyanaru, Sri Lanka, in the *maha* season 2015 - 2016. The soil type of this site is reddish brown earth. The chilli (*Capsicum annuum* L.) cv. MIPC was used in this experiment. The plot size was 180 x 180 cm. Seedlings were arranged at a spacing of 45 cm 30 cm (one plant / hill). This experiment was carried out using a Randomized Completely Block Design and replicated four times. The treatment combinations are given below.

Treatments

T_1- No fertilizer (control plot) T_2- 100% inorganic fertilizers (As recommended by the Department of Agriculture, Sri Lanka) T_3- 50% inorganic fertilizers + cattle manure (15 t ha $^{-1}$) T_4- 50% inorganic fertilizers + cattle manure (15 t ha $^{-1}$) + partially burnt paddy husk (250 kg ha $^{-1}$) T_5- 50% inorganic fertilizers + cattle manure (15 t ha $^{-1}$) + partially burnt paddy husk (500 kg ha $^{-1}$)

Agronomic practices and Statistical analysis

All the agronomic practices except to fertilizer applications were done as recommended by the Department of Agriculture, Sri Lanka. Growth and yield measurements of plant height, root length, average number of flowers, average pod length, number of pods per plant and average pod weight per plant were taken using destructive random sampling method. Collected data were analysed using SAS 9.1 portable version (SAS Institute Inc. Cary, NC, USA) and the treatment means were compared by using Duncan's Multiple Range Test (DMRT) at 1% and 5% significant levels.

Table 2: Number of flowers produced per chilli plants grown under different fertilizer combinations at 85 and 120 DAT.

Treatments	Number of flowers	
	At 85 days	At 120 days
T_1	1.75c	5.50b
T_2	3.75bc	6.50b
T_3	7.25a	8.75ab
T_4	5.25ab	10.25ab
T_5	7.50a	12.75a
F test	$P < 0.01$	$P < 0.05$

The data represents means of four replicates.
Mean values in a same column having the similar letter/letters indicate not significant differences at 5% level of significance by DMRT. T_1- No fertilizer (Control plot), T_2- 100% Inorganic fertilizers, T_3- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}), T_4- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (250 kg ha^{-1}), T_5- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (500 kg ha^{-1}).

Results and Discussion

Plant Height

It was observed that the combined application of organic and inorganic fertilizers had a significant influence on the vegetative growth of the chilli crop. The results

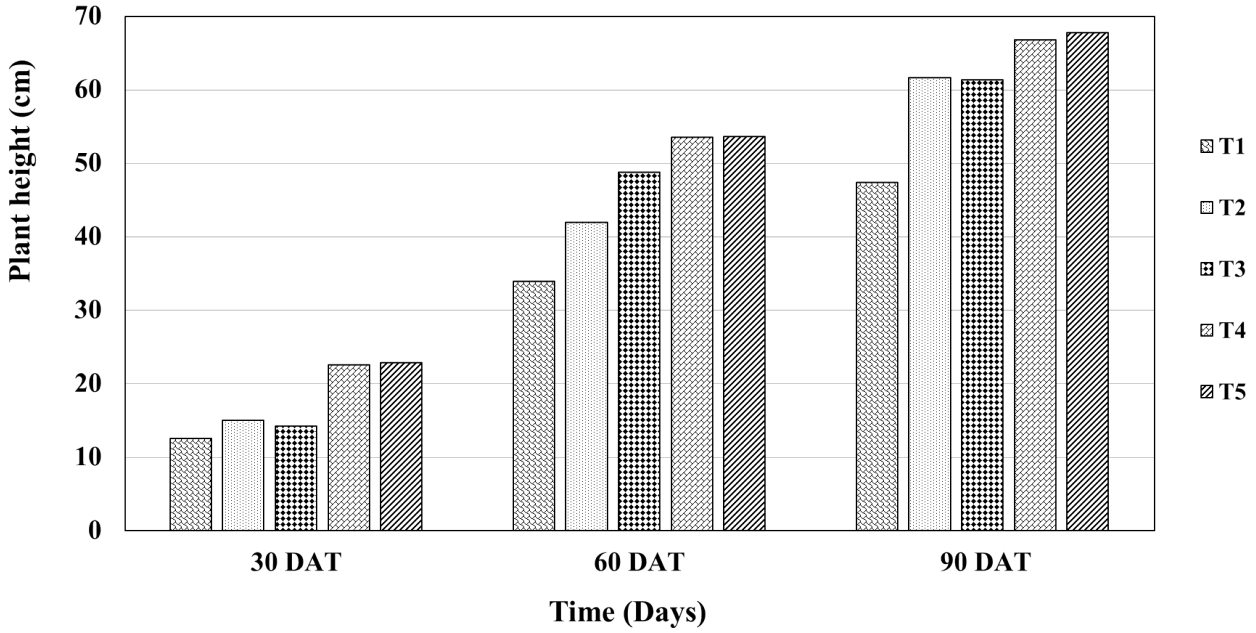

Figure 1: Effect of inorganic and organic manures on plant height of chilli at 30, 60 and 90 DAT.
T_1- No fertilizer (Control plot), T_2- 100% Inorganic fertilizers, T_3- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}), T_4- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (250 kg ha^{-1}), T_5- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (500 kg ha^{-1}).

revealed that the lowest plant height of 12.58 cm and highest height of 67.73 cm were observed in T_1- No fertilizer (Control plot)] and T_5- 50% RIF + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (500 kg ha^{-1}) at 30 and 90 DAT respectively as shown in Figure 1. These results indicated that the mixing cattle manure and partially burnt paddy husk had significantly ($p<0.05$) increased the plant height during growth period.

Nitrogen is an important element required for successful plant growth [Liu, 2014]. Optimum nitrogen must be added either in organic or inorganic forms for better growth and development of chilli plants. The nitrogen uptake by plants can be increased by increasing concentration of different types of nitrogen fertilizers. Organic manures activate many species of living microorganisms which may stimulate the plant growth and absorption of nutrients [Arisha *et al.*, 2003] and such organisms require nitrogen for their multiplication [Ouda & Mahadeen, 2008].

On the other hand, the application of organic manure alone could not increase the vegetative and reproductive growth of chili plants as they release nutrients at a slower rate. According to the literature survey, application of inorganic fertilizer alone is also less effective than the combined application of organic and inorganic fertilizers. These might be the reasons for highest plant height observed in this combination at 90 DAT. The result was in conformity with the finding of [Jose *et al.*, 1988] in the integrated use of urea and poultry manure resulted in a higher nutrient uptake and plant growth. This finding is also in accordance with [Ullah *et al.*, 2008] who also observed increased plant height when use the inorganic fertilizers combined with cattle manure and poultry manure.

Average Root Length

Root length is an important crop parameter as it is a dynamic structure for water and nutrient uptake for plant growth. The average root length of chilli plants was significantly ($p<0.01$) influenced by the different fertilizer combinations used in the present experiment as indicated in Table 1. The result showed that the lowest root length (6.23 cm) was recorded from plant grown in T_1 (control plot) and the highest value (9.58 cm) was obtained in T_5 at 30 DAT. The reasons for the results obtained may be that the combined application supplies the macro and micro nutrients continuously. At 60 DAT, the lowest average root length of 8.38 cm and highest length of 12.25 cm were observed in T_1 and T_5 treatments respectively. However, the highest mean root length of plants which were grown in T_5 was not significantly differed ($p<0.01$) with T_4 where the average root length of 11.68 cm was recorded.

At the 90 DAT, maximum mean root length of 15.80 cm was recorded in T_4, followed by 15.70 cm in T_5 and 14.35 cm in T_3 while minimum root length of 8.93 cm was recorded in chilli cultivated without using any fertilizers. The observations agree with findings reported by [Iyamuremye & Dick, 1996] who stated that organic materials can enhance phosphorous availability, improve

Table 3: Average pod length and number of pods per chilli plants grown under different fertilizer combinations at 120 and 150 DAT.

Treatments	Average pod length		Number of green pods per plant	
	120 DAT	150 DAT	120 DAT	150 DAT
T_1	2.30d	2.35d	0.50c	6.25d
T_2	2.97cd	2.85c	3.50b	15.25c
T_3	3.60bc	3.43b	10.75a	19.00b
T_4	3.90ab	4.30a	8.25a	23.50b
T_5	4.53a	4.73a	10.50a	24.50a
F test	$P < 0.01$	$P < 0.01$	$P < 0.01$	$P < 0.01$

The data represents means of four replicates.

Mean values in a same column having the similar letter/letters indicate not significant differences at 5% level of significance by DMRT. T_1- No fertilizer (Control plot), T_2- 100% Inorganic fertilizers, T_3- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}), T_4- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (250 kg ha^{-1}), T_5- 50% Inorganic fertilizers + cattle manure (15 t ha^{-1}) + partially burnt paddy husk (500 kg ha^{-1}).

phosphorous recovery or result in better utilization by plants. Organic materials add carbon source into the soil that provides substrate for microbial growth and their subsequent activity. Decomposed organic materials improves the nutrient cycling and nutrient availability to the plants especially nitrogen and phosphorous which boost root development and subsequently vegetative growth of plants. Our finding is further supported by [Rahman *et al.*, 2012] who found that applications of biocompost, cow dung compost with NPK fertilizers significantly enhanced the number of roots and the length of the roots of chilli plants.

Average Number of Flowers

The numbers of flowers produced per chilli plants were increased at different growth periods after transplanting. From the data, it showed that there were significant differences observed in numbers of flowers at 85 and 120 DAT as shown in Table 2. The number of flowers per plant was significantly ($p<0.05$) influenced by different combination of the fertilizers (Table 2). Plants grown without added any forms of fertilizers (T_1) produced minimum number of flowers among the all treatments while the maximum number (7.5) was recorded in T_5 at 85 DAT. The levels of inorganic and organic fertilizer incorporation had significant effect on number of flowers per plant. Production of minimum number of flowers per plant might be due to inadequate supply of essential macro and micro nutrients for their growth and flower production.

The number of flowers produced per chilli plants were increased at 120 days growth period than that at 85 days. The minimum number of flowers (5.50) per plant was produced by treatment T_1 while the maximum number of flowers (12.75) per plant was noted in T_5. In both growth periods, the lowest value was obtained in T_1 (control plot). It might be due to inadequate supply of essential macro and micro nutrients for flower production. On the other hand, application of inorganic fertilizer alone may affect the soil health, which in turn may affect flower production. Therefore, the combined application of cowdung, partially burnt paddy husk and inorganic fertilizers may supply the macro and micro nutrients timely for flowering and their growth in chilli. The finding is supported by [Ullah *et al.*, 2008], who noted the highest flower formation per plant in eggplant when applied cow dung with inorganic sources of nutrients.

Average Pod Length

Average pod length was significantly ($p<0.01$) influenced by amalgamation of the fertilizers at 120 and 150 DAT (Table 3). Plants grown without any fertilizer (T_1) showed minimum pod length of 2.30 cm while the maximum length (4.53) was recorded in T_5 at 120 DAT. Minimum and maximum pod length of 2.35 cm and 4.73 cm was noted in T_1 and T_5 respectively at 150 DAT. It might be due to adequate supply of available macro and micro nutrients from cattle manure and partially burnt paddy husk for the pod formation and their development. Our findings are accordance with [Appireddy *et al.*, 2008] where the number of fruits per plant and fruit yield was significantly higher under integrated nutrient management compared with organic nutrient supply in chilli. Similar experimental results were also stated with [Singh & Kumar, 1999], who reported that highest fruit setting percentage and number of fruits per plant of chilli was found, when the fertilizer was applied both from organic and inorganic sources.

Table 4: Average green pod weight per chilli plant grown under different fertilizer combinations at 120 and 150 DAT.

Treatments	Average pod weight per plant at	
	At120 days	At 150 days
T_1	0.88d	13.13d
T_2	8.75c	39.65c
T_3	29.56b	54.72bc
T_4	25.57b	76.37b
T_5	40.42a	90.16a
F test	$P < 0.01$	$P < 0.01$

The data represents means of four replicates.
Mean values in a same column having the similar letter/letters indicate not significant differences at 5% level of significance by DMRT. T_1- No fertilizer (Control plot), T_2- 100% Chemical fertilizer, T_3- 50%chemical fertilizer + cow dung (15t/ha), T_4- 50%chemical fertilizer + cow dung (15 t/ha) + partially burnt paddy husk (250 kg ha^{-1}), T_5- 50%chemical fertilizer + cow dung (15t/ha) + partially burnt paddy husk (500 kg ha^{-1}).

Number of pods per plant

The average number of pods per plant is an important yield component to achieve high green chill yield. The average numbers of pods per chilli plants that were grown in different inorganic and organic fertilizer combinations were increased at 150 DAT than those at 120 DAT. It seemed that pod formation in chilli plants were positively influenced by sources of nutrients applied in this experiment. The maximum number of pods per plant (10.75) was recorded in T_3, in which 50% of inorganic fertilizer and 15 t ha $^{-1}$ cattle manure were added. However, it did not show any significant different ($p>0.01$) with T_5 where the average numbers of 10.5 pods per plants were observed at 120 DAT. This results in conformity with [Kendaragama, 1999] who observed similar results in response of tomato and chilli to application of organic materials.

Green pod weight per plant

The result revealed that there were significant ($p<0.01$) differences observed in the average pod weights produced per chilli plant at 120 DAT and 150 DAT (Table 4). The minimum pod weight (0.88 g) per plant at 120 days was produced in T_1 while the maximum average pod weight per plant (40.24 g) was recorded in T_5. In both periods (120 DAT and 150 DAT), the lowest values were obtained from the control plot. This might be due to the nutrients released by the cattle manure along with partially burnt paddy husk that would have contributed for the highest pod weight per plant along with the nutrients from inorganic fertilizer.

The increase in the pod weight per plant in the partially burnt paddy husk added treatment along with cattle manure, and other inorganic fertilizers might be due to that the biochar produced from partially burnt paddy husk might improve the soil health and improve soil fertility. The combined application of organic manures and inorganic fertilizers may provide the nutrients on appropriate time and also could maintain the proper condition for flowering, fruiting and their growth. This finding is supported by [Shelke *et al.*, 1999], who found the highest fruit yield in eggplant with substituting of 60 % urea N by poultry manure. Thus, combination of organic and inorganic fertilizers could produce better yield than inorganic fertilizers alone. The present result agreed with previous findings obtained in onion [Abbey & Kanton, 2004, Gambo *et al.*, 2008] and tomato [Babajide *et al.*, 2008].

Conclusions

The results revealed that incorporation of the organic fertilizers such as cattle manure and partially burnt paddy husk with inorganic fertilizers leads to increase plant pod yield of chilli. A relatively high chilli yield was recorded in the pods added with recommended inorganic fertilizers alone as compared to control (no any fertilizer added plots) while combined application of the organic and inorganic fertilizers tested in this study increased chilli yield. The integrated application of 50% recommended inorganic fertilizers + 15t ha $^{-1}$ cattle manure along with 500kg ha $^{-1}$ partially burnt paddy husk gave the highest green pod yield of chilli. However, it is imperative to conduct further investigation for several seasons with different combinations of treatments as the effect of organic manures and partially burnt paddy husk to help in making recommendations to the farmers.

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