Proceedings of 15th Agricultural Research Symposium (2016) 249-253

Vegetative and Reproductive Characteristics of Locally Developed Chilli (*Capsicum annuum* L.) Varieties under Organic Farming System

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ABSTRACT

The indiscriminate use of agro chemicals has resulted environmental and health hazards to the humans. Therefore, it is an urgent need to develop more safer and intensive alternatives. Making agriculture organic and environment free from pollutants is one more specific and highly demanded option in current world. In organic farming techniques, crop variety, soil type, environment conditions, rate of application *etc.*, are important factors. Therefore, finding a most suitable variety may be benefited to obtain high yields in commercial cultivation. This study was carried out at Regional Agriculture Research and Development Center, Makandura, Gonawila, Sri Lanka to evaluate ten locally developed chilli varieties; MI *Waraniya*, MICH-3, MI Hybrid chilli-1, MI-2, MI Hot, MI Green, Galkiriyagama selection, MI PC-1, KA-2 and LGM under compost made using cow dung, grasses and banana stumps and under organic farming conditions to find out the best performing variety. The plant height, canopy width at 50%, 100% flowering and at 3rd harvest as the vegetative parameters and days to first flower, number of pods, pod characters and total yield were recorded as reproductive parameters. All parameters were significantly different among the varieties. According to the results obtained, the best performances were observed in MI- Hybrid, followed by Galkiriyagama Selection and KA-2 respectively. Further, this research should be continued for several years to obtain consistent results under organic farming conditions.

KEYWORDS: Chilli, Compost, Organic farming, Variety, Vegetative and reproductive

INTRODUCTION

Chilli (*Capsicum annuum* L.) is one of the important commercially grown vegetable and the largest commodity after black pepper (*Piper nigram* L.) in the international trade as a condiment. India and China are the leading chilli producers in the Asian region (Kannangara *et al.*, 2013). It is a member of the family Solanaceae rich in vitamins, minerals, and antioxidants (Pickersgill, 1997).

The per capita consumption of chilli in the form of dry chilli is estimated 2.32 kg per annum and the national annual requirement of dry chilli is around 45,000 mt. The annual production of dry chilli is about 14,108 Mt. Therefore, an amount of 46,422 mt of dry chilli is to be imported. The average extent under chilli at present is around 13,978 ha, of which 2/3 is cultivated in *maha* season. The cost of production of dry chilli under present practices exceeds 196,535 Rs/ac (Agstat, 2015).

Chilli is also one of the major cash crops grown mainly in the dry and intermediate zones of Sri Lanka (Kannangara, 2012). Chilli is cultivated under inorganic farming conditions. However, these non-harmonious and unsustainable agricultural practices have major impact on the environment, causing health hazards such as catarrh, cancer and chronic kidney disease in dry-zonal areas in Sri Lanka (Wimalawansa and Wimalawansa, 2014).

Increasing awareness of the negative effects of agro-chemical use has led consumers to seek agricultural products free of pesticides and other agro-chemicals (Chandrasekaran *et al.*, 2007). The principal elements in organic farming are creating a healthy soil, maintaining nutrient and energy flows in the soil eco systems, keeping the biological life in the cycle while providing sustainable yield. Organic manure is a more complete plant food, providing almost all essential nutrients and trace elements over synthetic fertilizers. Organic materials decompose and release their nutrients slowly, meeting the needs of the crop for a steady nutrient supply over a growing season (Chandrasekaran *et al.*, 2007). The organic agriculture industry finds itself with enormous market opportunities to supply a range of certified organic products.

Therefore, this study was undertaken to find out the best performing chilli variety under organic farming conditions, in order to recommend for organic farming.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Regional Agriculture Research and

Development Center (RARDC), Makandura, Gonawila, Sri Lanka situated in the Low Country Intermediate Zone (IL_1a), at the elevation of 25 m from mean sea level, from December 2015 to April 2016. During the period of study, the average maximum, and minimum temperature and relative humidity in the site were recorded as 35.6 °C, 20.8 °C and 80%.

Planting Materials

Seeds from ten chilli varieties, MI *Waraniya*, MICH-3, MI Hybrid Chilli-1 (MI-Hybrid), MI-2, MI Hot, MI Green, Galkiriyagama Selection (GS), MI PC-1 (PC-1), KA-2 and LGM were used for field evaluation under the organic farming system.

Some of newly released varieties; PC-1 or *Kaludawali* chilli, a kind of *Wanni Miris*, is a traditional cultivar of chilli grown in scattered small land pockets in the Eastern province in Sri Lanka. The pedigree of the cultivar is unknown (Kannangara *et al.*, 2014). Variety MI-*Waraniya* was developed at the Field Crops Research and Development Institute, Mahailluppallama from locally collected segregating population from Mathugama through Mass selection (Kannangara, 2014). Galkiriyagama selection is a selection from locally grown landrace in Galkiriyagama village in Anurdhapura District (Kannangara, 2012). MI Hybrid chilli-1 has originated from a cross between MI *Waraniya* and Galkiriyagama Selection (Herath *et al.*, 2015). LGM is a selection from variety KA-2.

Field Layout

Thirty raised beds of 7.2 m^2 (1.2×6 m) were prepared with 20 planting holes in each bed after getting the fine tilth. The spacing was maintained 60×60 cm for both between and within rows. Ten varieties were arranged in a completely randomized block design (RCBD) with three replicates.

Crop Establishment and Maintenance

Seeds from ten chilli varieties were sown in row seeding in a nursery and nursery management practices were done as recommended by the Department of Agriculture (DOA).

Thirty days after sowing, well grown, vigorous, healthy and uniform seedlings were transplanted in the field at a rate of two plants per hole for each bed. As a basal dressing, compost (produced by the RARDC, Makandura, using cow dung, grasses and banana stumps) was applied at a rate of 5 tons/ha. It was continued in two week intervals for five top dressings with same rate throughout the experimental period. Weeding, loosen the soil and earthing up were done according to DOA recommendations. Only organic pesticide ("OK"- Azadiractin) was used three times to control thrips (*Scirtothrips dorsalis*), aphids (*Aphis gossypii, Myzus persicae*) and leaf curl complex damage during the experimental period.

Data Recording

Vegetative Growth Parameters

Plant height and canopy width at 50% flowering, 100% flowering, and at the third harvest, were collected from ten randomly selected plants from each variety in each block.

Reproductive Parameters

Number of days to first flowering from the date of seed sowing, total fruit yield up to 4th pick, was recorded (four picks were harvested in all varieties, exceptionally, MI-Hybrid and GS were harvested five picks). Fruit characteristics such as stalk length, pod length and pod width were measured from ten randomly selected pods in each variety. Number of picks and number of pods in each pick were also recorded.

Disease Incidence

Leaf curl complex (LCC) and thrips attack were evaluated in two weeks interval as the percentage of affected plants over total number of plants in each plot.

Statistical Analysis

The data were statistically analyzed using Statistical Analysis System (SAS Version 9.2).

RESULTS AND DISCUSSION

Vegetative Parameters

The plant height and canopy width in all three stages (at 50% flowering, at 100% flowering, and 3rd harvest) were observed to determine the growth rate of selected chilli varieties. These characteristics were significantly different ($p<0.05$) among the tested varieties. At 50% flowering, the highest plant height was given by GS (39.34 cm; Table 1). Variety MI-2 gave the lowest height as 27.84 cm. MI-Green recorded the highest canopy width 40.94 cm while MI-*Waraniya* gave the lowest as 32.91cm. Plant height 44.65 cm was the highest in PC-1 while the lowest was 30.62 cm in MI-2 at 100% flowering stage. Canopy width of GS at this stage was recorded as the highest (45.79 cm) and MI-Green, MI-Hybrid and KA-2 also had shown higher canopy widths that they were not significant to each. Variety LGM showed the lowest plant height as 37.05 cm. At 3rd harvest PC-1 recorded the highest

Table 1. Vegetative parameters recorded at three growth stages

Variety	Parameter	At 50% flowering	At 100%flowering	At 3rd harvest
MI Waraniya	P ht	30.85±0.27^{ef}	35.63±0.38^{cd}	60.04±0.30^{bc}
	C wd	32.91±0.22^{e}	39.19±0.33^{cd}	58.18±0.61^{cd}
MICH-3	P ht	34.15±0.05^{bcde}	39.82±0.10^{bc}	54.52±0.18^{bcd}
	Cwd	38.53±0.04^{abcd}	41.40±0.23^{bc}	60.23±0.41^{bc}
MI-Hybrid	P ht	35.93±0.54^{abcd}	42.24±0.39^{ab}	52.67±0.93^{cde}
	C wd	40.34±0.60^{ab}	44.86±0.35^{a}	60.17±0.64^{bc}
MI-2	P ht	27.84±0.10^{f}	30.62±0.04^{e}	45.18±0.23^{e}
	C wd	35.34±0.22^{de}	39.06±0.22^{cd}	61.44±0.49^{abc}
MI Hot	P ht	33.04±0.51^{cde}	36.45±0.24^{cd}	52.79±0.54^{cde}
	C wd	36.02±0.30^{cde}	38.80±0.31^{cd}	54.83±0.29^{d}
MI Green	P ht	37.89±0.51^{abc}	41.11±0.63^{ab}	58.04±0.72^{bc}
	C wd	40.94±0.41^{a}	44.97±0.49^{a}	63.70±0.61^{ab}
GS	P ht	39.34±0.21^{a}	42.24±0.29^{ab}	57.64±0.88^{bc}
	C wd	39.91±0.46^{abc}	45.79±0.32^{a}	64.79±0.39^{a}
MIPC-1	P ht	38.99±0.17^{ab}	44.65±0.50^{a}	77.68±0.76^{a}
	C wd	36.55±0.26^{bcde}	39.34±0.20^{cd}	59.61±0.81^{bc}
KA-2	P ht	32.49±0.24^{def}	34.82±0.17^{de}	47.82±0.22^{de}
	C wd	34.97±0.46^{de}	42.96±0.46^{ab}	61.69±0.39^{abc}
LGM	P ht	30.03±0.29^{ef}	34.42±0.14^{de}	60.94±0.38^{b}
	C wd	34.86±0.27^{de}	37.05±0.39^{d}	61.75±0.41^{abc}
CV		8.37	6.93	8.06
		6.73	4.82	4.09
R-square		0.76	0.82	0.86
		0.73	0.84	0.83

Means followed by the same letters within a column are not significantly different at P < 0.05; n=30, P ht- plant height, C wd- canopy width

plant height (77.68 cm) and the lowest was 45.18 cm in MI-2. Variety GS showed the highest canopy width (64.79 cm) and MI Hot recorded the lowest (Table 1).

Reproductive Parameters

Days to 1st Flowering

There was a significant difference ($p<0.05$) for days to 1st flower among varieties. Variety MI Hot and LGM had taken maximum days to first flower (67 days) while KA-2 (58 days), MI-Hybrid (59 days), MICH-3 (60 days) and MI *Waraniya* (60 days) take minimum days to first flower and they were not significant to each other (Table 2).

Number of Pods

Considering the average number of pods in all four consequent picks, a significant difference ($p<0.05$) among the treatments was observed. Highest number of pods were observed in GS as 920 and the lowest was in MI-*Waraniya* (166) and LGM (217) (Table 2).

Pod Characteristics

Three pod characters such as stalk length, pod length and pod width were considered to determine the pod quality and they were significantly different ($p<0.05$) among ten varieties. According to the analyzed results, the highest stalk length was observed in PC-1 (3.23 cm) followed by MI-Hybrid and they were not significant to each other. Variety KA-2 showed the lowest (2.29 cm).

When comparing the pod length of each variety, MI-*Waraniya* showed the highest (11.95 cm) while the lowest was recorded by PC-1 (3.85 cm).

Table 2. Reproductive parameters of the tested varieties

Variety	Days to 1st flowering	No. of pods	Pod characters (cm)			Total yield (g/m^2)
			Stalk length	Pod length	Pod width	
MIWaraniya	60.00±0.19^{d}	166.3±4.59^{d}	2.59±0.00^{bcd}	11.95±0.01^{a}	1.49±0.00^{a}	475.00±12.9^{cd}
MICH-3	60.00±0.19^{d}	476.1±14.2^{bc}	2.71±0.00^{bc}	7.54 ±0.01^{de}	1.20±0.00^{c}	661.34±21.1^{bc}
MI-Hybrid	59.00±0.19^{d}	517.6±30.1^{bc}	3.20±0.00^{a}	10.74±0.01^{b}	1.34±0.00^{b}	1023.98±58.6^{a}
MI-2	61.33±0.39^{cd}	550.9±24.3^{b}	2.71±0.00^{bc}	5.20±0.01^{f}	1.05±0.00^{de}	513.15±15.4^{cd}
MIHot	67.67±0.26^{a}	357.4±15.5^{bcd}	2.46±0.00^{cd}	5.80±0.01^{f}	1.15±0.00^{cd}	465.09±23.4^{cd}
MIGreen	65.00±0.44^{abc}	492.4±21.2^{bc}	2.49±0.00^{cd}	8.13±0.01^{d}	1.00±0.00^{e}	509.67±22.0^{cd}
GS	62.67±0.63^{bcd}	920.8±38.7^{a}	2.43±0.00^{cd}	7.79±0.01^{de}	0.89±0.00^{f}	825.37±39.6^{ab}
MIPC-1	66.33±0.26^{ab}	289.9±16.4^{d}	3.23±0.01^{a}	3.85±0.01^{g}	1.48±0.00^{a}	404.77±34.7^{d}
KA-2	58.00±0.00^{d}	588.8±10.7^{b}	2.29±0.00^{d}	7.10±0.01^{e}	1.06±0.00^{de}	703.05±17.0^{bc}
LGM	67.67±0.26^{a}	217.3±5.11^{d}	2.91±0.01^{ab}	9.78±0.01^{c}	1.25±0.00^{bc}	441.67±15.2^{cd}
CV	4.38	31.25	15.26	10.60	10.16	28.29
R-square	0.74	0.81	0.39	0.90	0.73	0.79

Means followed by the same letters within a column are not significantly different at P<0.05; n=30, For pod characters n=10

Differences of pod width of ten varieties were significant (Table 2). The highest width was recorded in MI-*Waraniya* (1.49 cm) followed by PC-1 1.48 cm value that was not significant. Variety GS showed the lowest (0.89 cm).

Total Yield

When considering the total yield of ten varieties, the highest yield was recorded in MI-Hybrid (1024 g/m^2) followed by GS (825.4 g/m^2) and KA-2 (703.1 g/m^2) respectively (Table 2). The lowest was 404.8 g/m^2 given by PC-1 and the values were significantly different ($p<0.05$) among varieties (Table 2).

Pest and Disease Incidence

There were no any significant differences ($p<0.05$) for LCC and thrips damage among treatments at the initial stages of cultivation. However, a considerable amount of aphids were recorded at the earliest stages in some varieties such as LGM, GS, KA-2 and MI-2, and later on they were negligible due to application of organic pesticide ("OK"- Azadiractin). However, at the later part of the cultivation (90 days after transplanting) some significant amounts of differences were observed in LCC and thrips damage among ten varieties. Variety MICH-3 recorded the highest disease incidence for LCC and MI Green also given the highest LCC value thus they were not significant to each while no disease incidence was observed in MI-Hybrid. When considering the thrips damage the highest was recorded by MI Hot and no disease incidence was recorded in KA-2 (Table 3).

Table 3. Pest and disease incidences recorded in tested varieties

Variety	LCC	Thrips damage
MI-Waraniya	0.97±0.19^{b}	22.64±0.91^{abc}
MICH-3	18.29±0.95^{a}	6.17±0.62^{dc}
MI-Hybrid	0.00±0.00^{b}	21.90±1.45^{abcd}
MI-2	7.50±0.73^{b}	6.39±0.69^{dc}
MI Hot	4.30±0.83^{b}	30.84±1.73^{a}
MI Green	17.30±1.06^{a}	24.13±0.93^{ab}
GS	6.05±0.34^{b}	5.83±1.12^{dc}
MI PC-1	8.85±0.33^{ab}	7.21±1.39^{cdc}
KA-2	5.26±0.51^{b}	0.00±0.00^{e}
LGM	0.95±0.18^{b}	14.31±1.55^{bcde}

Means followed by the same letters within a column are not significantly different at $P<0.05$; n=30, (data were recorded at 90 days after transplanting), LCC-Leaf Curl Complex

CONCLUSIONS

According to the yield results and the disease incidence of ten chilli varieties, MI-Hybrid give the highest yield than all the other varieties with no or least disease incidence.Variety GS and MI-Hybrid also give the higher yielding values. Variety KA-2 and MI-Hybrid were the early flowering varieties as they took minimum days to first flowering. The highest number of pods was observed in GS. Considering about the disease incidence, less pest and disease were recorded in MI-Hybrid. Due to the fast growth rate of MI-Hybrid and GS, they gave the highest number of picks per a given period of time. Thus, MI-Hybrid has performed best over the other nine varieties giving a remarkable yield (10.42 tons/ha) within first four picks under organic farming conditions. However, variety GS and KA-2 also performed well when compared to other varieties.

Further, this study should be continued for several consecutive seasons to reach the best and consistent results under effective organic farming conditions.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Ms. N. Wijesinghe, Technical Assistant, Ms. E. Wasana, Field Assistant and all the staff members of Vegetable Division, Regional Agriculture Research and Development Center, Makandura, Sri Lanka for their assistance provided in field operations throughout the study. Also wish to acknowledge the staff members of the Soil Division of the RARDC Makandura, Sri Lanka for their assistance on soil and compost analysis. Sincere thanks are extended to Mr. K.H.M.I. Karunarathne, Instructor, Information and Communication Technology (ICT) Centre, Wayamba University of Sri Lanka for the guidance on statistical analysis.

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