INFLUENCE OF CLYBIO AND ECOAGRA CONCENTRATION ON GROWTH AND YIELD OF POTATO (*Solanum tuberosum* cv. Lalpakri)

RUMANA RAHMAN TUSI

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY

RUMANA RAHMAN TUSI

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APPROVED BY:

Prof. Dr. A.F.M. Jamal Uddin
Department of Horticulture
SAU, Dhaka
Supervisor

Prof. Dr. Mohammad Humayun Kabir
Department of Horticulture
SAU, Dhaka
Co-Supervisor

Prof. Dr. Khaleda Khatun
Chairman
Examination **C**ommittee

In the name of Allah, The Most Gracious and The Most Merciful.
Most [All] praise is [due] to Allah, Lord of the worlds.
The Entirely Merciful, the Especially Merciful,
(Surah Fatiha 1:1-3)

DEDICATED TO
MY BELOVED PARENTS

Department of Horticulture
Sher-e-Bangla Agricultural University
Sher-e -Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled ***"INFLUENCE OF CLYBIO AND ECOAGRA CONCENTRATION ON GROWTH AND YIELD OF POTATO (Solanum tuberosum cv. Lalpakri)*** *submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE in HORTICULTURE****, embodies the result of a piece of authentic research work carried out by* ***RUMANA RAHMAN TUSI,*** *Registration No.* ***19-10173*** *under my supervision and guidance. No part of the thesis has been submitted to any institute for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: June, 2021
Dhaka, Bangladesh

Dr. A F M Jamal Uddin
Professor
Department of Horticulture
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka- 1207
Supervisor

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- ***Author***

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ABSTRACT

A field experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2019 to February 2020 to evaluate the influence of clybio and ecoagra concentrations on growth and yield of lalpakri. The experiment was consisted of nine treatments namely T_0: Untreated (control); C_1: Clybio @ 1.0 ml/L; C_2: Clybio @ 2.0 ml/L; E_1: Ecoagra @ 1.0 ml/L; E_2: Ecoagra @ 2.0 ml/L; C_1+E_1: Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C_1+E_2: Clybio @ 1.0 ml/L + Ecoagra @ 2.0 ml/L; C_2+E_1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C_2+E_2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L. All the treatments were applied to the soil of potato field along with leaves of potato plants. The single factorial experiments were laid out in Randomized Complete Block Design with three replications. Among the treatments maximum number of tuber (15.3/hill), tuber length (46.8 mm), tuber diameter (45.7 mm), individual tuber weight (29.4 g), yield (451.0 g/hill), yield (30.07 t/ha) was found in the case of C_2+E_2 treatment. On the other hand minimum number of tuber (11.3/hill), tuber length (31.2 mm), tuber diameter (31.0 mm), individual tuber weight (12.4g), yield (138.7 g/hill), yield (9.2 t/ha), was found from T_0 treatment. In view of overall performances, C_2+E_2 treatment that implies Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L provided the best result for growth and yield attributes.

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ABBREVIATIONS AND ACCORONYMS

AEZ = Agro-ecological Zone

Agric. = Agricultural

ANOVA = Analysis of Variance

BARI = Bangladesh Agricultural Research Institute

Biol. = Biology

CV = Coefficient Variance

DAP = Days after Planting

EPB = Export Promotion Bureau

et al. = And others

GDP = Gross Domestic Product

Hort. = Horticulture

J. = Journal

LSD = Least Significance Difference

mm = Millimeter

RCBD = Randomized Complete Blocked Design

Res. = Research

SAU = Sher-e-Bangla Agricultural University

Sci. = Science

SRDI = Soil Resource Development Institute

Technol. = Technology

UPOV = Union of Protection of Plant Varieties

Viz. = Namely

CHAPTER I

INTRODUCTION

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INTRODUCTION

Potato (*Solanum Tuberosum* L.) belongs to the family Solanaceae, which is originated from the Andean region (Hawkes, 1978). It is the 3rd most consumed food crops in the world just after rice and wheat (Champouret, 2010). Potato is considered the king of all vegetables because of taste and nutrition and demand. Now it is one of the staple foods in Bangladesh. In many countries, including those of Europe, America, and Canada, potato is a staple food. The potato is herbaceous annual plant and propagated by planting pieces of tuber. Tuber is rich in starch and is good source of protein, Vit-B, Vit-C, potassium, phosphorus and iron. In Bangladesh, potato is used as vegetables, chop, chips, flakes, French fry and so on. The total area and production of potato of the country in 2016-2017 was 1.24 million acre and 10.22 million tons, respectively (BBS-2017). Bangladesh Agricultural Research Institute (BARI) has developed more than 81 varieties of potato in Bangladesh. Besides these, local varieties like Lalpakri, Dolhazari, Lal Kaberi, Shilbilati,etc. produce acceptable yield and also play an important role in increasing the agricultural production in Bangladesh(Ahmed and Kader,1981). These indigenous potato varieties are highly priced and popular with the elite families.

In recent years, the Tuber Crops Research Centre of BARI has collected many new varieties of potato from the International Potato Research Centre, Peru, and from other sources. The Centre has already made good contribution towards the development of some high yielding potato varieties. Though constant evaluation of the traits, varietal performance, and considerations of other characteristics, about 10 HYV have been released for cultivation in the country. However, most of the HYV are disease and pest sensitive. On the other hand, most of our indigenous variety of potato are less disease sensitive and can be grown with minimum care and most of them are suitable for our environmental condition.

In agricultural industries, chemical fertilizers and synthetic pesticides are dramatically used to enhance crop production. The excessive use of agricultural chemicals deteriorates the soil quality and is one of the major constraints in improving crop productivity (Dwivedi and Dwivedi,2007), and pollutes the air, water, and soil leads to serious health problems. In the recent era, consumer preference for organic and safe production as well as public concerns about the negative effects of chemicals fertilizer on the environment and human health are increasing. Therefore, the use of Organic amendments acts as a sustainable tool to recovery fertility in intensive agricultural systems without negative effects on human health and the environment (Scotti *et al*., 2015). Organic fertilizers reduce soil erosion (Shahvali and Abedi, 2006), and saline and sodium problems as a result of indiscriminate chemical fertilization and irrigation (Allahyari *et al*., 2008). Due to their safe and environment-friendly nature, bio-fertilizer applications are increasing day by day. Bio-fertilizer application is very efficient for organic and safe crop production (Uddin *et al.*, 2019). The use of organic fertilizer increases plants vegetative growth and yield (Rakibuzzaman *et al.,* 2019). Furthermore, various studies on horticultural crops have shown that the use of beneficial microorganisms improves vegetative growth and boosts crop yield (Uddin *et al.,* 2020, Rakibuzzaman *et al*., 2021) and suppress diseases (Rakibuzzaman *et al.,* 2021).

Clybio is the unique and complex microbe that contains bacteria like Lactobacilli bacteria, Lactic acid bacteria, Bacillus natto bacteria, and yeast fungus. Lactic acid bacteria (Shrestha *et al.,* 2014), Bacillus bacteria (Tiwari *et al*., 2019), Yeast (El-Tarabily and Sivasithamparam, 2006) are a fruitful factor to maintain ecology, efficient bio-fertilizer that increases soil fertility, bio-control agent against bacterial diseases and have bio stimulating effect to promote growth and yield. Lactobacillus bacteria have bio-stimulating effect to promote growth, yield and obviously for quality. Lactic acid bacteria act as plant growth promoting bacteria. Bacillus Natto bacteria has been known to have potent antibacterial function and was used for the treatment of bacterial infectious diseases (Senbon *et al*., 1940).Yeast Fungus can promote plant growth and health through arrange of mechanisms, including supplying plants with biologically fixed nitrogen, phytohormones, volatiles, defense compounds and enzymes.

Besides, various studies of horticultural crops also shown that bio-preferred growth enhancer may promote vegetative growth and yield. Eco-Agra is one kind of bio preferred growth enhancer. It is nonmaterial's and cleansing molecules which potential for sustainable agriculture (Rakibuzzaman *et al.,* 2018) also allows entering the plant cells of the leaves, which causes an accelerated increase in photosynthesis. Eco-Agra provides many of the benefits as fertilizers but it is not classified as such because its main function is not provides nutrients to the soil or plant, its delivers trace amount. It also delivers dissolving NPK from the roots, thereby enhancing nutrient uptake. In turns, ecoAgra will stimulate the root growth of the plant, which improves the health and yield of the plants.

Considering the above facts, the present study was undertaken with the following objectives:

1. To evaluate the influence of Clybio concentrations on growth and yield of lalpakri potato.

2. To determine the influence of Ecoagra concentrations on growth and yield of lalpakri potato.

3. To determine the combined application of clybio & ecoagra on growth & yield of lalpakri potato.

CHAPTER II

REVIEW AND LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Potato (*Solanum Tuberosum* L.) is one of the most important vegetable crops in Bangladesh. Potatoes are staple plants as the fourth largest carbohydrate source in the world after rice, wheat, and maize, so they can support food diversification programs. Potatoes are one of the leading commodities that have good National and International market prospects. Farmers generally apply chemical fertilizers, pesticides, fungicides for better yield on potato field. During last four decades indiscriminate use of inorganic fertilizers, pesticides and fungicides caused environmental pollution, especially into the soil there by affecting its fertility on long term basis (Das *et al*., 2015). To avert this situation, reduced use of fertilizers without compromising on yield and quality can be achieved if the nutrient supply through organic manure and biofertilizer are used (Sheeba *et al*., 2015). Moreover, Effective microorganisms (EM) are mixture of some beneficial microorganisms. Application of EM has influences on growth, yield and yield contributing characters of potato as well as other vegetables. Adoption of organic farming has been increased which have a reduced impact on environment. Some of the significant research work have been done home and abroad related to this experiment have been presented (Year wise) in this chapter.

Rakibuzzaman *et al*. (2021) indicated that excess use of chemical fertilizers and synthetic chemicals to increase the growth and yield as well as controlling disease often reduced soil fertility, adversely affect human health and environment and accomplished an experiment in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2016 to March 2017 to study the impact of Trichoderma application as bio-stimulator on potato production. The study comprised of three Trichoderma treatments, (i) T0= No Trichoderma application, (ii) T1=

106spores/ml and (iii) T2= 108spores/ml. Trichoderma 1ml/L (1000 ppm) solution was applied two times in each plot at 15 and 45 days after planting (DAP). Data on growth yield and disease suppression parameters showed significant variation. The results explained that application of Trichoderma increased the growth attributes positively and produced 23.82% and 11.33% higher yield in T2 and T1 compared to no application of Trichoderma, respectively. Trichoderma (108spores/ml) improved tuber yield by optimizing the dry matter content. Furthermore, application of Trichoderma decreased the disease infestation and the best result (1.60%) recorded in T2. Therefore, 108spores/ml of Trichoderma application can be considered the potential bio-stimulator for prospective potato production with higher growth, yield, and suppress of disease.

Rakibuzzaman *et al*., (2021) conducted a field experiment was conducted in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2016 to March 2017 to study the performance of potato germplasm with the bio-stimulating effect of Trichoderma application on potato production. Potato germplasm viz., G1 (Sokal), G2 (Bijita), G3 (JP Blue yellow), G4 (JP Blue white), G5 (Burma-1), G6 (Burma-2), G7 (Cardinal as check), and Trichoderma application: T0 (No application), T1 (Once application), T2 (Twice application) were used in this experiment arranged in Randomized Complete Block Design with three replications. Data on different growth and yield attributes were showed significant variations. Among them, the highest plant height, maximum leaf number, SPAD value, stem number, tuber length, tuber weight observed in germplasm Sokal with twice application of Trichoderma. Highest yield per hectare (38.92 t) were found in G1T2 and lowest (21.7 t) in G4T0. In view of overall performances, germplasm G1 with twice application of trichoderma (G1T2) has the potentiality for potato production with higher vegetative growth and yield.

Fusarium solani (*F. solani*) is one of the most important pathogenic fungi that bring out Fusarium dry rot and Fusarium wilt in potato, responsible for low potato yield globally. However, the mechanistic understanding regarding the biocontrol of *F. solani* remains largely unknown. Here, Mehmood *et.al.,* (2021) observed the plant growth-promoting and antagonistic capability of *Bacillus* sp. PM31 against phytopathogen *F. solani.* The *Bacillus* sp. PM31, isolated from field-grown potato was analyzed for plant growth-promoting and extracellular enzyme activities. The strain PM31 exhibited phosphate, zinc, and potassium solubilization, nitrogen fixation, siderophore, exopolysaccharides production, and extracellular enzyme activities. The mycelial growth of *F. solani* was inhibited by strain PM31 with inhibition coefficient of 47.5. Under the storage conditions, inoculation of strain PM31 minimized the development of dry rot symptoms by 57% as compared to uninoculated diseased tubers. Under greenhouse conditions, inoculation of strain PM31 enhanced potato plant growth under fungal stress, while reduced the development of wilting, foot rot, chlorosis, and necrosis of inoculated potato plants by 92%, 75%, 64%, and 82%, respectively, as compared to diseased plants. Results inferred that the inoculation of native antagonistic *Bacillus* sp., PM31, could favor in global food security through biocontrol of important potato diseases *viz*. Fusarium dry rot and Fusarium wilt.

Potassium solubilizing bacteria (PSB) are capable to dissolve K from K-minerals and enhance plant growth and yield. A field experiment was conducted by Ahmed *et al.*, (2021) during 2017/2018–2018/2019 growing seasons in a randomized complete block design (RCBD) with three replicates. This study aims to evaluate the performance of bio-fertilization (*Bacillus cereus*) as PSB on the growth of potato (Kara Spp) and availability of N, P, and K. Potato plants were fertilized with K-feldspar and inoculated with PSB. The results showed that the PSB significantly increased the plant height (PH), branches number (BN), and shoot dry weight by about 15%, 27%, and 26%, respectively, compared to the untreated one. Soil available K increased by 42%

as a result of PSB inoculation, moreover, K uptake by potato tubers increased by 62% in compassion with untreated plants. Leaf N, P, and K concentrations as well as the uptake were significantly increased in the plants inoculated with PSB compared to the un-inoculated plants. The graded weights of potato were increased by 20%, 26%, and 25%, for large, medium, and small size of tubers, respectively as a result of applying of bio-fertilizer. The bio-fertilization of potato with *Bacillus cereus* significantly increased the total yield of potato by 21% above the untreated plants. The application of K-feldspar (12% total K_2O) at a rate of 240 kg K_2O ha^{-1} to potato .

Uddin *et al.,* (2020) carried out a pot experiment on the rooftop of Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2019-February 2020, to study the efficacy of Eco-Agra on organic cherry tomato production. The study was accomplished with three replications following completely Randomized design. The experiment comprised of three treatments: (i) No Eco-Agra application (E0), (ii) Eco-Agra 2ml/L (E1) and (iii) Eco-Agra 4ml/L (E2); at 20 days' interval. Data on growth and productivity were taken. The results showed that Eco-Agra 4ml/L application had a synergistic effect on growth attributes positively and influenced to produce 89.0% higher yield compared to control treatment. Eco-Agra 4ml/L application also showed an increase in Brix percentage and maximum (7.2) recorded. Therefore, Eco-Agra application could be the effective technique for organic cherry tomato production with higher yield.

A field research on "Effect of potassium mobilizing bacteria on growth and yield of potato (*Solanum tuberosum* L.) in loamy sand" was carried out by *Chaudhary et al.,* (2019) at the Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardar krushinagar Dantiwada Agricultural University, Sardar krushinagar during rabi season of 2017-18. The soil of experimental plot was loamy sand in texture, neutral to alkaline in reaction and soluble salt content under safe limit. It was low in organic carbon and available N; medium in available P2O5, K2O, S and DTPA-extractable Fe and

Zn and having sufficient DTPA- extractable Mn and Cu status. The results showed that an application of 75% RDK along with soil application of KMB (potassium mobilizing bacteria) i.e. Frateuria aurentia (T7) was significantly higher which was par with 100% RDK (T1) and 75% RDK + soil application of KMB strains i.e Enterobacter asburiae + Frateuria aurentia (T8) significantly enhanced grade wise tuber yield such as small, medium and large size, total tuber yield as well as haulm yield of potato over rest of treatments. Similar trend was also observed in case of total tuber yield on dry weight basis. The improvement in total tuber yield was the tune of 6.42 percent over T1 treatment.

Abdel-Gawad and Youssef (2019) investigated that a study was conducted at Experimental Farm, Faculty of Agriculture, Al-Azhar University, Egypt during the winter season of 2017 to 2018. The purpose was to evaluate the response of Faba bean to foliar application of yeast extract, Bio-fertilizer and Humic acid. Results showed that foliar application of Yeast extract (10 g/L) increased growth and yield significantly.

Al Rubaye *et al*. (2019) directed a field experiment that was carried out in loam soil at the research station of the College of Agriculture University of Baghdad, using randomized complete block design. The experiment included three local biofertilizers types **(***Bacillus megaterium***,** *Pseudomonas fluorescens***,** *Azotobacter chrococcum***)** and an imported biofertilizer (Nitrosoil) by Iraqi's Ministry of Agriculture, beside, two levels of mineral fertilization (50% and 75%) of the mineral fertilizer recommendation with use of two types of carriers (corn cobs residue, broth liquid medium) in addition to the control treatments. Three replicates for each treatment were used on growth and yield of potato. The results showed a significant effect of biofertilizer in most of the studied traits. The results also showed that use of local biofertilizer with (75%) of mineral fertilizer increased plant height, dry weight of the total vegetables part of plants and total yield tuber with value reached 73.53 cm, 2.48 and 21.97 Mg ha^{-1} 12.33 respectively, compared with the imported biofertilizer and control treatments, while the results showed that the use of half of the fertilizer recommendation with local bio-fertilization carried with liquid medium was sufficient to reach the best amount of nitrogen and phosphorus concentration by the plants in which the value reached to 2.62%, 0.79% compared to imported biofertilizer treatment which showed superiority in the amount of potassium absorbed to the same level of the recommendation and the value was 1.20%.

Kantikowati et al., (2019) conveyed a experiment that aimed to evaluate the characteristics of growth and yield of potato due to the application of chicken manure and biofertilizer. The research began on from February until June 2018, in Pangalengan. The study arranged as factorialized randomized block design, consisted two factor with three replications. Chicken manure dosage (k1 = 5 ton ha-1 , k2 = 10 ton ha-1 , k3= 15 ton ha-1) and Biofertilizer concentrate (h1 = 2,5 mL L-1 , h2 = 5,0 mL L-1 , h3= 7,5 mL L-1). The measured parameters were the growth (plant height, number of stem, number of leaf) and yield of potatoes (weight number of tuber, weight of tuber per plot, number of tuber per plant, weight of tuber, potato weight classification).The result revealed that the interactions between the chicken manure dosage and biofertilizer concentrate affected the number of potato tubers per plant, weight of potato tubers per plant, and potato yield per plot. The maximum yield (55.30 kg per plot) was obtained by combination k2h3 (chicken manure dosage 10 ton ha-1 and biofertilizer concentrate 7,5mL L-1). These findings concluded that the chicken manure combined with biofertilizers could be applied to increase the growth and productivity of potatoes.

Robert M. Harveson (2019) conveyed an experiment in which five different procommercially available copper compounds (Kocide and MasterCop). The new alternatives included two growth-promoting chemicals (Ecoagra A300, WakeUP Summer), and three contact sanitizers (Goldshield 5, SaniDate, and OxiDate). Treatments with SaniDate and Ecoagra A300 more consistently produced higher yields than other treatments. The experiment resulted that Kocide and Ecoagra A300 produced significantly higher yields after harvest than any other treatment. However, yields for Ecoagra A300 increased more than 400 ka/ha compared with the Master Cop treatment or almost 300 ka/ha compared with the nontreated control. Again, two specific products (SaniDate and Ecoagra A300) more consistently produced higher yields than other treatments. The Ecoagra A300 product apparently enhances vigor and plant growth, allowing improved total seed yields.

Abdel-Naby *et al*. (2018) conducted two field experiments during the two successive summer seasons of 2016 and 2017 at a private farm near Kafr saad center, Damietta Governorate, Egypt to study the impact of NPK fertilization at (100%, 50% and 0% NPK of the recommended doses) and some bio-stimulants (without, effective microorganisms (EM) 2ml/L, microbial mixture 1L/20L, yeast extract 10g/L and seaweed extract 1g/L) as well as their interaction on yield and its components and quality parameters of sweet potato plants Abees cultivar. Obtained results revealed that increasing NPK fertilization levels from 0% to 100% of the recommended doses gave significant increments in total yield/fed, dry matter and quality parameters *i.e.* crude protein (%), total carbohydrates (%), starch%, total sugar %, beta-carotene and vitamin-C (vit.c) in tuberous roots of sweet potato in the two seasons. All bio-stimulants treatments increased significantly of all the previous mentioned parameters and decreased nitrate and nitrite contents in tuberous roots compared with untreated plants, EM gave the best values of all studied parameters. Doses 100 % and 50 % NPK plus EM gave the best significant increases in the studied parameters in both seasons and the interaction between 0% NPK plus EM decreased significantly nitrate and nitrite contents in the both seasons.

Trdan *et al*. (2017) conducted a field experiment to test the influence of a mixture of two plant growth promoting bacteria (Pseudomonas fluorescens and Azospirillum brasilense) on the yield of three potato varieties. In addition, the influence of the mixture on potato susceptibility to infection by the pseudofungus Phytophthora infestans and fungus Alternaria solani and to attacks by the Colorado potato beetle (Leptinotarsa decemlineata) was investigated. It was the first experiment of its kind in Europe. In the unusually hot and dry year, a positive influence on the yield (17%–31%) was found in all three varieties when the tubers were soaked in the bacterial mixture prior to sowing. It was noticed no significant differences in potato resilience/susceptibility to harmful organisms among the different treatments (soaked tubers, sprayed tubers, untreated tubers); however, there were significant differences in the productivity between the tuber varieties. The results of this experiment indicate the bacterial mixture used in this study has a high potential to support satisfactory potato yields under dry conditions and under low levels of infection by foliar fungal diseases and attacks by foliar insects.

Singh *et al.,* (2017) reported that infliction of different bio-fertilizers alone or in combination with others as seed, soil and foliar spray showed that the bio-fertilizers have stimulatory effect on germination, sprouting behavior and growth parameter of potato. The maximum germination and number of bud with 5 in number per tuber was recorded from T7 treatment in which treatment was given as soil application FYM @ 150gm/pot + Mustard cake @ 150 gram/pot + tuber treatment with T. viride + foliar spray with bio-formulation of T. viride. It was also cleared that bio-fertilizers have stimulatory effect on vigour of plants. The maximum plant height was recorded in treatment T7 (soil application of mustard cake + tuber treatment and foliar spray with T. viride) with the value of 11.16cm at 30 day age of plant followed by treatment T4 (soil application of mustard cake + tuber treatment and foliar spray with Azotobacter), T1 (soil application of neem cake + tuber treatment with PSB), representing value of 11.06cm and 10.73cm, respectively. The effect of seed treatment and foliar spray with bio-fertilizer on tuber size and yield was recorded that maximum number of large size tubers (5) and yield (844.85gm) was found in T7 treatment, where treatment was given as soil application FYM @ 150gm/pot + mustard cake @150gm/pot + tuber treatment with T. viride + foliar spray with bio-formulation of T. viride.

Karunarathna and Seran, (2016) conducted a study to assess the effect of effective microorganisms (EM) along with cattle manure on growth and yield of capsicum (Capsicum annum L.) at the Crop farm, Eastern University, Sri Lanka. Six treatments with three replications were arranged in a Randomized Complete Block Design. The treatments were T1: Inorganic fertilizer application, T2: No fertilizer application, T3: Cattle manure 5 t/ha + EM, T4: Cattle manure 10 t/ha + EM, T5: Cattle manure 15 t/ha + EM and T6: Cattle manure 20 t/ha + EM. The results showed that there was no significant difference in canopy height among the treatments up to 20 DAT. Remarkable variations in number of leaves per plant at 10, 20 and 30 DAT which was confirmed with P values of 0.197, 0.700 and 0.075 and chi-square of 7.33, 3.00 and 10.00 respectively. The diameter of pod was increased up to 3^{rd} picking thereafter it was decreased in most of the treatments. Increasing cattle manure from T3 to T4 increased number of pods per plant. Fresh weight of pods, number of seeds per pod and dry weights of pods and seeds were high in T4.

Shih-Feng *et al*. (2016) used yeasts as plant growth-promoting (PGP) agents in their experiment. In this experiment, yeast isolates from the phyllosphere and rhizosphere of the medicinally important plant Drosera spatulata Lab. were assessed for their PGP traits. All isolates were tested for indole-3-acetic acid-, ammonia-, and polyamine-producing abilities, calcium phosphate and zinc oxide solubilizing ability, and catalase activity. Furthermore, the activities of siderophore, 1-aminocyclopropane-1-carboxylate deaminase, and fungal cell wall-degrading enzymes were assessed. The antagonistic action of yeasts against pathogenic Glomerella cingulata was evaluated. The cocultivation of Nicotianabenthamiana with yeast isolates enhanced plant growth, indicating apotential yeast–plant interaction.

Kang (2016) directed a study on the govern of Lactobacillus in Modern Agriculture Practice using Lactobacillus to fortified fertilizer, put them in the land, cultivation improves. It also allows for slow release of nutrients found in the rhizosphere to be absorbed by the plants slowly over time. The roots become healthy upon inspection and exudates composition dependent and disease suppressive soil allows for a progressive soil remediation. Most amazing the farmers also attested to the benefits of using lactobacillus, such as being able to grow low land crops in the highland and vice-versa.

538 yeast strains were isolated from dark chestnut soil elected from under the plants of the legume family (Fabaceae). Among the 538 strains of yeast 77 (14.3%) strains demonstrated the ability to synthesize IAA. 15 strains were attributed to high IAA-producing yeasts (above 10 μg/ml). The most active strains were YA05 with 51.7 ± 2.1 μg/ml of IAA and YR07 with 45.3 ± 1.5 μg/ml. In the study Ignatova, L.V. *et al*. (2015) observed the effect of incubation time on IAA production the maximum accumulation of IAA coincided with maximum rates of biomass: at 120 h for YR07 and at 144 h for strain YA05. 10 strains demonstrated the ability to inhibit the growth and development of phytopathogenic fungi. YA05 and YR07 strains made the largest zones of inhibition compared to the other strains – from 21.6 ± 0.3 to 30.6 ± 0.5 mm. Maximum zone of inhibition was observed for YA05 against Phytophtora infestans and YR07 strains against Fusarium graminearum.

Kang *et al*. (2015) carried out a study to find out the effect of plant growth promoting microorganisms on cucumber. Rhodobacter sphaeroides, Lactobacillus plantarumand Saccharomyces cerevisiae microorganisms were used as treatment. Result showed that treatment with all three bio-inoculants significantly increased the shoot length, root length, shoot fresh weight, shoot dry weight, and chlorophyll content, via secretion of IAA and organic acids. Inoculation with R. sphaeroides had more positive effect on plant growth than did inoculation with L. plantarum or S. cerevisiae, by significantly enhancing gibberellin and reducing abscisic acid contents.

Olle and Williams (2015) directed an experiment at the Estonian Crop Research Institute during 2014 to evaluate the influence EM on growth and nitrate content of cucumber, pumpkin and squash. Two treatments were T1: Without EM and T2: With EM. Result revealed that Plant height (cm), stem diameter (cm) and yield of cucumber, pumpkin and squash were highest at T2.

To investigate the potential relevance and practical infliction of rhizophagy, Lonhienne *et al*. (2014) investigated brewers' yeast (Saccharomyces cerevisiae), a waste product of the brewing industry, for its role as biofertilizer. The addition of live or dead yeast to fertilized soil substantially increased the nitrogen (N) and phosphorus (P) content of roots and shoots of tomato (Solanum lycopersicum) and young sugarcane plants.Yeast addition to soil also increased the root-to shoot ratio in both species and induced species-specific morphological changes that included increased tillering in sugarcane and greater shoot biomass in tomato plants. These findings support the concept that brewers' yeast is a cost effective biofertilizer that improves not only plant nutrition but also plant vigor during the early growth phase.

Wu *et al*. (2013) indicated that the primary obstacles for potato production are the high demands of fertilizers and the occurrence of widespread diseases. Traditional intensively managed agro-ecosystems depend on fertilizers and biocides, which could induce soil degradation and environmental problems. This review mark the effects of inoculating crops with plant growth promoting bacteria, endophytes, especially arbuscular mycorrhizal fungi (AMF), as well as the potential application of these microbes in the establishment of a sustainable potatoes cultivation system. It was terminated that it is worth to isolate the most efficient microbial strains during the process of microbial diversity investigations. And it is also worth to apply flavonoids and other stimulators to promoter beneficial microbes growth since emerging evidence implies that these compounds can stimulate native mycorrhizal activity and subsequent potato yield. In summary, more practical application of biofertilizers and bio-control methods should be encouraged to facilitate potato production.

Olle and Williams (2013) gathered data from various scientific papers and indicated that effective microorganisms (EM) had positive effect on the growth of vegetables while in other 30% they had no significant influence. Investigation among 22 reports on the effect of effective microorganisms (EM) on vegetables 84 % showed positive effect, 4% negative effect and 12 % showed no significant effect.

Agamy *et al*. (2012) investigated that the use of yeast as a bio-fertilizer in agriculture has received considerable attention because of their bioactivity and safety for human and the environment. They evaluated the effect of soil amendment with three newly isolated yeast strains on the productivity and the external and internal structure of sugar beet to prove their application as bio-fertilizer. A two-year pot experiment was conducted to investigate the effects of Kluyveromyces walti, Pachytrichospora transvaalensis and Sacharromycopsis cataegensis on the growth and productivity of sugar beet. Soil was inoculated with three doses of each strain (0.0, 50.0 and 100.0 ml pot-1 with concentration of ~108 cfu ml-1). Results revealed that application of the yeasts significantly increased the photosynthetic pigments and soluble sugars of sugar beet. K. walti showed the best results among the three yeasts. It increased the sucrose content by about 43% of the control. Anatomy of the leaf and the root showed an increase in thickness of the blade and mid vein as the result of application of yeasts. They assume that application of K. walti, P. transvaalensis and S. cataegensis as biofertilizers is a good alternative of the chemicals in the sustainable and organic farming.

Fawzy *et al*. (2012) directed two field experiments at Wady Elmollak, Ismailia Governorate, Egypt in two successive seasons of 2009 to 2010 and 2010 to 2011. The target of the study was to assess the foliar effect of EM, amino acids and yeast on growth and yield of on onion. Two cultivars Giza 20 and Super X were used. There was ten treatments control (spray with tap water), EM1 (1cm/L), EM2 (2cm/L), EM3 (3cm/L), AG1 (1 cm/L), AG2 (2 cm/L), AG3

(3cm/L), Y1 (1gm/L), Y2 (2gm/L) and Y3(3gm/L). Results showed that Giza 20 gave the highest amount of vegetative growth plant height (51.23 cm; 42.23 cm) in the two seasons. With regard to foliar application treatments the results indicated that using EM, amino acids and yeast had positive promoting effects by providing supplemental doses of these components on growth, yield and its quality as well as all chemical composition compared with control plants. It may be concluded that using yeast at rates of Y3 gives the highest growth parameters. However, using EM at rates of EM3 gives the highest yield (15.69 t/ha).

Ahmed et al., (2011) carried out two field experiments during the two successive winter seasons of 2007 and 2008 at the experimental station of the Agriculture Research Center (ARC), Kafr El-Zayat, El-Gharbia Governorate, Egypt to investigate the response of potato plant (*Solanum tuberosum* L.) cv. Valor to the effects of foliar application of yeast and zinc on vegetative growth, yield and zinc on vegetative growth, yield and tubers quality as well as chemical constituents of potato plant. The experiment included 24 treatments representing the interaction of six active yeast extract treatments (0, 1, 2, 3, 4 and 5 g/l) with four zinc treatments (0, 100, 200 and 300 ppm). Results revealed that increasing of foliar application of active dry yeast concentration up to 5g/l increased the vegetative growth characters of potato plants in terms of plant length, stem and leaves number/plant, leaf area/plant fresh and dry weight of whole plant. Moreover, increasing of zinc concentration up to 300 ppm increased the vegetative growth characters as mentioned above. Addition of foliar spray of yeast at 5 g/l. along with foliar spray of zinc at 300 ppm resulted in the highest values of the above mentioned plant growth characters. Increasing of the yeast concentrations were gradually increased the productivity of potato plants. Also, tubers quality in terms of specific gravity, starch %, protein % and dry matter % as well as N, P, K and Zn revealed positive responses to various yeast concentrations. Likewise, increasing of zinc concentrations showed similar trend of the above mentioned findings. Addition of foliar application of yeast at the rate of 5 g/l combined with foliar application of zinc at the rate of 300 ppm gave the highest total tubers yield (ton/fed.); 1 feddan (fed.) = 4200 m2. Similarly, tubers quality and chemical constituents showed the same trend of total tubers yield as mentioned previously.

Newsham (2011) exposed that plant relationships with root endophytic fungi can become beneficial when organic nutrients are present in soil, owing to the ability of fungi to saprotrophically break down complex organic molecules and mobilize sequestered nutrients.

Botha (2011) focuses on his experiment about the interactions of soil yeasts with biotic and abiotic factors in their environment. Soil yeasts not only affect microbial and plant growth, but may also play a role in soil aggregate formation and maintenance of soil structure. Serving as a nutrient source for bacterial, faunal and protistan predators, soil yeasts contribute to essential ecological processes such as the mineralization of organic material and dissipation of carbon and energy through the soil ecosystem. Some soil yeasts may also play a role in both the nitrogen and sulphur cycles and have the ability to solubilize insoluble phosphates making it more readily available for plants. Recently, the potential of soil yeasts as plant growth promoters and soil conditioners has been studied with the goal of using them in the field of sustainable agriculture.

Javaid and Mahmood (2010) carried out a field experiment to investigate the effect of a symbiotic nitrogen fixing bacterium Bradyrhizobium japonicum and a commercial EM (effective microorganisms) on growth and yield of soybean (Glycine max L.) in soils amended either with farmyard manure or Trifolium alexandrinum L. green manure @ 20 t/ha each. In green manure amendment, Effective microorganisms (EM) inoculation significantly enhanced number and biomass of nodules resulting in a significant increase of 27, 65 and 55% in shoot biomass and number and biomass of pods, respectively. As a result a significant increase of 45 and 47% in shoot biomass and number of pods was recorded respectively.

Karlidag *et al*., (2010) carried out an experiment which aim to evaluate possible effects of three plant growth promoting rhizobacteria (PGPR) strains as biofertilizer on growth, yield and ionic composition of leaves of strawberry plants. The application treatments included the control (without bacteria inoculation and mineral fertilizers), mineral fertilizers, and plant growth promoting rhizobacteria species [Bacillus cereus, (N2- fixing), Brevibacillus reuszeri (phosphate solubilizing), and Rhizobium rubi (N2-fixing and phosphate solubilizing)]. Data suggest that root inoculation of strawberry plants with PGPR strains tested increased root weight, shoot weight, ionic composition of leaves of strawberry and yield. The results of the study reveal that PGPR application may increase organic manure use efficiency and have capacity to stimulate strawberry growth and yield.

Idris *et al.,* (2008) carried out a field experiment at Research Farm in Wad Medani, University of during 2004-05 to study the response of tomato (Lycopersicon esculentum Mill) to the application of effective microorganisms (EM). Effective microorganisms (EM) applied at three rates of 0.01%, 0.02% and 0.05% either alone or in combinations with chicken manure or urea. Chicken manure (6 tons/ha) was added to the soil and urea (0.10 ton/ha) was applied. Spraying intervals were 7 and 14 days and application methods were soil and foliar application. Findings showed that significant differences between the different treatments. EM sprayed at a dilution rate of 0.05% every seven days in combination with chicken manure gave significant increases in plant height, number of branches/plant, number of fruits/cluster and total yield.

Harman *et al.*, (2004) directed a study to assess the Trichoderma spp. on plant that common in soil and root ecosystems. Recent discoveries show that they are opportunistic, avirulent plant symbionts, as well as being parasites of other fungi. They produce or release a variepathogenicity to plants. These root microorganism associations cause substantial changes to the plant proteome and metabolism. It was highly noticeable that plants are protected from numerous classes of plant pathogen by responses that are similar to systemic acquired resistance and rhizobacteria induced systemic resistance. Therefore, root colonization by Trichoderma spp. also frequently enhances root growth and development, crop productivity, resistance to abiotic stresses and the uptake and use of nutrients.

Yadav (2002) directed an experiment to find out the effect of effective microorganism (EM) on vegetable crops at Kakani, Kathmandu vally, Nepal during the year 1999. There were three replication and designed randomized complete block design (RCBD). Foliar spray of EM was at 15, 30 and 45 days interval of cabbage and radish. EM solution was diluted at 1: 1000 and 1: 500 concentrations. Results showed that foliar application at 15 days interval 1:500 given the highest yield to cabbage and radish. The highest yield (36.30 kg) of cabbage was obtained with 1: 1000 at 15 days intervals. The highest yield (16.20 kg) radish was with 1:1000 at 15 days intervals. EM 1:1000 at 15 days interval foliar spray increase the yield of cabbage and radish 91.05% and 71.50 % compared with no foliar spray of EM respectively.

Kumar *et al*., (2001) conducted field experiments during 1999-2000 and 2000-2001 to evaluate the efficacy of biofertilizers on growth and yield of potato. The results showed that 100% Nand P + soaking of seed tubers in solution containing 1% urea and 1% sodium bicarbonate + Azotobacter and Phosphaobacteria increased plant height at 45 and 75 days, yield of tubers (750g/plant) and total yield (271 q/ha). However, maximum number of tubers (8.89)/plant were obtained with 75% N and P + treatment of tubers with Bacillus (Strain MJ).

Xiaohou *et al.,* (2001) conducted various studies in China to observe the effect of foliar application of beneficial microorganisms on yield and quality of various crops.He reported that in field trials, sprinkling of 0.1% beneficial microorganisms solution improved the quality and enhanced yields of tea, cabbage, and sugar corn by 25%, 14%, and 12.5%, respectively.

Yousaf *et al*., (2000) explored the effect of seed treatment and foliar application of beneficial microorganisms on growth and yield of two varieties of groundnut (Arachis hypogaea L.). Two varieties ICG-2261 and ICGV-86550 and three treatments T1: Control, T2: Seed inoculation with EM, T3: Seed inoculation with EM + EM spray. Result showed that Root length and Plant height range from 13.4 cm and 83.0 cm to 13.1 cm and 79.8 cm. Maximum root length, plant height, number of branch (29.13) and weight (198.1 gm) were at T3, while minimum number of branch (21.3) and weight (144.4 gm) were at in T1.

Daly *et al*., (1999) carried out an experiment at organic farms in Canterbury, New Zealand during 1994-1995 to assess the effect of effective microorganisms (EM) on vegetable production. Total three crops were tested (onion, pea and sweet corn). Effective microorganisms (EM) and molasses were both applied at (10 L/ha in 10000 L/ha water) three times were applied at onion, twice at pea and seven times to sweet corn. Results showed that EM and molasses increased the onion, pea and sweet corn yield by 29%, 31% and 23% respectively.

Widdiana and Higa (1998) directed a field plot experiment during 1993 at crop production center for horticultural Crops, Lembang, West Java to determine the effects of foliar applied EM on the production of garlic, onion, tomato, and watermelon. T1: Control (fertilizer + manure only), T2: EM(0.1%) applied weekly, T3: EM (0.5%) applied weekly, T4: EM (1.0%) applied weekly, T5: EM (0.1%) applied biweekly, T6: EM (0.5%) applied biweekly and T7: EM (1.0%) applied biweekly treatments were used. The highest garlic yield (98.4 kg/ha) was obtained at T2 the highest yield of onion (167.4 kg/ha) at T4; and the highest yield of tomato (265.0 kg/ha) at T4. Yield increase percentage of garlic, onion and tomato (from EM) of 12.5, 11.5 and 19.5% compared with the fertilized (no EM) controls. There was no significant increase in watermelon yields from foliar application of EM at any treatment.

Hussain *et al.,* (1995) investigated many field and greenhouse experiments in Pakistan since 1990 to determine the use of effective microorganisms (EM) as an alternative to chemical fertilizer in crop production. One such study was a long term field experiment conducted for 5 years on a rice-wheat rotation with the treatments: control, chemical fertilizer (NPK), green manure (GM), and farmyard manure (FYM), all with and without the application of EM. Results showed that EM increased crop yield and improved soil physical properties, especially when applied with organic amendments.

Sharifuddin *et al*., (1993) carried out an experiment at Malaysia to evaluate the effect of Effective microorganisms (EM) on crop production in Malaysia. Results showed that EM using with soil amendments increase the growth and yield of sweet corn and leaf mustard.

Chowdhury *et al*., (1991) directed a series of studies at research filed of Institute of Post Graduation Studies in Agriculture (IPSA), salna, Gazipur during 1992-1993 to evaluate the effect of EM on growth and yield of some selected crops. Onion (*Allium cepa* L.) and String bean (*Vigna sequipedalis* L.) were cultivated at field and chili pepper (*Capsicum fulctescens* L.) was at pot. Four treatment were used with EM and without EM (T1: Control, T2: Cow dung @ 10 t/ha, T3: Rice straw @ 10 t/ha, T4: Recommended N-P-K fertilizer rate). The highest onion yield (7.2 t/ha) was obtained by T2 with EM and was greater than that produced by T4 (6.3 t/ha)). EM increased leaf chlorophyll and yield of string bean significantly. Highest yield of chili peppers was obtained with EM but was not significantly different than the other treatments.

CHAPTER III

MATERIALS AND METHODS

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A field experiment was accomplished at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from November, 2019 to February, 2020 to observe the influence of clybio and ecoagra concentration on growth and yield of lalpakri potato. This chapter contains a brief description of location of the experimental site, climatic condition and soil, materials used for the experiment, treatment and design of the experiment, production methodology, intercultural operations, data collection procedure and statistical etc. which are presented as following headings.

3.1 Experimental site

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2019 to February, 2020.The location of the site is $23^{0}74'$ N latitude and $90^{0}35'$ E longitudes with an elevation of 8.2 meter from the sea level (Anon., 1989) in Agro-Ecological Zone of Madhupur Tract (AEZ No. 28)

3.2 Climatic conditions

The experiment site was located in the subtropical monsoon climatic zone, set aparted by heavy rainfall during the months from April to September (Kharif season) and scanty of rainfall during the rest of the year (Rabi season). In addition, under the sub-tropical climatic, which is individualized by high temperature, high humidity and heavy precipitation with seasonal unexpected winds and relatively long in Kharif season (April- September) and sufficient sunlight with moderately low temperature, intensity of humidity and short day period of during Rabi season (October-March). The information of weather regarding the atmospheric temperature, relative humidity, rainfall, sunshine 22 hours and soil temperature persuaded at the experimental site during the whole period of observation.

3.3 Characteristics of the soil

The experimental soil belongs to the Modhupur Tract under AEZ No. 28 (UNDP-FAO, 1988). The land which selected was medium high and the soil series was Tejgaon. The soil characteristics of experimental plot were analyzed in the SRDI, Soil Testing Laboratory, Khamarbari, Dhaka and the experiment field primarily had a Ph of 6.5 and organic matter content 0.84%. Physiochemical properties were present in the soil appropriately.

3.4 Experimental materials

3.4.1 Planting materials

Lal pakri potato tubers were used in this experiment. The genetically pure and healthy seed tubers were collected from ACI.

3.4.2 Clybio and Eco-agra properties

Composition of clybio:

1. A mixture of lactic bacteria, Yeast & Bacillus Bacteria : 0.5-0.6%
2. Sugar contents: 1.8%

Characteristics:

Physical condition: Liquid

Color: Light brown

Specific gravity: 1.058

Solubility: Dissolved to water

pH: 3.0 to 4.0

Flammability: Non-flammable

Toxicity: Non-toxic

Table: 1 Physical and chemical properties of Eco-Agra

Ingredients	Trace ingredients		Specification	
Alkanolamines	Total solids	0.37%	pH	9.7
Amino acids	Total Nitrogen(N)	0.033%	Flash point	None
Corn oil	Ammoniacal (N)	0.014%	Odor	Vegetable smell
Soy	Phosphorus (p)	< 0.1%	Boiling point	214.4^0F
Coconut oil	Iron (Fe)	< 2.5 mg/kg	Freezing point	28.0^0F
Nonionic surfactants	Magnesium (Mg)	< 2.5 mg/kg	Specific Gravity	1.001
Plant based substance	Potassium (K)	< 2.5 mg/kg	Solubility in H20	100%
No synthetics	Sodium (Na)	1.3 mg/L	Appearance	Clear gold

Sources: Eco-AgraeA300 booklet

3.4.3 Treatments

Comparative effectiveness of the following eight treatments in growth and yield of lalpakri potato were evaluated in the experiment :

$\mathbf{T_0}$= No application of Clybio and Ecoagra

$\mathbf{C_1}$= Clybio @ 1.0 ml/L

$\mathbf{C_2}$= Clybio @ 2.0 ml/L

$\mathbf{E_1}$= Ecoagra @ 1.0 ml/L

$\mathbf{E_2}$= Ecoagra @ 2.0 ml/L

$\mathbf{C_1+E_1}$= Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L

$\mathbf{C_1+E_2}$ = Clybio @ 1.0 ml/L + Ecoagra @ 2.0 ml/L

$\mathbf{C_2+E_1}$ = Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L

$\mathbf{C_2+E_2}$ = Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

3.4.4 Treatment application

All the treatments were prepared properly. Treatments were applied to the soil of potato field along with leaves with the help of a hand sprayer. First application was done after thirteen days of planting. Treatments were applied four times in total. Foliar application was done at 20 days interval during vegetative growth to harvest and four times Eco-agra was applied in the field and application was done through the plant and soil. Eco-agra collected from United States (USA). The physical and chemical properties of Eco-Agra are given in table 1.

3.5. Design and layout of the experiment

The single factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replication. The experiment comprised of 27 plots.

3.6. Spacing and plot size

The size of each plot was 2.4 m × 1.5 m. The distance between blocks and plots were 0.5 m and 1 m respectively. Row to row distance was maintained 60 cm and plant to plant distance was 25 cm.

3.7 Production methodology

3.7.1 land preparation

The land was first open by ploughing with the help of power tiller and then it kept open to sun for seven days prior to further ploughing. Afterwards it was prepared by ploughing and cross ploughing followed by laddering. The weeds and stubbles were removed after each laddering. Simultaneously, the clods were broken and the soil was made into good tilth.

3.7.2 Application of manure and fertilizers

In this experiment Urea, TSP and MoP were applied at the rate of 240 kg/ha, 150 kg/ha, and 250 kg/ha, respectively (BARI 2005).

Table 2. Manures and fertilizer with BARI recommended dose along with plot wise application dose

SL No.	Manures/ fertilizers	Recommended Dose
1	Cowdung	10 t/ha
2	Urea	240 kg/ha
3	TSP	150 kg/ha
4	MoP	250 kg/ha

During experiment whole amount of cowdung, half of urea, whole amount of TSP, MoP has been applied at the time of tuber seed sowing. Rest of the urea has been applied 30 DAP and 60 DAP with three installments followed by earthing up.

3.7.3 Planting of seed tuber

The well sprouted healthy and uniform sized potato tubers were planted according to treatment. Seed potatoes were planted in such a way that potato does not go much under soil or does not remain in shallow. On an average, potatoes were planted at 4-5 cm depth in soil on November 26, 2019.

3.7.4 Tagging of plants

Plants were tagged on 26thNovember, 2019 using cards.

3.8 Intercultural operations

Following operations were done:

3.8.1 Weeding

Weeding was necessary to keep the plant free from weeds. The newly emerged weeds were uprooted carefully from the field after complete emergence of sprouts and afterwards when necessary.

3.8.2 Irrigation and Drainage

Three times irrigation was done in the field to keep upon moisture status of soil retained as requirement of plants. Excess water was not given, because it always harmful for potato plant.

3.8.3 Top dressing

After basal doses, the remaining doses of urea top dressed in 30 days after planting. The fertilizers were applied on both sides of plant rows and mixed with the soil by hand. Earthling up was done with the help of spade immediately after top dressing of nitrogen fertilizer.

3.8.4 Earthing up

Earthing up process was done by pouring the soil in the base of the plant at two times, during crop growing period. First pouring was done at 45 days after planting and second was at 60 DAP.

3.8.5 Rouging

Rouging refers to the act of identifying and removing plants with undesirable characteristics from agricultural fields. Rogues are removed from the fields to preserve the quality of the crop being grown. Diseased plants were removed from the potato field.

3.8.6 Haulm cutting

Haulm cutting was done at 80 DAP, when 40-50% plants showed senescence and the tops started drying. After haulm cutting the tubers were kept under the soil for 7 days for skin hardening. The cut haulm was collected, bagged and tagged separately for further data collection.

3.8.7 Harvesting

Haulm cutting was done before seven days of harvesting. The crop was harvested depending upon the maturity of each variety.

3.9 Parameters of the experiment

Data were collected in respect of following parameters:

1. Growth related parameters

a. Plant height (cm)

b. Number of stem per hill

c. Number of leaves per hill

d. Days to maturity

2. Physiological parameters

a. Chlorophyll content (SPAD value)

3. Yield attributing parameters

a. Number of tuber per hill

b. Tuber length (mm)

c. Tuber diameter (mm)

d. Individual tuber weight (g)

e. Yield per hill (g)

f. Yield per ha (t)

3.10. Data collection

Three plants were randomely selected from each unit of plot for the collection of data. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. However, the yield of of all plants was considered per plot yield. Data have been collected on the basis of four attributed like- growth related parameters, physiological parameters, yield attributing parameters and quality attributes parameters.

3.10. 1 Plant height (cm)

Plant height of each sample plant was measured in centimeter from the ground level to the tip of the longest leaf and mean value was calculated and expressed in cm. (Plate 1.a.)

3.10.2 Number of leaves per plant

The number of leaves per plant was counted from the selected plants and their data was taken 60 days after planting.

3.10.3 Number of stem per hill

Number of stem per hill was recorded by counting all branches of selected plants after 40 DAP till 80 DAP and mean was calculated.

3.10.4 Days to maturity

Maturity of potato tubers were counted after observing their visual maturity. Mature plants have changed its color from green to brown color.

3.10.5 SPAD value

Chlorophyll content or SPAD value was measured at an interval of 15 days starting from 20 DAP till 80 DAP. Mature leaf (fourth leaves from top) were measured all time. Three mature plant of each plot were measured by using portable Chlorophyll Meter (SPAD-502, Minolta, Japan) and then calculated an average SPAD value for each plot. (SPAD-502) is a simple and portable diagnostic tool that measures the greenness or the relative chlorophyll concentration of leaves (Kariya *et al.,* 1982). (Plate 1.b)

3.10.6. Number of tuber per hill

The number of tubers per hill was counted individually after final harvested plants of each plot.

3.10.7. Tuber length (mm)

The length of tuber was measured with a slide calipers and their average was calculated in centimeter (cm) (Plate 1. e.).

3.10.8. Tuber diameter (mm)

Tuber diameter was measured using Digital slide caliper -515 (DC-515) in millimeter (mm) and mean was calculated (Plate 1. e.).

3.10.9. Individual tuber weight (g)

Tuber weight was measured by Electronic Precision in gram. Total tuber weight of each plot was obtained by addition of weight of the total number and average tuber weight was obtained from division of the total tuber weight by total number of tuber (plate 1. f.).

3.10.10.Yield per hill (g)

Weight of tubers per hill was recorded from the mean weight of tubers found from the total harvested plants of each plot and expressed in gram (g).

3.10.11. Yield per ha (t)

The yield obtained unit plot was converted into per hectare yield and expressed in tons.

3.11 Skin color measurement

Colorimetric measurement of the different treatment combinations was c using IWAVE WF32 precision colorimeter (Shenzen Wave) following L* (Lightness), a* and b* (two Cartesian coordinates) including C* and hab (Chroma & Hue angle) based on 37 CIE Lab scale with standard observer 100 and standard illumination D65 (CIE, 1986; McGuire, 1992).

3.12 Statistical Analysis

The data recorded for different parameters were statistically analyzed using Statistics-10 scientific analysis software to find out the significance of variation among the treatments and treatment means were compared by Duncan‟s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984) to determine the levels of significant differences among the application of Clybio and Ecoagra solution at different concentration levels.

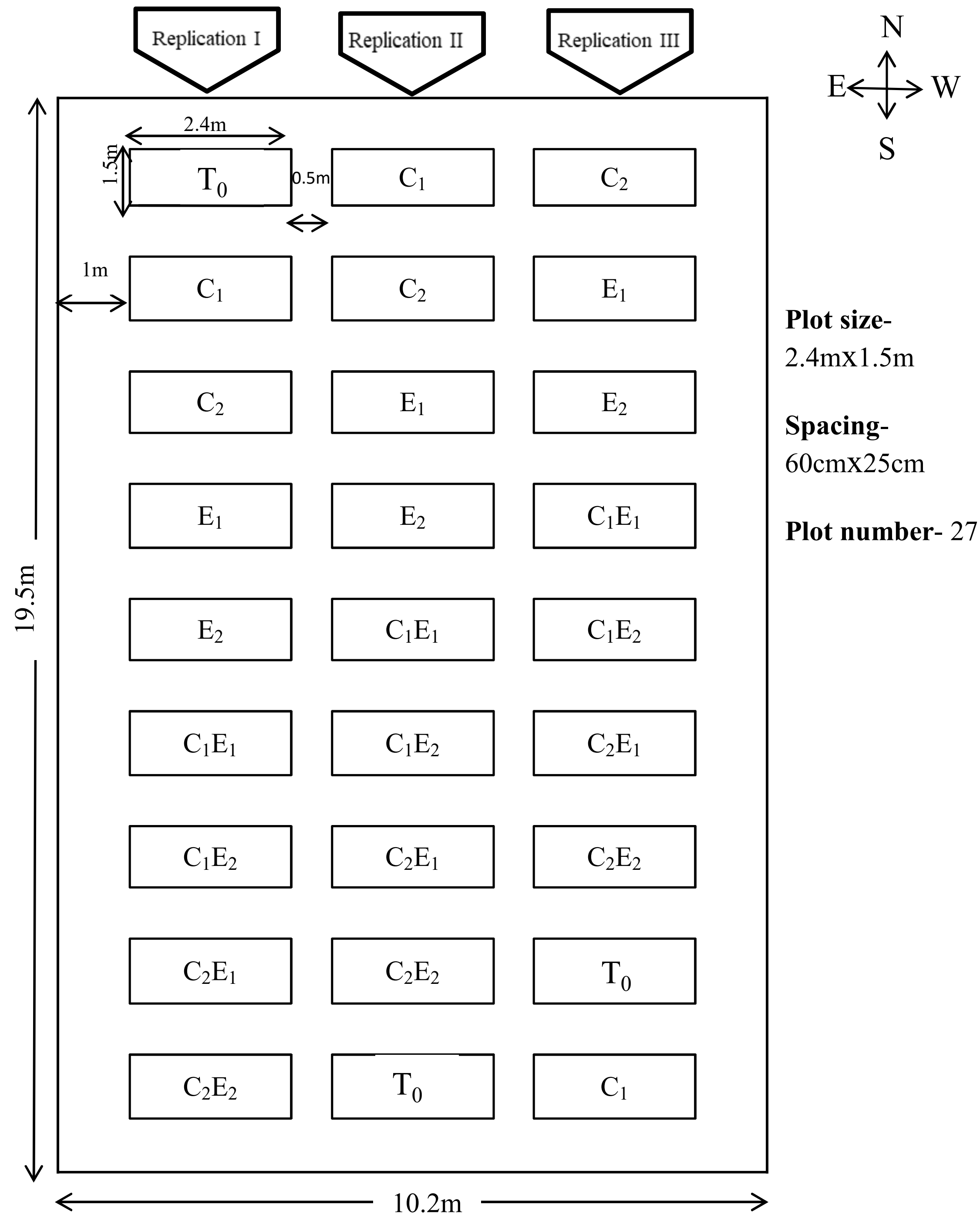


Figure 1: Layout of the experiment

Plate 1. Pictorial presentation of experiment : **a**.Measurement of plant height using meter scale in cm**;** **b**. Measurement of chlorophyll percentage using SPAD; **c.** Clybio solution; **d**. Application of Clybio and Eco-agra solution; **e.** Data collection**,** **f**. Measurement using Electric Precision Balance. of tuber weight

a

b

Plate 2. Pictorial presentation on data collection: **a** Tuber length & diameter measurement using Digital Caliper -515(DC-515); **b.** Colorimeter, 1.CIE Lab color scale

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1. Growth related parameters

4.1.1 Plant height (cm)

Plant height (cm) is obviously important growth parameters in potato which is positively correlated with yield and the growing conditions significantly influenced this trait. Statistically significant variation was found in plant height at 15 days after planting (DAP) due to the influence of Clybio and Ecoagra concentration to potato plant (Appendix I). Highly significant differences exist among different treatments with regard to plant height (cm) at 30 days, 45 days and 60 days after planting. The mean plant height ranged from 74.8 cm to 94.8 cm, the maximum plant height was at 60 days after planting. The tallest plant was found from C_2+E_2 (94.8 cm) where is the shortest from T_0 (74.8 cm) at 60 days after planting.

Ecoagra increase the availability of nitrogen to plants as ammonia cal and solid nitrogen and it may be reasoned that by supplying NH4+, energy is conserved and diverted to other metabolic processes including ion uptake and growth (Cox and Reisenauer, 1973).

Plant height showed significant variation with Trichoderma treatments. Uddin *et al.* (2016) found the higher plant height in tomato with trichoderma treatments. Similar opinion was put forwarded by Baker (1991) in tomato, bean and cucurbits. This may be due to enhanced nutrition uptake activity to the plants.

Singh (2018) also showed that plants grow tall with trichoderma treated than the untreated condition in linseed. More plant height can be attained due to stimulating effect of trichoderma on plant growth by Baker (1988) and Lynch *et al.* (1991).

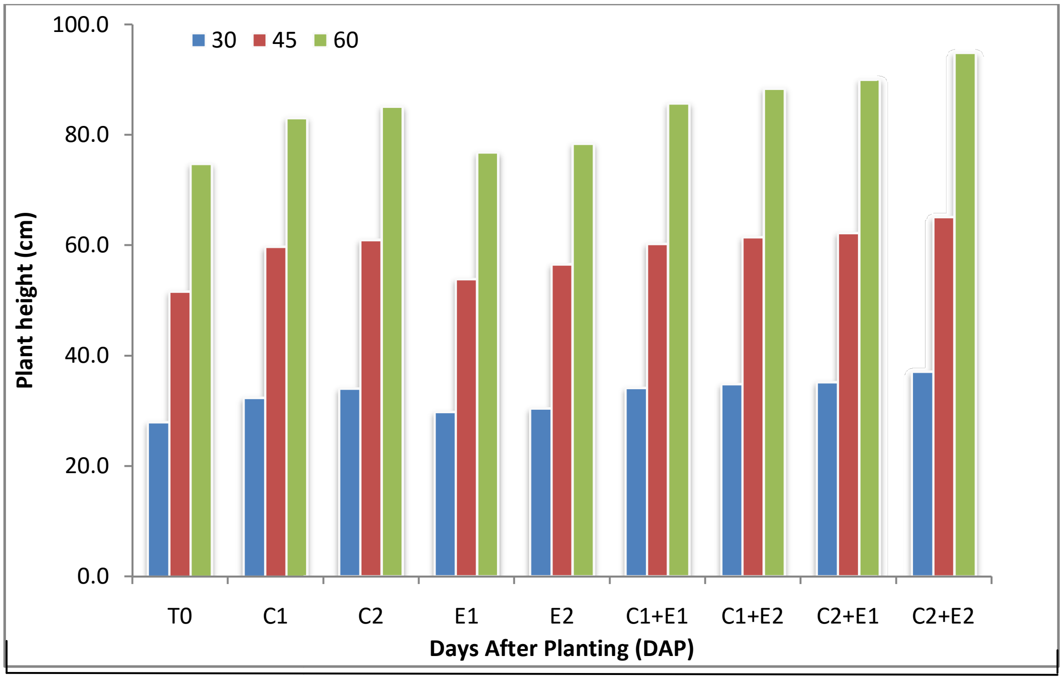


Figure 2. Effect of foliar application of clybio and ecoagra concentration on lalpakri potato plant height at different days after sowing

Here, T0 : No application of Clybio and Ecoagra; C_1 : Clybio @ 1.0 ml/L; C_2: Clybio @ 2.0 ml/L; E_1 : Ecoagra @ 1.0 ml/L; E_2: Ecoagra @ 2.0 ml/L; C_1+E_1:Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C_1+E_2: Clybio @ 1.0 ml/L + Eco agra @ 2.0 ml/L; C_2+E_1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C_2+E_2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

4.1.2 Number of leaves per hill

Leaves are the important organ which helps to physiological processes, photosynthesis and transpirations. Thus it influenced the growth of a plant very much and enhances the yield of a plant. The number of leaves per hill of potato significantly varied among the treatment (Appendix II).

In case of Clybio and Ecoagra application, significant variation in number of leaves was observed (Appendix II). The maximum number of leaves (64.3) was found from C_2+E_2 and minimum (57)from T_0 with 60 days after planting (Table 3). Similar results obtained by Karunarathna and Seran (2016). Clybio made of Bacillus spp. convert the complex form of essential nutrients, such as P and N, to a simple available form that enhanced plant growth and development (Kan g *et al.,* 2015), neem products can be used as a bio-fertilizer, providing the macronutrients essential for plant growth (Ramachandran *et al.,* 2007). Hossain (2007) observed highly significant variation in respect of number of leaves per plant in Raton tomato variety.

4.1.3 Number of Stem per hill

In case of different clybio and ecoagra treatment significant variation was observed in the number of stem per hill (Appendix II). Maximum number of stem (6.0) per hill was found in C_2 due to the application of clybio and this is statistically similar to C_1+E_1 (6.0) .On the other hand, minimum number of stem per plant (3.7) was found in control treatment (T_0) (Table 3). Many researchers studied the effect of trichoderma on vegetative parameters of plants and showed that increases vegetative growth allows more nutrient uptake and increases photosynthesis efficiency and improve vegetative growth of plants. Uddin *et al.* (2014) showed the maximum significant variation in number of branches as with trichoderma treated compared to infected control.

4.1.4 Days to maturity

Maturity is important for harvest index. In of case Clybio and Ecoagra treatment, days to maturity were varied significantly (Appendix II). Maximum days to maturity were found in (T_0) where no clybio and ecoagra used (90) and minimum days were found (80.0) in application of clybio and ecoagra treatment (C_2+E_2) (Table 3). Biofertilizer enhances maturity due to number of mechanism occurs in plant growth promotion. Harman *et al.* (2004) proposed the similar result in plant.

Table 3: Influences of different clybio and ecoagra concentration to number of leaves/hill, days to plant maturity, number of stem/hill of lalpakri potato

Treatment	Number of leaves/hill	Days to plant maturity	Number of stem/hill
T_0	57.0 c	90.0 a	3.7 b
C_1	60.3 a-c	85.7 a-c	5.0 ab
C_2	61.3 a-c	84.7 a-c	6.0 a
E_1	59.7 bc	86.3 a-c	5.0 ab
E_2	60.0 a-c	87.3 ab	5.0 ab
C_1+E_1	61.7 ab	83.7 a-c	6.0 a
C_1+E_2	61.3 a-c	82.3 bc	4.7 ab
C_2+E_1	62.3 ab	82.3 bc	5.3 ab
C_2+E_2	64.3 a	80.1 c	5.7 ab
LSD	4.63	6.71	2.05
CV	2.62	2.72	13.67

Here, T_0 : No application of Clybio and Ecoagra; C_1 : Clybio @ 1.0 ml/L; C_2: Clybio @ 2.0 ml/L; E_1 : Ecoagra @ 1.0 ml/L; E_2: Ecoagra @ 2.0 ml/L; C_1+E_1:Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C_1+E_2: Clybio @ 1.0 ml/L + Eco agra @ 2.0 ml/L; C_2+E_1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C_2+E_2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

Physiological parameters

4.1.5 Chlorophyll content (SPAD value)

Chlorophyll enhances the growth of a plant which is correlated with the yield. Chlorophyll (%) on leaves (SPAD reading) showed significant variation among the treatments (Appendix II). The highest chlorophyll content (44.4) was observed from (C_2+E_2) whereas the lowest chlorophyll content (31.7) was observed from (T_0) (table 4). It's may be the effect of Clybio. Clybio made of yeast and yeast promotes different essential amino acids, vitamins, and phytohormones that led to the growth and improve the chlorophyll content (Taha *et al.,*2020). Chlorophyll content of leaves is frequently correlated with photosynthetic capacity,with leaf N status, and RuBP carboxylase activity (Evans, 1998; Seemann *et al*., 1987) and less chlorophyll content decrease the development of growth as well as grain development. Variation in chlorophyll content was also observed in Rose (Ahmad *et al*., 2011). Moreover, the chlorophyll content was increased due to eco-Agra application because of addition of N and Mg fertilizer (Newcomb, 1999). Jamal Uddin *et al*., (2020) reported that, availability of N and S fertilizer increase SPAD reading on okra leaves. This result is in agreement with the findings of Iriti *et al*. (2019).Through spraying of Clybio and Ecoagra enhances photosynthesis of leaves through increased biomass, increases plant ability to fight pest and diseases.

Yield attributing parameters

4.1.6 Number of tuber per hill

Number of tuber per hill is the most prominent parameter for attributing yield. Significant difference was revealed on number of tuber per hill with different bio-fertilizer treatments (Appendix IV). Among the treatments (C_2+E_2) gave the maximum tuber (15.3) while (T_0) gave minimum tuber(11.3) per hill (table 4). Rakibuzzaman *et al*., (2019) observed that, foliar application of liquid organic fertilizer increase flower and fruit number due to contain essential nutrient Jamal Uddin *et al*., (2019) showed that application of bio -fertilizer increase number of pod in okra. This result supported the findings of Idris *et al*., (2008) in tomato.

Table 4: Influences of different clybio and ecoagra application to SPAD value, number of tuber per hill of lalpakri potato

Treatment	SPAD value		Number of tuber/hill	
T_0	31.7	d	11.33	b
C_1	35.6	b-d	13.33	ab
C_2	38.0	a-d	14.33	a
E_1	34.8	b-d	13.33	ab
E_2	33.1	cd	13.66	ab
C_1+E_1	38.9	a-c	14.66	a
C_1+E_2	40.7	ab	14.66	a
C_2+E_1	42.6	a	14.66	a
C_2+E_2	44.4	a	15.33	a
LSD	6.66		2.79	
CV	6.07		6.91	

Here, T0 : No application of Clybio and Ecoagra; C1 : Clybio @ 1.0 ml/L; C2: Clybio @ 2.0 ml/L; E1 : Ecoagra @ 1.0 ml/L; E2: Ecoagra @ 2.0 ml/L; C1+E1:Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C1+E2: Clybio @ 1.0 ml/L + Eco agra @ 2.0 ml/L; C2+E1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C2+E2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

**In a coloumn, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.1.7 Tuber length (mm)

Tuber length is very crucial parameters for increasing yield and for commercial production. Tuber length is also important for industrial purposes. Large sized tuber are considered for French fry, medium and round for chips and small sized are in canned and many other purposes. Length of tuber (mm)was significantly differences with different treatments(Appendix III). Among the treatments of potato (C_2+E_2) gave the longest tuber (46.8mm) while (T_0) gave the shortest tuber (31.2 mm) length which is statistically similar with E_1 (32 mm). Eco-agra extremely triggered and act as a transporter of nutrient (N, P, K, Fe, Mg) from the soil into the plant through root system, stimulate plant growth and thereby enhance fruit size. Different macro and micronutrient have prominent effect on fruit size (Sajid *et al*., 2013). Uddin *et al*., (2017) found the significant variation in fruit length due to the application of trichoderma in strawberry. Similar finding in respect of fruit length were also observed from (Dutta and Banik, 2007).

4.1.8 Tuber diameter (mm)

The difference in varieties for tuber diameter (mm) was found significant (Appendix III). Where, maximum tuber diameter was recorded 45.7 mm in C_2+E_2 and the lowest diameter of tuber was 31.0 mm in T_0(Table 4). Khan *et al*., (2011) also studied tuber size and they found variation in tuber diameters. Similar findings in terms of fruit diameter of tomato due to foliar application of micronutrient were also found from (Naga *et al.,* 2013). Nagaraju *et al*. (2012) reported that sunflower treated with Trichoderma spp. significantly increased the diameter of heads as compared to untreated plants.

4.1.9 Individual tuber weight (g)

Individual tuber weight showed significant variation among the treatments. (Appendix III). Maximum weight/ tuber (29.4g) was found in C_2+E_2 and minimum weight/tuber (12.4g) was found in $T_{0.}$(Table 5). Awal *et al.* (2007) found the variation in individual tuber weight. Montaser *et al.* (2014) showed that Trichoderma spp. increase the single fruit weight in eggplant.

Table 5: Influences of different clybio and ecoagra application to tuber length (mm), tuber diameter(mm), individual tuber weight(g) of lalpakri potato

Treatment	Tuber length (mm)	Tuber diameter (mm)	Individual tuber wt. (g)
T_0	31.2 c	31.0 c	12.35 e
C_1	32.1 c	33.7 bc	19.14 d
C_2	34.5 bc	35.1 bc	22.70 c
E_1	32.0 c	31.8 c	16.70 d
E_2	32.2 c	32.7 c	19.16 d
C_1+E_1	35.3 bc	35.1 bc	23.22 c
C_1+E_2	36.6 b	37.9 abc	24.98 bc
C_2+E_1	38.5 b	40.7 ab	27.81 ab
C_2+E_2	46.8 a	45.7 a	29.42 a
LSD	4.43	7.90	3.23
CV	4.30	7.56	5.12

Here, T0 : No application of Clybio and Ecoagra; C1 : Clybio @ 1.0 ml/L; C2: Clybio @ 2.0 ml/L; E1 : Ecoagra @ 1.0 ml/L; E2: Ecoagra @ 2.0 ml/L; C1+E1:Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C1+E2: Clybio @ 1.0 ml/L + Eco agra @ 2.0 ml/L; C2+E1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C2+E2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

**In a coloumn, means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

4.1.10 Yield g/hill, Yield ton/ha

Clybio and Eco-agra influence yield of lalpakri potato is exposed highly significant (Appendix IV). The maximum yield per hill (451.02g) was recorded from C_2+E_2 treatment whereas minimum yield per plant (138.7g) was found from T_0 treatment. Maximum yield ton/ha (30.07t) was recorded at C_2+E_2 treatment whereas the minimum yield ton/ha (9.2 t) was observed at T_0 (Table 6).This is due to the application of clybio and ecoagra because lactobacillus bacteria which help to nitrogen fixation and accumulation of auxin and cytokinin that trigger plant growth, flowering stage (Higdon *et al.,* 2020); Bacillus solubilize soil P, enhance nitrogen fixation, and produce siderophores that promote its growth (Hashem *et al.,* 2019); yeast stimulates plant hormones like auxins, gibberellins, cytokins, synthesis of vitamins, antifungal and antibiotic compounds, ability to solubilize minerals like phosphorus and other nutrients that enhances plant growth, enhance photosynthesis (Agamy *et al.,* 2013).

Table 6: Influences of different clybio and ecoagra application to yield per hill(g), yield per hectare(t) of lalpakri potato

Treatment	Yield/hill (g)		Yield/ha(t)	
T_0	138.7	g	9.24	g
C_1	255.36	e	17.02	e
C_2	325.29	d	21.68	d
E_1	222.7	f	14.84	f
E_2	260.2	e	17.34	e
C_1+E_1	339.34	c	22.62	cd
C_1+E_2	366.32	cd	24.42	c
C_2+E_1	407.89	b	27.19	b
C_2+E_2	451.02	a	30.06	a
LSD	32.29		2.15	
CV	3.61		3.61	

Here, T_0 : No application of Clybio and Ecoagra; C_1 : Clybio @ 1.0 ml/L; C_2: Clybio @ 2.0 ml/L; E_1 : Ecoagra @ 1.0 ml/L; E_2: Ecoagra @ 2.0 ml/L; C_1+E_1:Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C_1+E_2: Clybio @ 1.0 ml/L + Eco agra @ 2.0 ml/L; C_2+E_1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C_2+E_2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

4.2 Colorimetric measurement using CIELab

The colorimetric measurement of lalpakri potato under different treatments of the study were conducted using a precision colorimeter IWAVE WF32 (Shenzhen Wave) and L* (Lightness), a* and b* (two Cartesian coordinates) including C* and hab (Chroma & Hue angle) based on CIELab scale with standard observer 100 and standard illumination D65 (CIE, 1986; McGuire, 1992). The respective data for each of the treatments were presented in (Table 7)

Table 7. Variation in skin color attributes in different treatments of lalpakri potato

Treatments	L*	a*	b*	c*	h_{ab}
T_0	40.09	22.73	15.23	27.36	33.83
C_1	45.74	25.60	13.41	28.90	27.64
C_2	49.43	26.50	13.56	29.77	27.10
E_1	52.62	28.40	20.86	35.24	36.30
E_2	50.29	21.72	16.16	27.07	36.66
C_1+E_1	47.89	22.38	16.75	27.95	36.82
C_1+E_2	46.33	25.34	14.21	29.75	29.29
C_2+E_1	46.16	28.51	15.98	32.68	29.27
C_2+E_2	49.74	27.01	17.85	32.38	33.46

Here, T_0 : No application of Clybio and Ecoagra; C_1 : Clybio @ 1.0 ml/L; C_2: Clybio @ 2.0 ml/L; E_1 : Ecoagra @ 1.0 ml/L; E_2: Ecoagra @ 2.0 ml/L; C_1+E_1:Clybio @ 1.0 ml/L + Ecoagra @ 1.0 ml/L; C_1+E_2: Clybio @ 1.0 ml/L + Eco agra @ 2.0 ml/L; C_2+E_1: Clybio @ 2.0 ml/L + Ecoagra @ 1.0 ml/L; C_2+E_2: Clybio @ 2.0 ml/L + Ecoagra @ 2.0 ml/L

To C_1 C_2

E_1 E_2 C_1+E_1

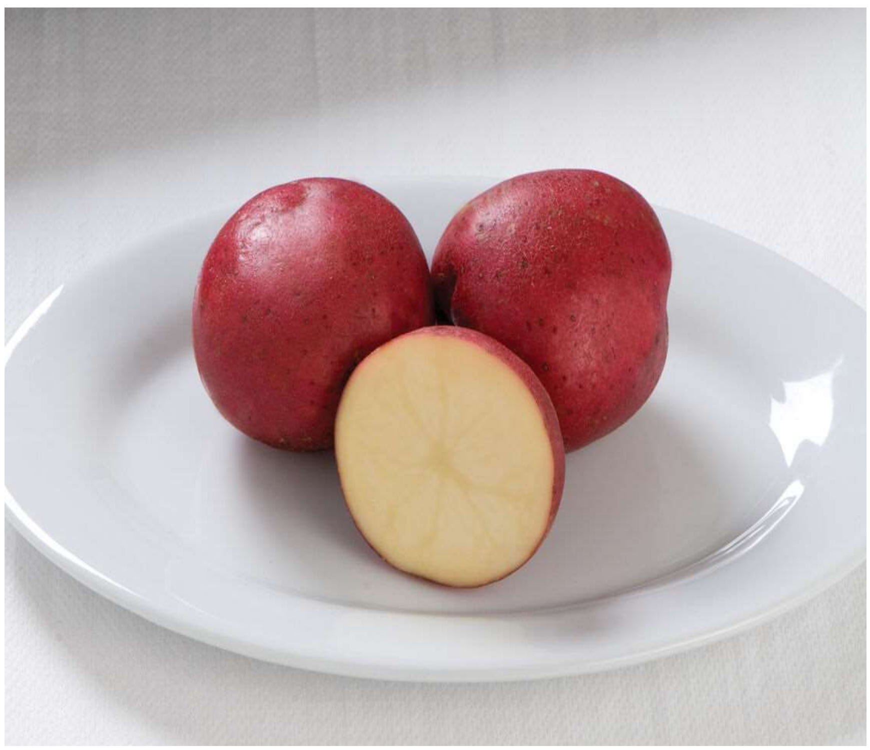
C_1+E_2 C_2+E_1 C_2+E_2

Plate 3.Pictorial presentation of lalpakri potato under different treatments

C_1=1ml/L Clybio application,C_2=2ml/L Clybio application,E_1=1ml/L Ecoagra application,E_2=2ml/L Ecoagra application, T_0=No treatment

CHAPTER V

SUMMARY AND CONCLUTIONS



CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

Potatoes are staple plants as the fourth largest carbohydrate source in the world after rice, wheat, and barley, so they can support food diversification programs. Potatoes are one of the leading commodities that have good national and international market prospects. For higher yield of potato, nutrient rich and fertile soil is necessary, but deficiency of nutrient due to repeated cultivation, people use different type of chemical and organic fertilizer. Application of organic fertilizer with bio-fertilizer is the best option for growth and yield attributes and environmental perspective.

The current research was aimed to investigate the impact of foliar application of clybio and ecoagra on growth and yield of lalpakri potato at Horticultural farm, Sher-e-Bangla Agricultural University, Dhaka during period from November, 2019 to February, 2020. This chapter contains a brief summry and conclusion of the result of the impact of Clybio and Ecoagra application in potato cultivation.

At 30 DAP, highest plant height of lalpakri potato plant was found in case of C_2+E_2 (37.04) due to the influence of Clybio and Ecoagra concentration which was followed by C_2+E_1 (35.2), C_1+E_2 (34.9), C_1+E_1 (34.1), C_2 (34.1), C_1 (32.4) and E_2 (30.5). On the other hand, lowest plant height at 30 DAP was found in case of T_0 (28.0) . At 45 DAP highest plant height was found in case of C_2+E_2 (65.0) which was followed by C_2+E_1 (62.2), C_1+E_2 (61.5), C_2 (60.96), C_1+E_1 (60.3), C_1 (59.7) and E_2 (56.6). On the other hand, lowest plant height at 45 DAP was found in case of T_0 (51.6). At 60 DAP highest plant height was found in case of C_2+E_2 (94.8) which was allowed by C_2+E_1 (90.0), C_1+E_2 (88.4), C_1+E_1 (85.7) and C_2 (85.1). On the other hand, lowest plant height at 60 DAP was found in T_0 (74.7).

Highest number of leaves per hill was found in case of C_2+E_2 (64.3) which was statistically similar to C_2+E_1 (62.3) and C_1+E_2 (61.3). This is due to the influence of clybio and ecoagra application. On the other hand, minimum number of leaves per hill was found in T_0 (57.0) which was statistically different from all other treatments.

In case of clybio and ecoagra treatment, maximum number of stem (6.0) was found in C2 which was statistically similar with C1+E1 (6.0), C2+E2 (5.7) and minimum (3.7) in T_0 .

Considering the clybio and ecoagra treatment needed least number of days (80.1) C2+E2 for maturity and while utmost number of days (90.0) required by T_0(untreated plants).

Considering the clybio and ecoagra treatment, the highest chlorophyll content (44.4) observed from C_2+E_2 which was statistically similar with C_2+E_1 (42.6), C_1+E_2 (40.7) and C_1+E_1 (38.9). On the other hand, minimum (31.7) was in T_0.

Maximum number of tuber per hill in case of clybio and ecoagra application (15.3) was found in C_2+E_2 which was statistically similar to C_2+E_1(14.7), C_1+E_2(14.7), C_1+E_1(14.7) whereas minimum (11.3) was in T_0.

In case of clybio and ecoagra application, maximum tuber length (46.8 mm) was observed under C_2+E_2 which was followed by C_2+E_1 (38.5 mm), C_1+E_2 (36.6 mm), C_1+E_1 (35.3 mm) and C_2 (34.5 mm) and minimum (31.2 mm) in T_0.

Maximum tuber diameter was recorded in C_2+E_2 (45.7 mm) which was followed by C_2+E_1 (40.7 mm), C_1+E_2 (37.9 mm) and C_2 (35.1 mm) and the smallest in T_0 (31.0 mm).

Considering clybio and ecoagra application, maximum individual tuber weight (29.4g) was found in C_2+E_2 which was followed by C_2+E_1 (27.8), C_1+E_2 (24.9) and C_1+E_1 (23.2)and minimum (12.4 g) in T_0.

Considering the clybio and ecoagra application, maximum yield per hill (451.02 g) was found in C_2+E_2 which was followed by C_2+E_1 (407.9 g), C_1+E_2 (366.3g) while the minimum yield (138.7 g) in T_0. In case of clybio and ecoagra application, maximum yield per hectare (30.06 t/ha) was observed under C_2+E_2 followed by C_2+E_1 (27.2 t/ha), C_1+E_2 (24.4 t/ha) and minimum (9.2 t/ha) in T_0.

5.2 Conclusions

Application of clybio (2.0 ml/L) and ecoagra (2.0 ml/L) increased not only growth but also higher yield compared to no application of clybio and ecoagra. It also suppressed different diseases as well as increased tuber quality.

Findings of the experiment reveal that the combined effect of Clybio and Ecoagra gives better result on growth and yield related attributes of lalpakri potato. So considering the more yield, availability of Clybio and Ecoagra, easy preparation and application process, combination of Clybio and Ecoagra at 2ml/L of water may be recommended for application to increase potato production.

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APPENDICES

APPENDICES

Appendix I. Analysis of variance on plant height at different days after sowing of lalpakri potato

Source of varitation	Degrees of freedom	Mean square of plant height		
		30 DAS	45 DAS	60 DAS
Factor A (Treatment)	8	25.4407*	53.5195*	126.173*
Error	16	2.0305*	3.2865*	5.147*

*: Significant at 0.05 level of probability

Appendix II. Analysis of variance on the data of number of leaves/hill, days to maturity, number of stem/hill, SPAD value of lalpakri potato

Source of varitation	Degrees of freedom	Mean square of			
		Number of leaves/hill	Days to maturity	Number of stem/hill	SPAD value
Factor A (Treatment)	8	12.2500*	26.5823*	1.59259*	56.1318*
Error	16	2.5417*	5.3227*	.49537*	5.2527*

*: Significant at 0.05 level of probability

Appendix III. Analysis of variance on the data of tuber length(mm),tuber diameter(mm),individual tuber weight (g) of lalpakri potato				
Source of varitation	**Degrees of freedom**	**Mean square of**		
		Tuber length (mm)	**Tuber diameter (mm)**	**Individual tuber weight (g)**
Factor A (Treatment)	**8**	**71.8425***	**67.5033***	**88.7003***
Error	**16**	**2.3209***	**7.3881***	**1.2369***
***: Significant at 0.05 level of probability**				

Appendix IV. Analysis of variance on the data of number of tuber/hill, yield per hill(g), yield per ha(t) of lalpakri potato				
Source of varitation	**Degrees of freedom**	**Mean square of**		
		Number of tuber/hill	**Yield per hill(g)**	**Yield per hectare(t)**
Factor A (Treatment)	**8**	**4.23148***	**28538.9***	**126.837***
Error	**16**	**.92593***	**123.4***	**.549***
***: Significant at 0.05 level of probability**				