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# Effect of naturally occurring amino acid stimulants on the growth and yield of hot peppers (*Capsicum annum* L.)

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**Key words**
*Capsicum annum* L., amino acid stimulants, vegetative growth, yield

## 1 SUMMARY
**Commercially available amino acid stimulants can improve fertiliser assimilation, increase uptake of nutrients and water, enhance the photosynthetic rate and dry matter partitioning, and hence increase crop yield. This study was conducted to assess the efficacy of two commercial formulations of naturally occurring amino acid stimulants (Perfectose™ Powder and Perfectose™ Liquid) at two different doses on hot pepper plants (*Capsicum annum* L.) cv. 'F1 Asha Jyothi'. Perfectose™ Powder applied at 0.45g and 0.27g/plant, in the first and second fertilizer dressings respectively, produced a significant increase ($p<0.05$) in plant height, canopy diameter, number of branches, shoot dry matter, fruit length, fruit diameter, % fruit dry matter content, ascorbic acid content and marketable yield. Shoot dry matter accumulated was 54.9 and 54.1 % higher under Perfectose™ Powder (0.45g/plant) than in the untreated control treatment at 27 and 40 days after transplanting (DAT), respectively. Plants treated with Perfectose™ Powder (0.45g/plant) resulted in a marketable yield of 16.5 t/ha, being 75.9% higher than in the untreated control plants. Compared to the untreated control plants, Perfectose™ Liquid (1.6mL/L) also resulted in significant ($p<0.05$) increases of plant height, canopy diameter, number of branches, shoot dry matter, fruit length, fruit diameter, % fruit dry matter content and ascorbic acid content. No significant differences ($p>0.05$) were observed when Perfectose™ Liquid was applied at 1.0 mL/L. This study supports the application of naturally-occuring amino acid stimulants to promote plant growth and marketable yield, as a promising and sustainable option for farmers to maximise the yield of hot peppers.**

## 2 INTRODUCTION
Hot pepper (*Capsicum annum* L.), also commonly referred to as chilli, is one of the most important solanaceous crop cultivated in Mauritius. It is appreciated for its pungency, colour, and aroma as well as its high phytochemical content. The average local pepper production increased from 1340 to 1512 t from 2004 to 2006 (ANON, 2006). Nevertheless, an additional import of around 181t was needed to meet the local demand. Mauritius imports a large quantity of processed chilli products, which amounts to a high import

value (MoA, 2007). This clearly indicates that chilli is a potential import substitution commodity. In order to address food insecurity of the increasing population at the national level and also to supply the booming tourist industry, it is necessary to maximise yield per unit area per unit farm input.

According to the Strategic Options in Crop Diversification and Livestock Sector 2007-2015 (MoA, 2007), in order to meet 70% self-sufficiency in chilli by 2015, around 3350 t of chilli need to be produced locally annually. Plant bioregulators represent one area of research that has the potential to increase crop productivity, fertilizer and water use efficiency and hence profitability (Pelt & Popham, 2006). Use of naturally occurring substances such as amino acids to enhance plant growth was reported recently (Abou Dahab & Abd El-Aziz, 2006). These naturally occurring growth substances, being derived from plants and seaweeds, have no detrimental effects on human beings, animals and the environment as do some synthetic auxins and cytokinins. Nevins (1995) reported that synthetic plant bioregulators have not gained widespread application due to the growing sensitivity related to the protection of farm workers exposed to these chemicals and the potential negative environmental impact caused by their applications.

Amino acids are organic nitrogenous compounds that are the building blocks in the synthesis of proteins (Davies, 1982). Proteins are formed by a process in which ribosomes catalyse the polymerisation of amino acids. Various hypotheses have been proposed to explain the role of amino acids in plant growth. Available evidence suggests several alternative routes of Indole Acetic Acid (IAA) synthesis in plants, all starting from amino acids (Philips, 1971; Russell, 1982; Hashimoto & Yamada, 1994). Waller and Nowaki (1978) also suggested that the regulatory effect of certain amino acids, like phenylalanine and ornithine on plant development is through their influence on gibberellins. Along this line, the objectives of this study were to: (1) assess the effect of two formulations of amino acid stimulants on the growth and development of chilli plants; (2) determine the effect of the application of amino acid stimulants on yield; (3) recommend the best product formulation for achieving highest growth and marketable yield.

## 3 MATERIALS AND METHODS

**3.1 Plant material:** Hot pepper cultivar 'F1 Asha Jyothi' was used in this study. This variety is characterized by intermediate growth habit, lanceolate leaf shape, elongate fruit shape and smooth fruit surface. The seeds were obtained from Kirsh Co. Ltd, Vacoas, Mauritius and sown in a greenhouse at the University of Mauritius. Seedlings were transplanted to the open field at seven weeks of age, at a density of 55,555 plants/ha. Cultural practices for irrigation, weeding, fertiliser and pesticide application were followed as per Le Guide Agricole (2004). A randomised block design with 4 blocks, each consisting of 5 treatments was adopted. Plants were cultivated in plots, spaced at 3.0 m x 1.5 m. Each plot comprised of 25 plants. Five randomly tagged plants from each plot were evaluated for plant height, canopy diameter and number of branches. Five plants were randomly chosen and used for shoot dry weight measurements. Chillies harvested from the remaining plants were assessed for fruit characteristics and marketable yield.

**3.2 Treatments:** The amino acid stimulants applied on the hot pepper plants were Perfectose™ Powder and Perfectose™ Liquid, which were both obtained from Priya Chemicals, India. The 5 treatments were: (1) control (no application of plant growth stimulants); (2) Perfectose™ Powder: 0.45 g/plant; (3) Perfectose™ Powder: 0.27 g/plant; (4) Perfectose™ Liquid: 1.6 mL/L (14.625 μL/ plant); (5) Perfectose™ Liquid: 1.0 mL/L (8.775 μL/ plant). Perfectose™ powder was mixed with the fertiliser dressing and incorporated into the soil, while Perfectose™ liquid was sprayed on the plant's foliage at an application rate of 650 mL/ha, as recommended by the manufacturer. Perfectose™

powder and Perfectose™ liquid were applied twice during the crop cycle: 15 and 45 DAT.

**3.3 Data recording:** Plant height, canopy diameter and number of branches were recorded every 10 days from tagged plants on the transplantation day (0 DAT) up to 50 DAT. Plant height, canopy diameter and number of branches were determined as per Abou Dahab and Abd El-Aziz (2006). Shoot dry weight was determined at mid-vegetative stage (27 DAT) and at early flowering stage (40 DAT). For the shoot dry weight determination, plants (above ground level) were randomly harvested at 27 and 40 DAT and dried in a ventilated oven (Sanyo Gallenkamp) at 70° C for 48h. Fruit length, diameter and % fruit dry matter content were evaluated from 15 chillies randomly sampled from all plots in each treatment at each harvest. Length of fruits was taken using a 30 cm ruler while the diameter was measured on the widest equatorial region using a digital calliper (Mitutoyo Corp., Japan ). The same 15 sampled fruits were in turn oven-dried at 70 °C to a constant weight to determine the % fruit dry matter content. Ascorbic acid content was determined on harvested chillies as per the AOAC Official Method 967.21 (AOAC, 1995) at 3rd harvest (98 DAT) and 4th harvest (111 DAT), whereby two samples were taken and analyses performed in triplicate. Marketable yield was recorded based on mature green fruits, which were hand-harvested randomly from 15 plants per plot, sorted out and weighed. Four harvests were carried out on 70 DAT (1st harvest), 82 DAT (2nd harvest), 98 DAT (3rd harvest), and 111 DAT (4th harvest). Fruit size and marketable yield were determined as per Berke and Gniffke (2006).

**3.4 Data analysis:** Statistical analysis was performed using Minitab 15® Statistical Software for Windows. The Richards growth function defined by W(t) = A(1+b*Exp(-kt))^M (Richards, 1959), was used to model both plant height and canopy diameter, using Microsoft Excel® 2003. The difference between the means were compared using the Duncan's multiple range test and LSD ($P$=0.05).

## 4 RESULTS AND DISCUSSION

**4.1 Plant height:** Mean height of chilli plants treated with Perfectose™ Powder at both 0.45 and 0.27g/plant (Figure 1A) as well as Perfectose ™Liquid at 1.6mL/L (Figure 1B) was significantly ($P$< 0.05) greater than for the untreated control plants at 50 DAT. A marked increase of 24.4 and 11.7% in height was noted as from 20 DAT for plants with 0.45 and 0.27g Perfectose™ powder/plant, respectively, as compared to the untreated control plants. As for Perfectose™ Liquid, an increase in plant height was observed as from 40 DAT. Higher plant height directly relates to more and larger leaves and hence it implies larger surface area for light interception, greater photosynthesis and therefore higher dry matter accumulation.

Regarding the effect of foliar amino acids on plant height, the results of this experiment are in agreement with those obtained by El-Bahar *et al.* (1990) on *Datura metel*, Talat and Youssef (2002) on *Ocimus basilicum*, and Attoa *et al.* (2002) on *Iberis amara* L., who reported that foliar application of amino acids significantly promoted plant growth. Abou Dahab and Abd El-Aziz (2006) also concluded that amino acid application significantly increased the height of *Philodendron erubescens* plants.

**4.2 Canopy diameter:** Fig. 2A and 2B show that Perfectose™ Powder (0.45g/plant), Perfectose™ Powder (0.27g/plant) and Perfectose™ Liquid (1.6mL/L) treatments resulted in significantly larger ($P$<0.05) canopy diameter of plants than the untreated control plants. Canopy diameter was most responsive to Perfectose™ Powder applied at 0.45g/plant as from 20 DAT; the increase in mean canopy diameter values was 13.4% (20 DAT), 19.6% (30 DAT), 22.7% (40 DAT) and 16.9% (50 DAT) as compared to the control.

These results are in line with those of Abou Dahab and Abd El-Aziz (2006) who found that application of amino acids (100 μL/L diphenylamine and 100 μL/L tryptophan) led to a significant increase in number of leaves/plant and leaf area over the non-treated *Philodendron erubescens* plants. A higher assimilate supply may result in more leaves being produced (Heuvelink & Marcelis, 1996), greater number of branches and thus resulting in larger canopy diameter.

**4.3 Number of branches:** Figure 3 reveals that the response of number of branches to Perfectose™ Powder treatments followed the same trend as plant height and canopy diameter. Branch numbers increased from 0 to 50 DAT in all treatments but was significant in treatments with Perfectose™ Powder at 0.45 and 0.27g/plant only. The application of Perfectose™ Powder at

0.45g/plant was the most effective treatment in increasing number of branches per plant, having 164 branches per plant at 50 DAT, that is, a significant increase ($P<0.05$) of 25% compared to the untreated control chilli plants. Abd El-Aziz and Balbaa (2007) also found that foliar application of amino acids (tyrosine) significantly promoted the number of branches of *Salvia farinacea*. El-Bahar *et al.* (1990) on *Datura metel*, Talat and Youssef (2002) on *Ocimus basilicum*, and Attoa *et al.* (2002) on *Iberis amara* L. reported that foliar application of amino acids significantly promoted plant growth.

**4.4 Shoot dry matter content:** Shoot dry matter determination of chilli plants at 27 and 40 DAT (mid-vegetative and flowering stages, respectively) revealed that plants treated with Perfectose™ Powder had statistically higher dry matter content than the other treatments (Fig. 4). Moreover, Perfectose™ Powder at 0.45g/plant and Perfectose liquid at 1.6 mL/L had a significant ($P<0.05$) increase in shoot dry matter content at 40 DAT, as compared to the untreated control plants (Table 1). The higher shoot dry matter may be attributed to the fact that this treatment gave the tallest plants, the largest canopy diameter and the highest number of branches. Abou Dahab and Abd El-Aziz (2006) observed an increase in dry weight of leaves and stems when amino acids were applied on foliage of *Philodendron erubescens* plants. These results are also in agreement with previous reports of Russell (1982) and Attoa *et al.*, (2002) on *Iberis amara*. The increase in the dry weight as a result of the amino acid biostimulants may be due to its conversion into indole-3-acetic acid (IAA) (Russell, 1982). IAA is a major plant growth promoter that leads to auxin-induced cell elongation (Taiz & Zeiger, 2002), thereby increasing plant height and canopy diameter. Abou Dahab and Abd El-Aziz (2006) showed that the chlorophyll content of *P. erubescens* plants treated with amino acids was higher than in the untreated plants. Moreover, spraying *Salvia farinacea* plants (Abd El-Aziz & Balbaa, 2007) and *Philodendron erubescens* plants (Abou Dahab & Abd El-Aziz, 2006) with different amino acids resulted in a significant increase in the total free amino acids content of the leaves

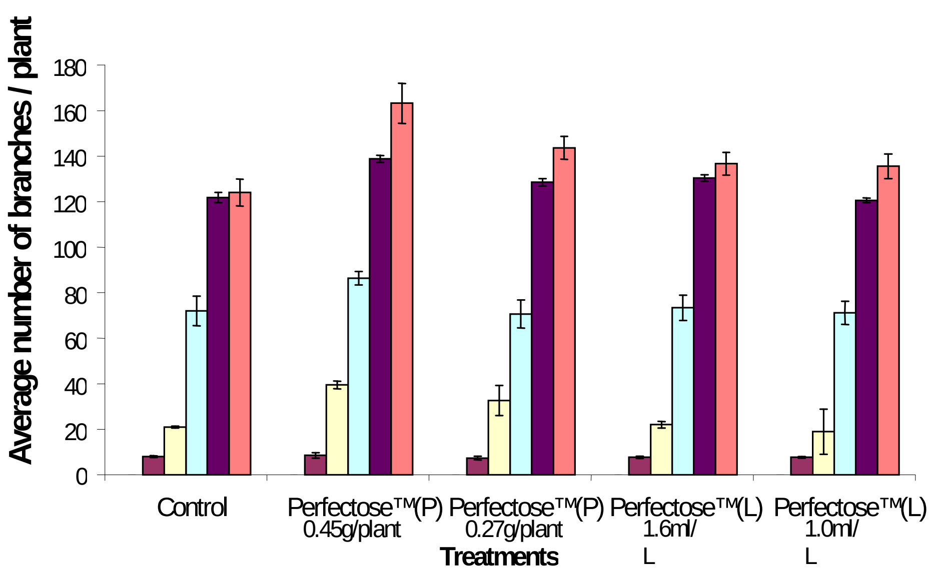


**Figure 3:** Canopy diameter of chilli plants from transplanting up to 50 days after transplanting (DAT), treated at Day 10 (■), Day 20 (□), Day 30 (□), Day 40 (■) and Day 50 (■) with varying amounts of Perfectose powder (P) or liquid (L). Vertical bars represent the standard error (SE) of means.

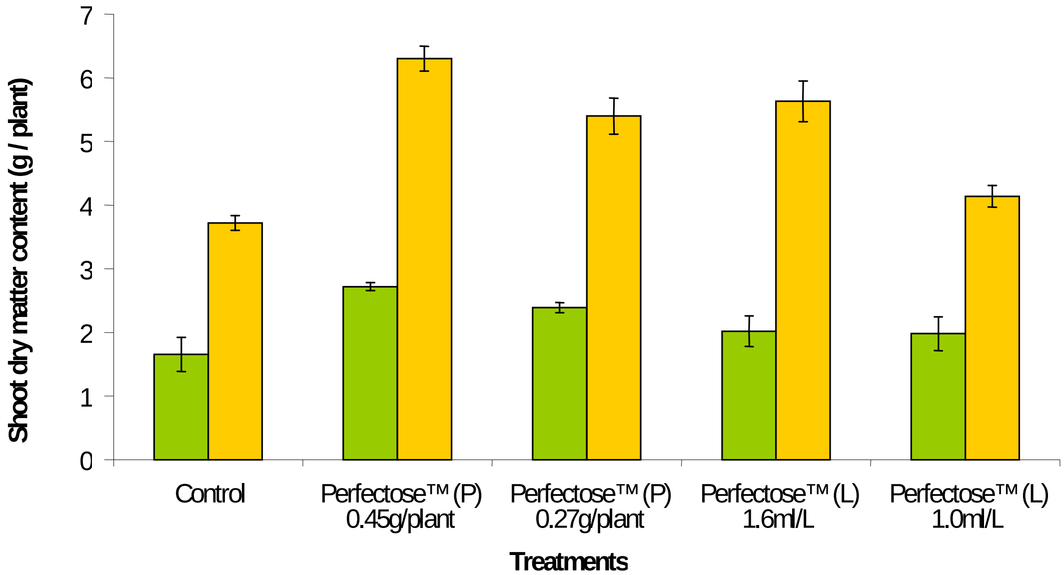


**Figure 4:** Shoot dry matter content (g) of chilli plants treated with varying amounts of perfectose powder (P) or liquid (L) at 27 days after transplanting (DAT) (mid-vegetative stage) ( columns) and 40 DAT (flowering stage) ( columns). Vertical bars represent the standard error (SE) of means.

**Table 1:** Shoot dry matter increase (g) of chilli plants treated with varying amounts of Perfectose powder (P) or liquid (L) from 27 to 40 days after transplanting.

| Treatments | Increase in shoot dry matter (g) |
|---|---|
| Untreated control | 2.32c |
| Perfectose (P): 0.45g/plant | 3.56ab |
| Perfectose (P): 0.27g/plant | 3.02b |
| Perfectose (L): 1.6mL/L | 3.71a |
| Perfectose (L): 1.0mL/L | 2.16c |

Means followed by the same letter are not significantly different at $P = 0.05$

## 4.5 Fruit characteristics

**4.5.1 Fruit size:** Perfectose™ Powder at both levels had a significant ($P<0.05$) effect on fruit length and diameter (Fig. 5). Perfectose™ Powder at 0.45g/plant had the longest fruits (18.7 cm) and widest diameter (12.3 mm) while those from untreated plots were 16.2 cm long and 11.0 mm diameter. The supply of amino acids along with fertilizers could have enhanced the utilization of assimilates by the growing chilli fruits. Ho (1996) found that the rate of fruit expansion is affected by assimilate supply.

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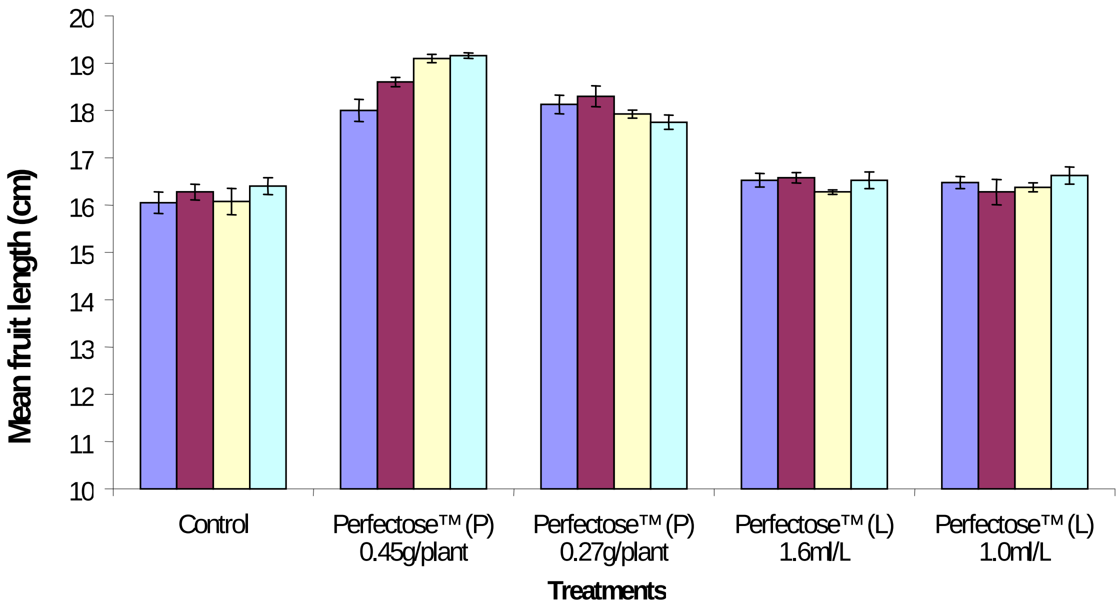


**Figure 5:** Effect of amino acid stimulants on mean fruit length (cm) of chilli plants treated with varying amonts of Perfectose powder (P) and liquid (L). Assessments were done at 1st harvest (), 2nd harvest (), 3rd harvest () and 4th harvest (). Vertical bars represent the standard error (SE) of means.

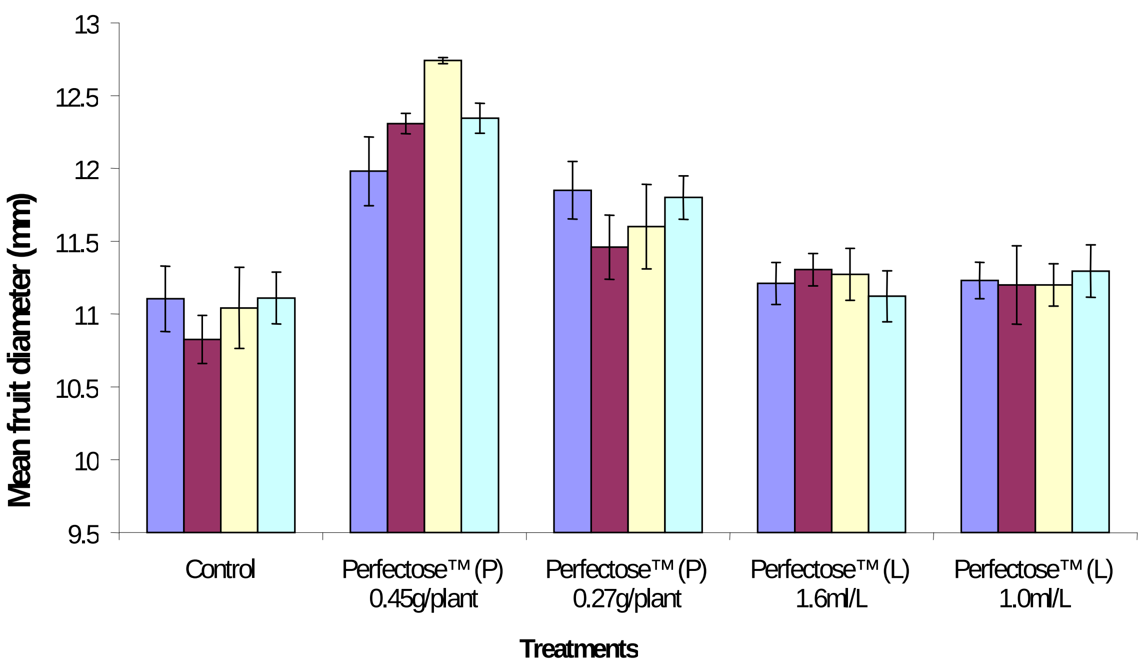


**Figure 6:** Effect of amino acid stimulants on mean fruit diameter (mm) of chilli plants treated with varying amounts of Perfectose powder (P) or liquid (L). Assessments were done at 1st harvest (), 2nd harvest (), 3rd harvest () and 4th harvest (). Vertical bars represent the standard error (SE) of means.

**4.5.2 Fruit dry matter content:** The biostimulating effect of Perfectose™ Powder at both levels was evident on the percentage fruit dry matter content (Fig. 7). The mean value (taken at first 4 harvests) for this parameter was highest (13.4 %) when Perfectose™ Powder was applied at 0.45g/plant, followed by Perfectose™ Powder at 0.27g/plant (11.8 %). These mean values were 31.8 and 22.6% higher than for the untreated control plants . Enhanced sink activity and rapid utilization of sucrose for the creation of other sugars, starch and cell wall substances in the developing fruit stimulate translocation of photoassimilates to the fruit (Ho, 1976). Utilization of sugars in growing sinks depends on the provision of amino acids (Paul & Foyer, 2001).

**4.5.3 Ascorbic acid contents:** The ascorbic acid contents of fresh chilli ranged between 0.16 and 0.21mg/100mg. Chilli from plants treated with Perfectose™ Powder at 0.45g/plant and Perfectose™ Liquid at 1.6mL/L had a mean ascorbic acid value of 0.20 mg/100mg, which was significantly ($P$<0.05) higher by 18.9 % than the untreated control plants (0.16 mg/100mg). Higher dry matter content in fruits treated with Perfectose™ could probably have led to greater vitamin C synthesis. Videki (1974) reported a good correlation between Vitamin C and dry matter contents in tomato fruits of the same variety. Data on dry matter and Vitamin C content of solanaceous fruits presented by Wuzhong (2002) also showed a strong relationship between these two parameters.

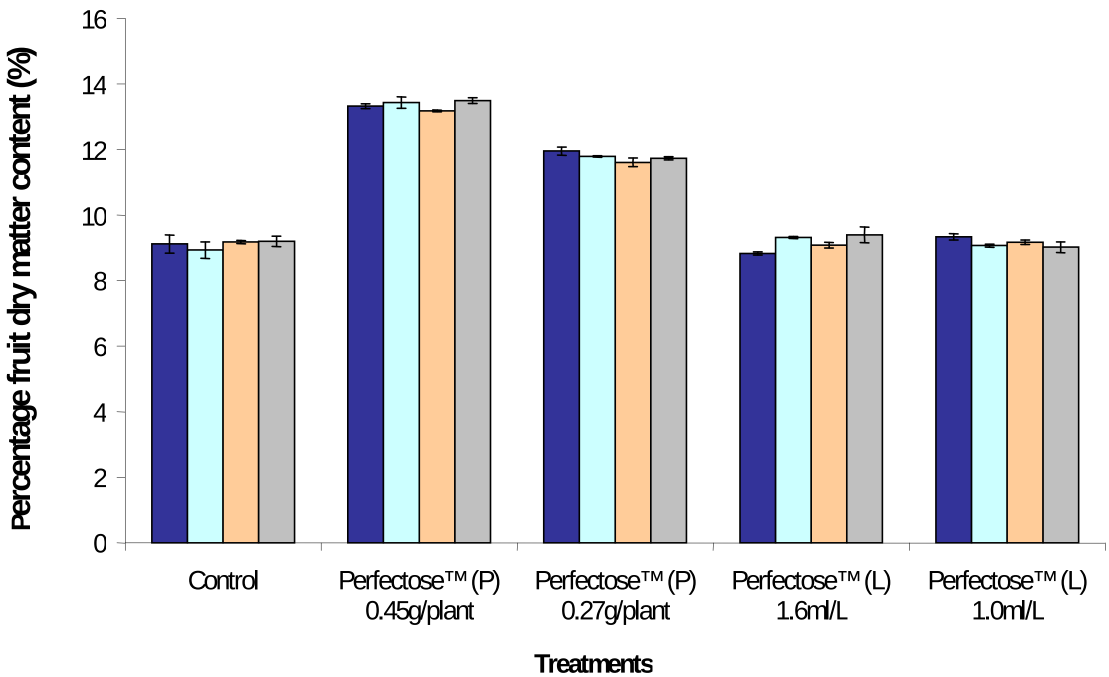


**Figure 7:** Effect of plant bioregulators on % fruit dry matter content of chillies. Plants were treated with varying amounts of Perfectose powder or liquid and assessed at 1st harvest (■), 2nd harvest (□), 3rd harvest (□) and 4th harvest (□). Vertical bars represent the standard error (SE) of means.

**4.5.4 Marketable yield:** As shown in Table 2, there were significant differences in total yield of chilli plants treated with the different bioregulators. Perfectose™ Powder (0.45g/plant) and Perfectose™ Powder (0.27g/plant) treatments resulted in chilli marketable yields that were significantly higher than the untreated control plants. The highest marketable yield (16 500 kg ha$^{-1}$) was obtained with Perfectose™ Powder at a rate of 0.45g/plant. This yield was 75.9% higher than that obtained from the control plants.

Before the plant can use nitrate, it has to be reduced to $NH_4^+$, an energy consuming process requiring 347 kJ/mole. This represents a significant loss of energy from the plant overall economy, while this energy could have been used for increasing the plant's productivity (Lewis, 1986). Thon *et al.* (1981) pointed out that amino acids provide plant

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cells with an immediately available source of nitrogen, which generally can be taken by the cells more rapidly than inorganic nitrogen. Viti *et al.* (1989) associated the application of amino acids with significant changes in the secondary metabolism and enzymatic systems of plants, especially oxidation/reduction systems. Research has shown that amino acids can serve as a source of carbon and energy when carbohydrates become deficient in the plant; amino acids are determinate, releasing ammonia and organic acid from which the amino acid was originally formed. The organic acids then enter the Krebs's cycle whereby they are used to release energy through respiration. Results of significant yield increase in our study are consistent with those of Ruiz and Romero (1999) who reported that amino acid translocation towards the fruits produced higher yield.

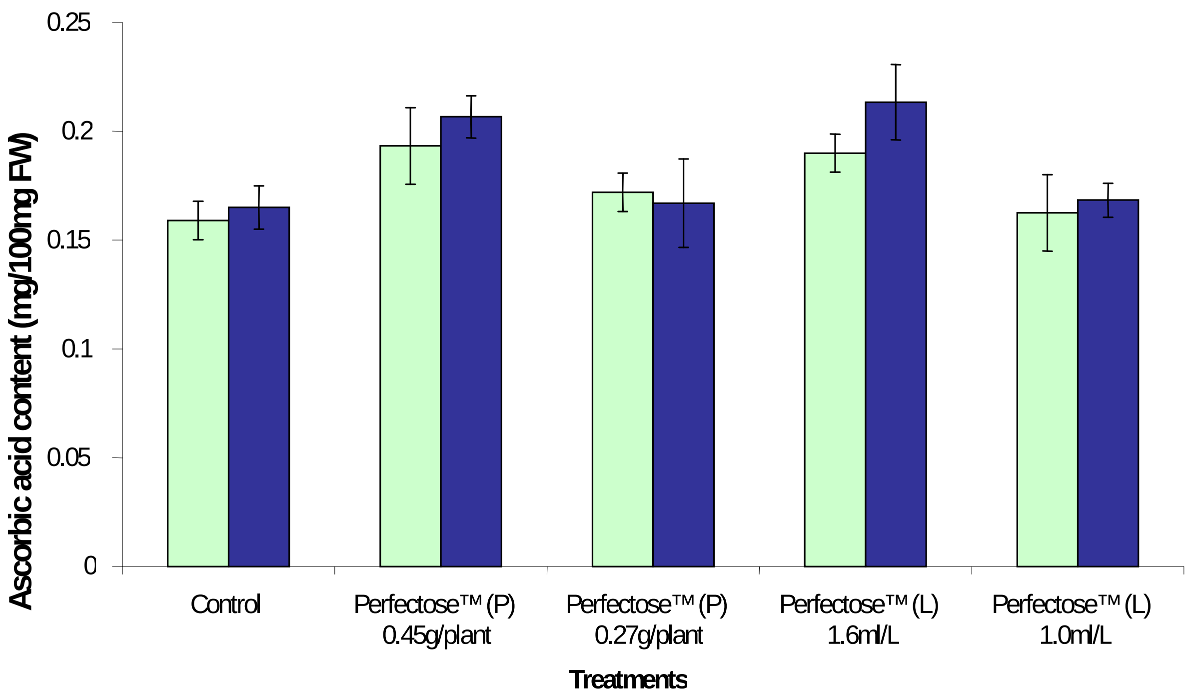


**Figure 8:** Ascorbic acid content (mg/100mg) in fresh chillies at 82 DAT (□) and 98 DAT (■). Vertical bars represent the standard error (SE) of means.

**Table 2:** Fruit production and equivalent yield of chilli plants treated with varying amounts of Perfectose powder (P) or liquid (L). Assessments are done at first four harvests.

| Harvest | DAT | Control | Perfectose powder™ (P): 0.45g/plant | Perfectose powder™ (P): 0.27g/plant | Perfectose liquid ™ (L): 1.6ml/L | Perfectose liquid ™ (L): 1.0ml/L |
|---|---|---|---|---|---|---|
| 1st | 70 | 1.67 | 2.94 | 2.69 | 2.06 | 1.8 |
| 2nd | 82 | 2.41 | 4.28 | 3.41 | 3.08 | 2.56 |
| 3rd | 98 | 2.81 | 5.04 | 4.15 | 3.23 | 3.07 |
| 4th | 111 | 3.22 | 5.56 | 4.79 | 3.75 | 3.27 |
| **Total yield (kg)** | | **10.13 c** | **17.82 a** | **15.03 b** | **12.13 bc** | **10.70 c** |
| **Yield (t/ha)** | | **9.38 c** | **16.50 a** | **13.92 b** | **11.23 bc** | **9.91 c** |

Means followed by the same letter are not statistically different according to Duncan's multiple range test ($p$=0.05). P: Powder formulation, L: Liquid formulation and DAT: Days After Transplanting.

## 5 CONCLUSIONS

Perfectose™ Powder (0.45g/plant) produced the most statistically significant agronomic responses in hot pepper plants. This study showed that significant increase in plant height, canopy diameter, number of branches, shoot dry matter, fruit length, fruit diameter, % fruit dry matter content, ascorbic acid content and marketable yield was noted with both Perfectose™ Powder at 0.45 and 0.27g/plant as compared to the untreated control plants. Plants sprayed with Perfectose™ Liquid (1.6mL/L) also resulted in significant increase in all the parameters except for marketable yield. However, no significant effect was observed upon application of Perfectose™ Liquid (1.0mL/L). The results of this research support the application of naturally-occurring amino acid biostimulants as a potential aid to stimulate plant growth and increase marketable yield of hot pepper plants, with minimal harmful risks to the environment and farm personnel.

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