ISSN: 18158129 E-ISSN: 18151027
Volume 18, Issue 05, May, 2022

Effects of SRF- PB Fertigation on Bell Pepper (*Capsicum annuum* L.) Soil Chemistry Properties

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ABSTRACT— Permanently frequent utilization of fertilizer posed problems in soil fertility that hinder farmers' crop production due to excessive soil erosion and rapid leaching of essential nutrients. It aimed to evaluate the effect of SRF-PB (Slow releases fertilize- Plastic bottles) on the chemical properties of soil and the yield potential of green bell pepper. It was assigned as chemical soil samples were organic matter (OM), pH, nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O). The experiment was laid out in RCBD with seven treatments and three replications, respectively. The results were collected T_0-control, T_1-water-soluble fertilizer application (WSF), T_2-commercial controlled-release fertilizers (CRF); and SRF-PB of 25%, 50%, 75%, and 100% with T_3-T_6 holed portion in the treatments, respectively. The soil pH of treatments applied with control, commercial CRF, and SRF-PB technology ranges from medium acidic (T_0 and T_2 -T_6) and slightly acidic (T_1). OM content, on the other hand, was found to be low among the treatments (T_0-T_4 and T_6) and desired with T_5 of the percentage treatments. The N level suggests that all sites reach a relatively low range. The phosphorus was high in T_1-T_5, and sufficient in T_0 and T_6 observed treatments. The potassium was acceptable in decreasing T_0 and T_2, slowly increasing at high T_6, and excessive in swiftly increasing T_1 and T_3-T_5. In contrast, the significantly *($p < 0.05$)* highest yielding findings revealed that using T_2 increased fertilizer efficiency, with T_6 having a higher root density and a higher harvest yield. In terms of increasing green bell pepper yield, T_6 might be a viable alternative to commercial T_2.

KEYWORDS: Control-release fertilizer (CRF), Slow releases fertilize- Plastic bottles (SRF-PB), Bell Pepper of Yield, Chemical Properties

1. INTRODUCTION

The family Solanaceae includes the green bell pepper (*Capsicum annuum* L.). It was a significant vegetable category that was widely produced and cultivated in practically every country on the planet [1]. Temperatures between 25 to 35°C were required in general [2]. After tomatoes, sweet peppers were the world's second most important vegetable [3].

Green bell pepper production was both cost-effective and appealing to farmers in this area. This type of production, however, necessitates large N-fertilization rates [4], [5]. Groundwater pollution by nitrate was becoming more of a worry in areas where intensive agriculture was practiced. Vegetables and other irrigated horticulture crops, which receive relatively substantial doses of N fertilizer, have the greatest potential for contributing to nitrate pollution of surface and groundwater [4]. The agro-ecological circumstances of a specific location must be effectively comprehended in order to bring irrigated agriculture, mineral N fertilization, and the environment into harmony. Vegetable production may be improved by employing management approaches and technology that do not jeopardize natural soil functions while also safeguarding the covering and groundwater. In all cultivars, the amount of water in the soil grew as the amount of shadow rose. Shade may have lowered evaporative demand and reduced transpiration, resulting in a reduction in green bell pepper soil water absorption [6- 9]. Growers often skip fertigation because the soil water content was sufficient.

Controlled-release fertilizers (CRF) stand for "products comprising sources of water-soluble nutrients, the release of which was controlled in the soil by a coating added to the fertilizer" [10]. A consistent nutrient supply may be achieved with a single application of CRF [11], [12], which was less reliant on technical background and meteorological conditions than fertigation. However, it was difficult to respond to genuine changes in the plant's nutritional requirements using this strategy. Although earlier sweet pepper research revealed that a single basal application of CRF produced comparable or superior yields to control fertilization techniques [13- 16]. CRFs were not compared to fertigation in any of these investigations. Slow-release fertilizer (SRF) stands for "low solubility molecules with a complex/high molecular weight chemical structure that releases nutrients by either microbial or chemically decomposable substances." [17]. SRFs, on the other hand, were N molecules degraded by microbes. The release of nutrients in SRFs was entirely determined by soil and environmental conditions. It may be organic or inorganic, and it releases nutrients gradually over time. Inorganic SRFs include things like nitroform [18]. Natural and synthetic SRFs were also available. Plant manure, animal dung, and compost were examples of natural SRFs [19]. Microorganisms were permitted to break down these components before they release nutrients into the crops because of their organic nature. These fertilizers may take longer to release nutrients and rely on microbial activity in the soil, which was regulated by soil moisture and temperature. Both macro-and micronutrients were found in organic SRFs. N, P, and K were the macronutrients. The micronutrients were iron, manganese, and copper. Synthetic SRFs were water-soluble to a degree. The availability of these plants was also determined by soil conditions. It has a greater concentration of a particular nutrient than natural SRFs. CRF was a subset of SRF that belongs to the fertilizer with a physical barrier group [20].

The purpose of this study was to investigate the chemical potential of soil pH, total N%, OM%, avail. phosphorus, exch. potassium; and growth parameters of green bell pepper fruit quality of effects of the combined use of water-soluble fertigation (WSF), CRF, and SRFs in intensive open-field sweet pepper cultivation. In particular, SRFs were supplied to 25%, 50%, 75%, and 100% of the holed area, respectively.

2. Methodology

2.1 Chemical Soil of Collection, Preparation, and Analyses

Chemical soil samples were collected and air-dried before being sent to the PRC-RTC, VSU, Baybay City, Leyte's Central Analytical Services. For the assessments of organic matter (OM), soil pH, Total N, and Extractable phosphorus and potassium, subsamples for initial chemical characteristics were submitted. The modified Walkley-Black technique [21] was used to calculate OM. Soil pH, on the other hand, was potentiometrically measured using a 1:2.5 soil-water suspension ratio [22]. The Micro – Kjeldahl technique [23] was then used to calculate Total N. Furthermore, the Bray #2 technique [22] was used to extractable phosphorus. Finally, the ammonium acetate method [22] was used to extract Exchangeable potassium.

2.2 Plant Tissue and Final Soil Analysis

On a computerized weighing scale, the oven-dried shoot and root samples were weighed and crushed to a specific size of 1 mm using a mill grinder. After that, it was packed in plastic bags to be tested for total phosphorus. The soil samples that were taken, on the other hand, were treated, processed, and placed away for chemical analysis.

2.3 Preparation of WSF, CRF and SFR-PB

As a PB, a 200 mL plastic clear barrier was used. Clean tap water was used to completely wash these PB. After that, using a tire wire, it was individually punctured at an equal distance of 2 cm apart with roughly 0.5 mm diameters. Before planting, 10 *g* pot^{-1} Complete Fertilizer (14-14-14), 15 *g* pot^{-1} Urea (46-0-0), and 10 *g* pot^{-1} Muriate of Potash (0-0-60) were used to supplement the appropriate N, phosphorus and potassium fertilizer rate for green bell pepper. Fertilizer components with the same rate of application as previously specified were mixed in the soil and placed separately within the SRF-PB. Commercial CRF "osmocote" fertilizers, on the other hand, were applied in the field at a depth of about 5 cm and a distance of 10 cm from the base of the green bell pepper. Meanwhile, WSF-10 *g* pot^{-1} of Complete Fertilizer (14-14-14) was applied during planting. Green bell pepper was side dress with Urea (46-0-0) at the rate of 15 *g* pot^{-1}. At the flowering stage, 10 *g* pot^{-1} of Muriate of Potash (0-0-60) was applied.

2.4 Cultural Management Practices

2.4.1 Land preparation, seed sowing, and seedling preparation

A total land area of 200 square meters was plowed and harrowed with carabao-drawn equipment to eliminate weeds and pulverize the soil before planting. This was then split into one-meter-wide, three-meter-long blocks, each with a 0.25-meter alleyway. Green bell pepper seedlings were seeded in a certified shed house with plastic film roofing to protect them from rain. Every morning, the plant was watered. Pricking was carried out by transplanting individual seedlings in a seedling tray after 6-8 days of seed germination when the seedlings had reached the two-true leaf stage. Before transplantation, the seedlings were gradually exposed to sunshine and/or outside settings, and hardening was recommenced for one week.

2.4.2 Crop establishment of transplanting of the seedlings

Green bell pepper seedlings from the seedling tray were assumed to be sample plants because of their vigorous growth. In double row planting, the plants were transplanted at a depth of 15-20 cm, with 75 cm between rows and 25 cm between pots.

2.4.3 Harvest Management

Picking just those that were properly developed or as the green bell pepper transmitted physiological maturity was used as the priming technique of harvesting was used. Early in the morning, the harvest was completed. After harvest, the green bell peppers were classed or graded and weighed.

2.4.4 General Care and Managements

The application water was used first thing in the morning, about 6 a.m. Weeding was done manually with a trowel or bolo when the weeds sprouted. The roots were hilled up to keep them from being exposed to sunlight from above ground. Insect, pest, and disease infestations were constantly monitored. As an organic insecticide, mashed garlic with red-hot chili pepper was used to control pests.

2.5 Foliage of Experimental Design and Layout

The experiment was carried out modified in a Single Factorial-Randomized Complete Block Design (RCBD) with six (6) treatments and replicated three (3) times with eight (8) samples. The six treatments were assigned as follows: T_0-Control; T_1-WSF application; T_2 -CRF; T_3 -25% holed portion of SRF-PB; T_4-50% holed portion of SRF-PB; T_5-75% holed portion of SRF-PB; and T_6-100% holed portion of SRF-PB.

2.6 Statistical Analysis

All data gathered was subjected to Analysis of Variance (ANOVA). Treatments were compared through Least Significance Difference (LSD) to determine the level of significance among the different treatments combined using the Statistical Tool for Agricultural Research (STAR) at $p < 0.05$ level of significance.

3. Results

3.1 Initial chemical Properties before Crop Establishment

The initial chemical soil analysis in Table 1a shows that the soil used was moderately acidic to neutral soil (pH 6.43), had a lower level of organic matter content (2.09%), with a minimal amount of total N (0.14%), high amount of available phosphorus (59.03 mg kg^{-1}), and high in exchangeable potassium (135.48 mg kg^{-1}). Thus, the results of the soil analysis, such as a very low or minimal amount of N content could partly explain why yellowing of leaves and stunted growth were observed particularly in those plants without any application.

3.2 Chemical characteristics of WSF, CRF and SRF-PB application

The final analysis of chemical soil characteristics after application of SRF-PB treatments (Table 1b). The soil pH of treatments applied with control, commercial CRF, and SRF-PB technology ranges from medium acidic (T_0 and T_2 -T_6) and slightly acidic (T_1). Slightly acidic that the results of WSF application (T_1) responded differently was significantly *($p < 0.05$)* treatment (5.88 pH) as soil test result. This result corresponds to the finding [24] that soil technology was in the range of weak acid to neutral soil. In terms of OM content, results showed that among the treatments at low from (T_0-T_4 and T_6). Whereas, desirable with T_5 (2.4% OM) of the percentage. The N level recommends among all sites comes to a range of very low (0.07-0.12% percent of N) results. However, phosphorus was T_1-T_5 (42 -62 mg kg^{-1}) as high, and in the T_0 and T_6 (36 and 38 ppm) as adequate observed treatments. Besides, potassium was adequately decreased T_0 and T_2 (105 and 116 mg kg^{-1}), slowly up to high T_6 (151 mg kg^{-1}), and excessive in the rapidly increased T_1, and T_3 -T_5 (276 mg kg^{-1}, 186 mg kg^{-1}, 199 mg kg^{-1}, and 224 mg kg^{-1}), respectively.

3.3 Green bell peppers produce a large quantity of fruit.

As shown in Table 2, the yield of green bell pepper was significantly *($p < 0.05$)* influenced by the control, CFR, and SRF-PB treatments. Furthermore, within the ton ha^{-1} value, T_6 and T_2 quality yields were significantly *($p < 0.05$)* higher, at 12.42 and 11.82, respectively (Figure 1).

Table 1a. Initial chemical soil analysis prior to planting of a green bells pepper.

Sample	pH	Organic matter	Total N	Avail. phosphorus	Exch. potassium
Soil	6.43	2.09	0.14	59.03	135.48

Soil pH- (1:2.5 H_2O); Organic matter- (%); Total Nitrogen- (%); Available P_5O_2 - (ppm); and Exchangeable potassium - (mg kg^{-1})

Table 1b. Final pH, OM, N, Avail phosphorus, and potassium analysis of chemical soils.

Treatments	Chemical Analysis				
	pH (H_20)	OM (%)	N (%)	Avail. Phosphorus (ppm)	Exch. Potassium (mg kg^{-1})
T_0	6.70	1.7	0.085	38	105
T_1	5.88	1.6	0.080	62	276
T_2	6.43	1.5	0.075	59	116
T_3	6.43	1.6	0.080	43	186
T_4	6.02	1.8	0.090	42	199
T_5	6.30	2.4	0.120	55	224
T_6	6.16	1.4	0.070	36	151

**T_0 – control; T_1 – WSF application; T_2 - Commercial CRF; T_3 - 25% holed SRF-PB; T_4 - 50% holed SRF-PB; T_5 - 75% holed SRF-*

PB; and T_6 - 100% holed SRF-PB.

Table 1c. Characteristics of soil fertility factors for the crop.

Soil Fertility Factors	Class		
	High	Moderate	Low
pH (1:2.5 H_2O)	5.5-7.5	5.0-5.5	< 5.0 & > 8
OM (%)	> 3	1-3	< 1
Total N (%)	> 0.25	0.15-0.25	< 0.15
Avail. Phosphorous (ppm)	> 35	26-35	< 25
Exch. Potassium (mg kg^{-1})	> 250	150-250	< 150

Source: BSWM-ELREP, 1985

Table 2. The yield green bell pepper at 70 DAHs of the soil was used in the experiment.

Treatments*	Variables			
	Marketable	*Cull*	*Total Yield (ton. ha^{-1})*	*Av. Fruit weight*
T_0 – *control*	4.60	0.96	5.79 c	98.73 b
T_1 – *WSF application*	6.29	1.93	7.76 b	112.75 a^z
T_2 - *commercial CRF*	9.07	2.26	11.82 a^z	117.13 a^z
T_3 - *25% holed portion of SRF- PB*	5.77	1.57	8.85 b	109.78 ab
T_4 - *50% holed portion of SRF- PB*	5.56	1.43	7.28 b	111.73 a^z
T_5 - *75% holed portion of SRF- PB*	6.48	1.39	8.22 b	112.26 a^z
T_6 - *100% holed portion of SRF- PB*	9.75	2.16	12.42 a^z	118.38 a^z
CV (%)	*49*	*38*	*27.32*	*16.82*

[z]Mean separated within columns (by the main factor and by treatment) by the LSD test ($p < 0.05$)

Figure 1. Green bell peppers have a significant fruit yield (ton ha^{-1}).

4. Discussion

4.1 Soil chemical properties

Soil pH. This might be owing to the impact of pH, as described by T_1 (Table 1b), which has solubility as a chemical feature, such as when the dissolving point of water was still salt or when potassium permanganate was considered [25]. Nonetheless, soil pH of 5.88 of strongly acid had recorded an increase such as maize [26] and a higher value of the mineral contents than those grown on other media of [27], respectively. They also feature significant levels of soluble aluminum, iron, and manganese, which may be hazardous to some plants' development [28]. Aside from that, the ideal pH range for plant development differs depending on the crop. While certain crops (excluding T_2) thrive in the 6.0 to 7.0 pH range, others thrive in somewhat acidic circumstances [29] and enhance the quick availability of plant nutrients (N, P, K, and so on) [28].

Organic Matters (OM). As a result, the acidity of the soil caused by organic acid deprotonation was determined by the vegetation [30]. OM does not have a direct role in soil acidification; instead, it functions as a cation exchanger [31]. Nevertheless, plants and animals that were living, dead, or in the process of decomposition were considered OM [32]. The release of OM into the soil, resulting in an increase in plant nutrient absorption capacity, such as the ability to break down OM and release mineral nutrients into the soil [33], might speed up nutrient transformation and boost bell pepper development. The content of soil organic matter in paddy soils varies greatly between different areas, such as those with higher OM content, ranging from 2.5 to 3.0 percent (expect 2.4 percent and OM of research at T_5), and those with lower OM content, ranging from 1.0 to 1.5 percent [34]. Similarly, OM makes up only 2–10% of most soil bulk but plays a critical role in the chemical processes of agricultural soils [35]. Soils with high salt concentration and low OM content were more prone to aggregate disintegration and surface crusting concerns [36], [37].

Nitrogen (N). Conversely, N losses were too high, owing to an oversupply of nitrogen, low plant population, inadequate application methods, improper management, and other factors, and can amount to up to 70% of total available N or be lost in irrigated areas [38], [39]. Improved N management has been increasingly important in recent years; as a result, improper N fertilizer use not only results in financial losses but also raises the risk of environmental degradation [40], [41]. In dry and semi-arid places [42], such as the Philippines, N was also a limiting issue, along with a lack of water. In general, low pepper yields might be attributed to water stress or nutritional deficiencies in the soil [43], [44]. Furthermore, because the application rate in many vegetable-growing areas sometimes exceeds crop requirements and was accompanied by intense soil washing, the danger of nitrate-nitrogen leakage increases [45]. Plants' growth and development might be hampered by a lack of accessible N. Nitrogen can also boost root development by increasing volume, area, diameter, total, and main root length, dry mass, and nutrient intake, hence improving nutritional balance and dry mass production [46- 49]. Low N levels, on the other hand, lead some plants to convert from growth to reproductive mode, hastening *Arabdopsis* flowering [50]. Additionally, solarized soil technology [24] increases plant development while also offering improved management of soil-borne diseases, resulting in higher bell pepper and other agricultural plant growth, productivity, and quality [51], [52].

Phosphorus (P_2O_5). Despite, because mineralization of this nutrient was sluggish, the T_0 and T_6 with 36 and 38 ppm (Table 1b), respectively, of availability phosphorus as appropriate observation treatments were low [53]. Phosphorus was never easily soluble in soil, but it was most readily available in soil with a pH of 6.5 or above [28]. Because prior years' phosphorus application for the 2016 and 2017 locations was unknown, it's impossible to say if a previous year's phosphorus treatment was insufficient to sustain a high soybean yield [54]. Healthy levels of phosphorus between 25 and 50 ppm should be maintained with a modest application of phosphorus once a year. Apply a beginning fertilizer to soils with levels below 25 ppm, and no fertilizer was required after levels reach around 50 ppm [53].

Potassium (K_2O). It signifies that potassium was adequately reduced with T_0, T_2, and T_6 and that the results showed that it helps keep water and other nutrients flowing through a pepper plant with macronutrients, which were sometimes referred to as the "big three" because of their important role in the life of a healthy plant [55]. It also implies that poor pollination might result in peppers or flowers falling off the plant. Furthermore, a 100 g meal of normal pepper will provide between 5 and 8% of your daily potassium intake [56]. Regardless, long-term use of mineral fertilizers in agricultural soils causes plant nutrients (phosphorus and potassium) to accumulate in the soil, which was dependent on fertilizer rates [57], [58]. There were studies in the literature that show a favorable effect of N and potassium fertilization on bell pepper crop yields, with a linear or quadratic response [59- 62]. Leaf potassium responded to rising potassium rates in a linear or quadratic manner, as seen in the graph. When compared to leaf sufficiency ranges for bell pepper plants, treatments K_1-

0.25 and K_2-1.25 mM were found to be below the acceptable potassium range of 2.5-5 percent at the 30 DAT period [4], and research published in their study from 14 percent of potassium of pepper; carrots and such in 20 vegetables [63]. Similar results were found by [64] where potassium fertilization did not affect significantly the total phosphorus concentration of senescent leaves. Most of the phosphorus fractions reached their highest concentrations at the lowest potassium treatment; however, higher potassium concentrations boosted pepper plant yield.

Assessment of Agriculture Using Chemical Fertilizers. Although field studies at 10 *g* pot^{-1} (T_2) CFR (14-14-14) and 10 *g* pot^{-1} Muriate of Potash (0-0-60) in the SFR-PB (T_3-T_6) were conducted during planting, evaluating the influence of potassium treatments (dose) in bell pepper crop produced a maximum of three fruits per plant at 10 g pot^{-1} treatments [59]. Although, the effects of different irrigation levels and potassium treatments on bell pepper growth and yield produced an average of 6.5 fruits plant^{-1} at treatments of 80 and 120 kg ha^{-1} [65]. Just from the other hand, a 10 *g* pot^{-1} treatment of a bell pepper yielded 117.13 and 118.38 kg ha^{-1} of average fruit weight with CFR (T_2) and a 100 % real holed portion of SFR-PB (T_6), respectively (Table 2). Regardless, all three macronutrients (NPK) were rapidly depleted in soil, N was the most quickly depleted or slow to become deficient. De-nitrifying bacteria degrade the soil by consuming available N. A lot of the available N was also sucked out by excessive agricultural use of the soil. When N levels were high, crops that develop roots, branches, and fruits, on the other hand, were the most likely to struggle [38]. Due to its nutritional and chemical characteristics, such as convention fertilizer, SFR-PB, and CRF, which were also reflected in the production of bell pepper seedlings [66], as well as bell pepper fruits [67], the substrate has a high potential as a fertilizer in agriculture, promoting a higher yield and increase in the content of photosynthetic pigments in the bell pepper crop [68].

4.2 Fruit Quality of Green Bell Pepper

Green bell pepper yields per hectare were evaluated and analyzed using soil fertility characteristics (Table 2). It demonstrates that the treatments with SRF-PB application of T_6 and T_2 yielded 12.42 and 11.82 t ha^{-1}, respectively, with a significantly high actual yield. In terms of computed yield, the T_6 treatment, followed by T_2, has a numerically larger value than the other treatments, particularly T_3, T_4, and T_5 (conventional and other SRF-PB treatments), and the T_0 treatment. T_6's computed yield of 12.42 t ha^{-1} was over double that of the average state production of green bell peppers, which was 9.8 t ha^{-1} or 4 t acre^{-1}, as stated by [69]. This suggests that the average yield of green bell pepper produced by using a 100 % SRF-PB treatment could outperform conventional and commercial CRF. However, compared to other industrialized countries, the Philippines' cabbage yield was relatively poor due to unbalanced fertilizer application or a lack of attention to N, phosphorus, and potassium [70]. Farmers may have been confident that the fertilizer they administered was being used to its maximum potential during the crop's producing phase.

5. Conclusions

According to the study's findings, significantly *($p < 0.05$)* affected the application of treatment the T_6 and T_2 treatments achieve a significantly better impact on yield (CFR and 100 percent of SRF-PB). The soil pH of treatments applied with control, commercial CRF, and SRF-PB technology ranges from medium acidic (T_0 and T_2 -T_6) and slightly acidic (T_1). On the other hand, OM content was discovered to be low among the treatments (T_0-T_4 and T_6) and desirable with T_5 of the percentage treatments. According to the N level, all of the locations were in the low range. The phosphorus was high in T_1-T_5 observed treatments, but not enough in T_0 and T_6. On the other hand, potassium was appropriate when it came to reducing T_0 and T_2, gradually growing at high T_6, and excessive when it came to rapidly raising T_1 and T_3 - T_5.

6. References

[1] Channabasavanna, A.S. and R.A. Setty. 2000. Influence of different Irrigation intervals on growth and yield of pepper pp: 5-9.

[2] Olalla, F., and J.A. Valero. 1994. Growth and production of bell pepper under different irrigation intervals. Research series Arkansas-Agric Experimental Station. pp: 125-128.

[3] Anonymous. 1989. Tomato and pepper production in the tropics. Asian Vegetable Research and Development Center, Taiwan.

[4] Hochmut, G.J., 1992. Concepts and practices for improving nitrogen management for vegetables. In: Proceedings of the Workshop Fertilizer Management in Horticultural Crops: Implications for Water Pollution. Hort. Technology 2 (1), 121–125.

[5] Olsen, J.K., Lyons, P.J., Kelly, M.M., 1993. Nitrogen uptake and utilization by bell pepper in subtropical Australia. J. Plant Nutr. 16 (1), 177–193.

[6] Allen, L.H., Jr. 1975. Shade-cloth microclimate of soybeans. Agron. J. 67:175–181.

[7] Kittas, C., N. Katsoulas, N. Rigakis, T. Bartzanas, and E. Kitta. 2012. Effects on microclimate, crop production, and quality of a tomato crop grown under shade nets. J. Hort. Sci. Biotechnol. 87:7–12.

[8] Moller, M., J. Tanny, Y. Li, and S.T. Cohen. 2004. Measuring and predicting evapotranspiration in an insect-proof greenhouse. Agr. For. Meteorology. 127:35–51.

[9] Valli, V., J.H.H. Bryan, and H.W. Young. 1965. The effect of shade on the bio-climate and production of vegetable crops. Fla. State Hort. Soc. Proc. 78:95–101.

[10] AAPFCO . Official Publication No. 48. Association of American Plant Food Control Officials, Inc.; West Lafayette, IA, USA: 1995.

[11] Shaviv, A.200l. Advances in controlled-release Fertilizers. Adv. Agron. 11:1-49.

[12] Trenkel, M.E. l997. Improving Fertilizers use efficiency. controlled--released stabilized fertilizers in agriculture. International Fertilizers Industry Association, Paris.

[13] Everett, H. 1977. Controlled release fertilizers: effect of rates end placements on plant stand, early growth, and fruit yield of peppers. Proc. Florida State Hort. Soc. 90:390- 393.

[14] Csizinszky, A.A. 1994. Yield response of bell pepper and tomato to controlled-release fertilizers on the sand. J. Plant Nutr. l7:1535-1549.

[15] Guertal, A. 2000. Preplant slow-release nitrogen fertilizers produce similar bell pepper yields as split applications of soluble fertilizer. Agron. J. 92:38U-393.

[16] Ombodi, A. and Saigusa, M.2000. Broadcast application versus band application of polyolefin-coated fertilizer on green peppers grown on Andisol. J. Plant Nutr. 23:1485-1493.

[17] Shaviv A. 2005. Controlled release fertilizers; Proceedings of the IFA International Workshop on Enhanced-Efficiency Fertilizers; Frankfurt, Germany. 28–30.

[18] Irfan, S. A., R. Razali, K. KuShaari, N. Mansor, B. Azeem, A.N. Ford Versypt, 2018. A review of mathematical modeling and simulation of controlled-release fertilizers. J. Contr. Release 271.

[19] Lustosa Filho, J.F., C.F. Barbosa, J.S. da Silva, and L.C.A. Carneiro. 2019. Melo, Diffusion and phosphorus solubility of biochar-based fertilizer: visualization, chemical assessment and availability to plants. Soil Tillage Res. 194.

[20] Lawrencia, D., S.K Wong, D. Low, B.H. Goh, J.K. Goh, U.R. Ruktanonchai, A. Soottitantawat, L.H Lee, and S.Y Tang. 2021. Controlled Release Fertilizers: A Review on Coating Materials and Mechanism of Release. Plants (Basel, Switzerland), 10(2), 238. DOI: https://doi.org/10.3390/plants10020238.

[21] Nelson, D.W. & L.E. Sommer. 1982. Total Carbon, Nitrogen, and Organic Matters In: a.l. page, hand D.R. keen (ends) methods of soil Analysis: part2.chemical a microbial Properties, Agron Manegr.9. (2nd ed.) ASA and SSSA, Madison

[22] PCARRD. 1980. Standard Methods of Analysis for Soil Plant Tissue, water and fertilizer. Los Baños Laguna, 194 pp.

[23] Bremmer. J.M, & Mulvancy, C.S. 1982. Nitrogen-total in: Page AL, Miller RH, keeny. OR (ed) Methods of soil Analysis, Chemical and microbiological properties, part2, 2nd edn ASA-SSSA, Madison Wi,. PLANTS database. United States Department of Agriculture. pp 595-624. Retrieved 2012-08-10.

[24] Abdallah, M.M.F. 2000. Improving vegetable transplants using soil solarization. III. Tomato ‘‘Lycopersicon esculentum’’. Arab Univ. J. Agric. Sci., Ain. Shams Univ., Cairo. 8 (3), 719–733.

[25] Loughran, J., A. Berry, and P. Mulhall. 2012. Understanding and Developing Science Teachers’ Pedagogical Content Knowledge. 2nd. Sense Publishers. Netherlands. ISBN 978-6091-821-6.

[26] Ibeawuchi, I.I., C.I. Duruigbo and E.U. Onweremadu, E.U. 2021. Effect of crop geometry and poultry manure rates on the growth and yield of yam/maize/cassava mixtures in a degraded ultisol. Nigeria. file:///C:/Users/Hp/Downloads/90582-Article%20Text-227767-1-10-20130711.pdf.

[27] Okunlola AI, Ogungbite OC (2016) Influence of Different Growth Media on the Morphometric Characters of Sansevieria liberica. Adv Crop Sci Tech 4:240. doi: 10.4172/2329-8863.1000240.

[28] Bickelhaupt, D. and R. Schmedicke. 2021. Instructional Support Specialist, Department of Forest and Natural Resources Management. State University of New York. https://www.esf.edu/pubprog/brochure/soilph/soilph.htm.

[29] Soil pH.2021. Adapted from "The Efficient Fertilizer Use Manual" by Synder, C. The mosaic company. https://www.cropnutrient.com/nutrien-management/soil-ph.

[30] Hudnall, W.H., 1991. Taxonomy of acid rice growing soils of the tropics. In: Deturck, P., Ponnamperuma, F.N. (Eds.), Rice Production on Acid Soils of the Tropics, pp. 3–8 Proceedings of an

International Symposium, 26–30 June 1989, Kandy, Srilanka. Institute of Fundamental Studies, Sri Lanka.

[31] Van Breemen, N., Driscoll, C.T., Mulder, J., 1984. Acidic deposition and internal proton source in acidification of soils and water. Nature 307, 599–604.

[32] Sejian, V., J. Gaugham, L. Baumgard and C. Prasad 2051. Climate Change Impact on Livestock; Adaption and Mitigation. Springer. ISBN 978-81-322-2265-1.

[33] Kumar, A., B.R. Maurya, R. Raghuwanshi. 2014. Isolation and characterization of PGPR and their effect on growth, yield and nutrient content in wheat (Triticum aestivum L.). Biocatal. Agric. Biotechnol. 3, 121–128.

[34] Swaminathan, M.S. 1984. Organic matter and rice. International of Rice Research Institute: Development of organic matter-based agricultural systems in South Asia by A. Venkataraman. Manila, Philippines. pp.57-78.ISBN971-104-104.

[35] Edwards, T. 2021. Agriculture and Food. Department of Primary Industries and Regional Development. Government of Western Australia. https://www.agric.wa.gov.au/measuring-and-assessing-soils/what-soil-organic-carbon?nopaging=1#skip-link.

[36] Hiel, M.P., M. Chelin, N. Parvin, S. Barbieux, F. Degrune, G. Colinet, A. Lemtiri, A. Degre, B. Bodson, and S. Garre. 2016. Crop residue management in arable cropping systems under temperate climate. Part 2: Soil physical properties and crop production. A review. Biotechnology, Agronnomy, Society and Environment. 20(S1):245-256.

[37] Ramos, M.C., S. Nacci, and I. Pla. 2003. Effect of raindrop impact and its relationship with aggregate stability to disaggregation forces. Catene. 53(4):365-376. DOI: 10.1016/S0341-8162(03)00086-9.

[38] Roberts, L.T. 2008. Improving nutrient use efficiency. Turkish Journal of Agriculture and Forestry 32(3):177-182.

[39] Anas, M., F. Liao, K.K. Verma, M. A. Sarwar, A. Mahmood, Z.L. Chen, Q. Li, X.P. Zeng, Y. Liu and Y.R. Li. 2020. Fate of nitrogen in agriculture and environment: agronomic, eco-physiological and molecular approaches to improve nitrogen use efficiency. Biological Research. Vol. 53, Article number: 47.

[40] Zhu, J.H., X.L Li, P. Christie, and J.L Li .2005. Environmental implications of low nitrogen use efficiency in excessively fertilized hot pepper (Capsicum frutescens L.) cropping systems. Agriculture, Ecosystems and Environment. 111:70-80.

[41] Stagnari, F., and M. Pisante. 2012. Slow release and conventional N fertilizers for nutrition of bell pepper. Plant, Soil and Environment. 58(6):268-274.

[42] Cetin, O., and C. Akinci. 2015. Effects of drought on optimizing nitrogen use of winter wheat in a semi-arid region. Agriculture & Forestry. DOI: 10.17707/AgricultForest.61.1.36.

[43] Wiertz, R., and F. Lenz. 1987. The growth and yield of pepper (Capsicum annum L.) depending on water and nutrient supply. Gartenbauwissenschaft. 52:39-45

[44] Abayomi, Y.A., M.O. Aduloju, M.A. Egbewunmi, and B.O Suleiman. 2012. Effects of soil moisture contents and rates of NPK fertilizer application on growth and fruit yields of pepper (Capsicum spp.) genotypes. International Journal of AgriScience. 2(7):651-663.

[45] Candido, V., V. Miccolis, A.R. Rivelli. 2009. Yield traits and water and nitrogen use efficiencies of bell pepper grown in plastic-greenhouse. Italian Journal of Agronomy. 3: 91-100.

[46] Stitt, M., and A. Krapp. 1999. The interaction between elevated carbon dioxide and nitrogen nutrition: the physiological and molecular background. Plant Cell Environ. 22:583–621.

[47] Good, A.G., A.K Shrawat, and D.G. Muench. 2004. Can less yield more? Is reducing nutrient input into the environment compatible with maintaining crop production? Trends Plant Sci. 9:597–605.

[48] Ding, L., K. Wang, G. Jiang, D. Biswas, H. Xu, L. Li, and Y. Li. 2005. Effects of nitrogen deficiency on photosynthetic traits of maize hybrids released in different years. Ann Bot. 96:925–30.

[49] Diaz, C, V. Saliba-Colombani, O. Loudet, P. Belluomo, L. Moreau, F. Daniel-Vedele, J-F Morot-Gaudry, and C. Masclaux-Daubresse. 2006. Leaf yellowing and anthocyanin accumulation are two genetically independent strategies in response to nitrogen limitation in Arabidopsis thaliana. Plant Cell Physiol. 47:74–83.

[50] Sanagi, M., S. Aoyama, A. Kubo, Y. Lu, Y. Sato, S. Ito, M. Abe, N. Mitsuda, M. Ohme-Takagi, T. Kiba, H. Nakagami, F. Rolland, J. Yamaguchi, T. Imaizumi, and T. Sato. 2021. Low nitrogen conditions accelerate flowering by modulating the phosphorylation state of FLOWERING BHLH 4 in Arabidopsis. Proceedings of the National Academy of Sciences, 118 (19).

[51] Kurt, K., and B. Emir, 2004. Effect of soil solarization, chicken litter and viscera on populations of soil borne fungal pathogens and pepper growth. Plant Pathol. J. 3 (2), 118–124.

[52] Cimen, I., B. Turgay, and V. Pirinc. 2010. Effect of solarization and vesicular arbuscular mychorrizal on weed density and yield of lettuce (Lactuca sativa L.) in autumn season. Afr. J. Biotechnol. 9 (24), 3520–3526.

[53] Syngenta. 2018. Interpreting Phosphorus and Potassium Levels. https://knowmoregrowmore.com/interpreting-phosphorus-and-potassium-levels/.

[54] Kaiser, D. 2020. Another look at phosphorus fertilizer application timing in soybean. Minnesota crop news. University of Minnesota Extension. https://blog-crop-news.extension.umn.edu/2020/03/another-look-at-phosphorus-fertilizer.html.

[55] Wroblewski, M.T. 2021. Nutrient Requirements of Pepper Plants. SFGate. https://homeguides.sfgate.com/nutrient-requirements-pepper-plants-64028.html

[56] Bray, M. 2020. Potassium In Peppers: The Fact And Fiction. https://www.pepperscale.com/potassium-in-peppers/

[57] Vigovskis, J., A. Jermuss, A. Svarta and D. Sarkanbarde. 2016. “The changes of soil acidity in long-

term fertilizer eksperiments”, emdirbystė. Agriculture, Vol.103 (2), pp. 129 - 134.

[58] Vigovskis, J., A. Jermuss, A. Svarta and D. Sarkanbarde. 2015. The changes of nutrient content in soil in long-term fertilizer experiments: Materials of the 10th international Scientific and practical Conference: “Environment. Technology. Resources.” Rezekne, Latvia, vol 2, pp. 329 – 332.

[59] Melo, A.S, M.E.B. Brito, J.D.M Dantas, C.D. Silva Júnior, and P.D. Fernandes. 2009. Yellow pepper yield and quality under potassium levels in a greenhouse. RBCA 4: 17-21.

[60] Frizzone, J.A. P.S.L Freitas, Rezende, and M.A Faria. 2012. Micro irrigation: drip and micro sprinkler. Eduem , Maringa , Parana.

[61] Almuktar, SAAAN and M. Scholz. 2016. Experimental assessment of recycled diesel spill-contaminated domestic wastewater treated by reed beds for irrigation of sweet peppers. International Journal of Environmental Research and Public Health. 13: 1-20.

[62] Marcussi, F.F.N, L.G Godoy, and R.L Villas Boas. 2004. Nitrogen and potassium fertigation in sweet pepper culture based on N and K accumulation by plants. Irriga 9: 41-51.

[63] Esther, G and N.J. Newark. 2011. Dirt Poor: Have Fruits and Vegetables Become Less Nutritious? British Food Journal of 1930 to 1980. Scientific American Arabic. Springer Nature America, Inc.https://www.scientificamerican.com/article/soil-depletion-and-nutrition-loss/

[64] Baghour, M., E. Sánchez, J. M. Ruiz, and L. Romero. 2001. Metabolism and efficiency of phosphorus utilization during senescence in pepper plants: Response to nitrogenous and potassium fertilization. Journal of Plant Nutrition, 24(11): 1731-1743.

[65] Albuquerque, F.S, E.F.F Silva, JAC Albuquerque Filho, M.F.N Nunes. 2011. Growth and yield of pepper fertigated under different irrigation depths and potassium doses. Agriambi. 15: 686-694.

[66] Rodriguez-Canche, L.G., L. Cardoso-Vigueros, J. Carvajal-Leon, C. de la, and S. Poot Dzib. 2010. Production of habanero pepper seedlings with vermicompost generated from sewage sludge. Compost Sci. Util., 18, 42–46.

[67] Tzortzakis, N., S. Gouma, E. Dagianta, C. Saridakis, M. Papamichalaki, D. Goumas, and T. Manios. 2012. Use of fertigation and municipal solid waste compost for greenhouse pepper cultivation. Sci. World J. , 973193.

[68] Berova, M., G. Karanatsidis, K. Sapundzhieva, and V. Nikolova. 2013. Effect of organic fertilization on growth and yield of pepper plants Capsicum annuum L. Folia Hortic., 22, 3–7.

[69] Zandstra, B.H. 2016. Peppers: Commercial Vegetable Recommendations (E1815). Michigan State University. Accessed from https://www.canr.msu.edu/resources/peppers_commercial_vegetable_recommendations_e1815 on May 17, 2019 at 11:42 am.

[70] Islam, A. F. M. S., Forooque, A. M., Islam M. N. and Nasiruddin. K. M. 1989. Effect of age of seedlings and spacing on the performance of cabbage. Bangladesh Horticulture, 17(2): 25-29.