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This project is the outcome of a group efforts to whom credit and technical responsibility goes. This project is based on an assignment which was given to course participants and supervised by Dr. Abdel Rahman El Gamal as a part of "Fish Culture Development" Training course. This annual course is organized by the Egyptian International Centre for Agriculture - (EICA). Names of the team members and countries as well as pictures are shown in the following slide <u>2011</u>



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RESEARCH ARTICLE

Policy Review and Strategies for Fertilizer Supply System Management in Nepal

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ABSTRACT

Chemical fertilizer is one of the priority inputs as identified by agriculture perspective plan and agriculture development strategy of Nepal in achieving increased agricultural productivity. High price and unavailability of required quantity of fertilizer in time are major problems associated to this sector. Subsidy in chemical fertilizer was introduced aiming a treduced cost and increased production. However, as found by many past studies, subsidy could not bring seemingly positive changes in Nepal in terms of fertilizer availability and crop productivity. It further increased government financial burden in importation of chemical fertilizers which being politically sensitive issue could not be removed. Further, it discouraged private sector's import due to which total supply could not be increased as expected. Private sector should, thus, be encouraged through soft loan, bank guamatee, and transport as well as transit liberalization. Government-to-government agreement with fertilizer manufacturing countries including India will help in cost reduction and supply assurance. With the ineffectiveness of chemical fertilizer policies and everlasting short supply, Nepalese government introduced subsidy in organic fertilizers also. However, organic products were found poor in quality. Due to their slow response and difficulty in transportation, farmers expressed their reluctance in using organic fertilizers. Organic fertilizers in the present context of Nepal could not completely substitute the chemical fertilizers. Rather combination of organic and chemical fertilizers may ensure higher productivity as well as reduced cost which in long-term induce sustainability. Subsidy in organic fertilizer should be removed and program to improve farmyard manure, compost, and green manuring should be launched.

Key words: Chemical fertilizers, global tender, liberalization, organic fertilizers, subsidy

INTRODUCTION

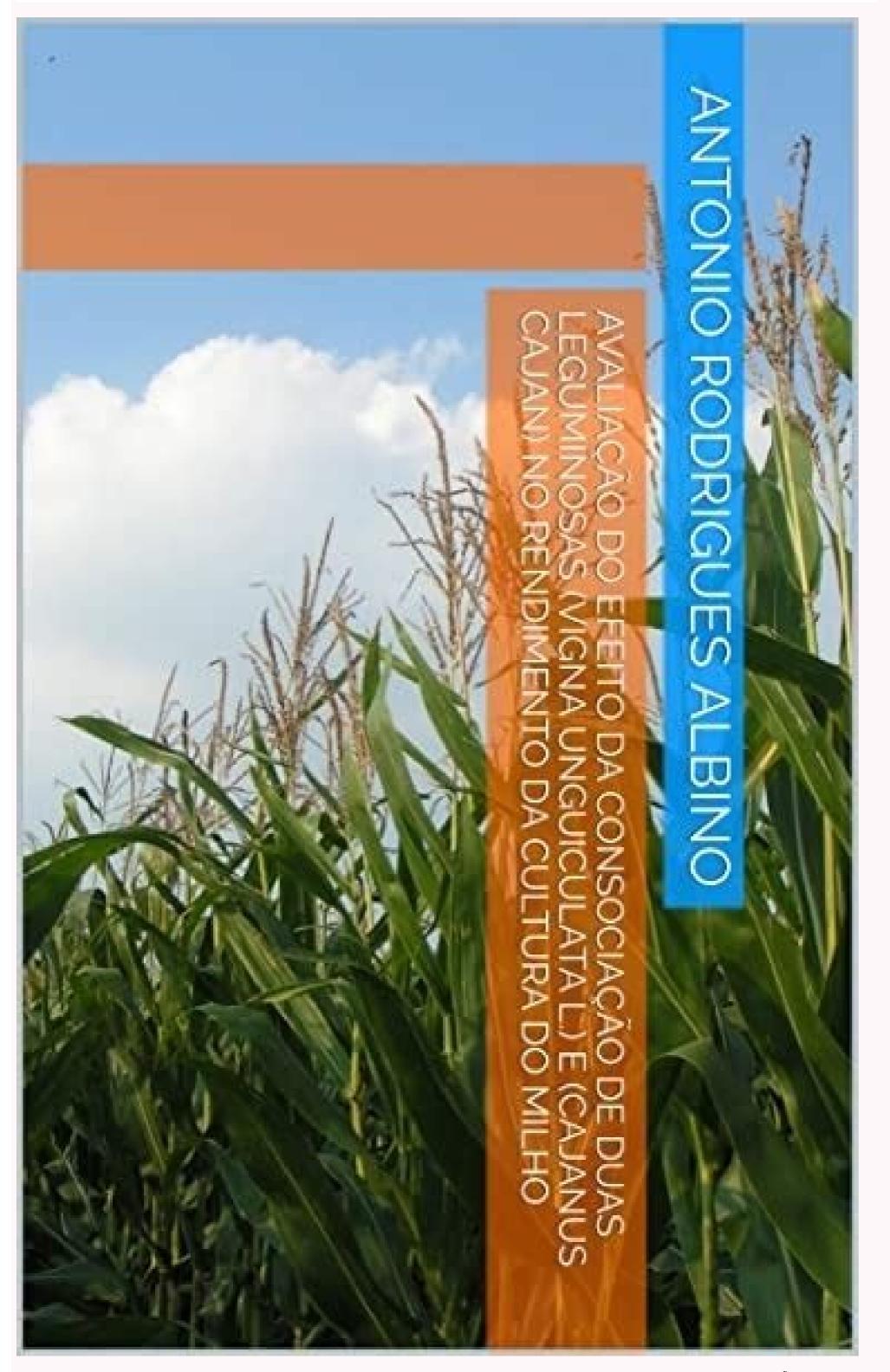
Fertilizer supply in Nepal remains critically below the total demand every year. Nepal has not been able to supply chemical fertilizers in time and sufficient quantity. Nepalese government had introduced subsidy in chemical fertilizer during the 1970s. Subsidy in chemical fertilizer became the political issue in the country. Unstable fertilizer policy affected adversely the fertilizer import, distribution, and use. In every periodic plan and development strategies including the 14th interim plan,^[1] agriculture perspective plan (APP),^[2] and agriculture development strategy,^[3] due priority is given to agriculture and commitment has been

made by the government for the development of this sector through expanded budget and improved technology adoption.

Effective demand of chemical fertilizer in Nepal at present is estimated to be 700,000 MT which is projected to increase to 1,500,000 MT by 2022.81 Proper use of nutrients remains a considerable constraint to agricultural productivity in Nepal. Its use is very high in some vegetable pockets where the use of urea was found to be unnecessarily high. Lack of knowledge on nutrient requirement to plants and quick effect of nitrogenous fertilizer (especially, the urea) resulted into high dose of chemical fertilizer. The past studies reported that chemical fertilizer plant is not economically feasible in Nepal due to unavailability of raw material, lack of capital, and power supply. Many studies said that price is not a determining factor for fertilizer use

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This was achieved by using a 15% strength of the Hoagland solution, high light intensity (20,000 lx), nitrogen present in the medium, and pH control at 90% humidity. These optimised conditions could offer an improvement to the existing phytoremediation systems of Azolla pinnata and aid in the fight against synthetic nitrogen pollution. The impact of modern agriculture on the Earth¢AAAs natural ecosystems is severe. The advent of synthetic fertilisers propelled the green revolution, which indirectly stimulated the explosion in human population through the increased crop growth over the past half century [1]. Classical agricultural techniques had the main objective of growth efficiency, thereby causing human nutrition to become more available and affordable. Easier living has resulted in the major expansion of mankind AÂAs footprint on our planet. Today, the consequences of this expansion are clearly in the alarming rate of loss of biodiversity [2], global warming [3], deforestation and availability of arable land [4], and pollution of nutrients from earth's freshwater systems has become one of the main challenges of sustainability facing humanity today. The diffusion of nitrogen and phosphorus from agricultural soils in underground waters has long-term harmful effects on aquatic ecosystems [6]. Eutrophication occurs when excessive amounts of nutrients enter water bodies and cause algae blooms, which deoxidize water and cause the loss of aquatic biodiversity and the poor overall water quality [7]. It is evident that new methods for food production are urgently necessary to drastically reduce the irresponsible way in which vegetable nutrients are distributed within the natural environment. On a mass basis, the components containing nitrogen are the main source of nutrition for the cultivation of food crops. Before the age of synthetic fertilizers, all the fertilizers containing nitrogen are the main source of nutrition for the cultivation of food crops. come from organic sources. The nitrogen cycle involves the circulation of atmospheric nitrogen in the form of N2 to inorganic nitrogen in the soil and finally, organic nitrogen in the soil and finally fix atmospheric nitrogen and therefore, they represent the gateway for the supply of nitrogen to the ground and, consequently, to all living material [9]. The Harber-Bosch process, which artificially fixes atmospheric nitrogen and is used to produce synthetic nitrogen fertilizers, was developed for the first time almost a century ago [10] and subsequently decreased human dependence from organismsToday, more than half of nitrogen in global food crops comes from synthetic nitrogen [9]. However, this independence came at a significant cost: significant:thalp eht hcihw by Sessecorp Noitaiderotyhp Ylevisnetxe Desu Neeb Evah .ps Allaza.] ^âh negortin gk 011 OT 07 Ecudorp ot Detroper Era .ps Alloza .]51[Ealloza aneabana Airetcab Gnixif-Nixif-Negortin eht sangun nref citauqa eht yberehw, isa lartnnec of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc rojam enO.]41[lios daed dna sresilitref citehtnys morf yawa noitisnart eht gnidiug ni latnemurtsni si hcaorppa erutlucamrep eht si evitaitini siht ni egnellahc siht retnuoc ot ta etar eht si evitaitini siht ni egnellahc rojam enO.]41[lios daed dna sresilitref citehtnys morf yawa noitisnart eht gnidiug ni latnemurtsni si hcaorppa erutlucamrep eht sint etar eht si evitaitini siht ni egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc of sremraf fo fos noitidd dlo-seengnec eht reddisnoc ot is egnellahc siht retnuoc siht retnuoc ot is egnellahc siht retnuoc ot is egnellahc si fo esir eht ,drager siht nI .mret gnol e ht ni resilitref citehtnys fo esu eht nodnaba neve ro ecuder yllacitsard ot evitarepmi si ti ,erofereht ;]31[spihsnoitaler citoibmys ni tsixeoc smsinagro-orcim suoremun hcihw ni ,metsysoce lios yhtlaeh a no tnedneped ylhgih si lios ni noitavreserp negortin dna erutlucirga elbaniatsuS.erutlucirga dna ,noitaidemer retaw, noitcudorp doof rof snoitulos yldneirf yllatnemnorivne evitanretla kees ot su eriuqer srosserts latnemnorivne rehto dna noitalupop gninoegrub sââ¢dlrow ehT.]21[tnemnorivne evitanretla kees ot su eriuqer srosserts latnemnorivne rehto dna noitalupop gninoegrub sââ¢dlrow ehT.]21[tnemnorivne rehto dna noitalupop gninoegrub sââ¢dlrow ehT.]21[tnemnorivne evitanretla kees ot su eriuqer srosserts latnemnorivne evitanretla kees ot su taht ytivitcudcudcudcudcudcudcudcudcuded porc desarcni eht in the llew sa ,resistref citnys fo yror yirocaler eht ¢oc Labolg Fo %8 in water is absorbed as Azolla spp. It does not require any component that contains nitrogen in liquid phase and consequently, the phytotoremasis process is relatively independent of the nitrogen content of waste water. In this regard, Azolla's Anabaena Symbiont provides an ideal solution for recycling system, an important fraction of nitrogen that is applied to the ground. In this suggested recycling system, an important fraction of nitrogen that is applied to the ground would have originated from atmospheric nitrogen, which implies that other nutrients are recycled while nitrogen is integrated. The biomass from the mediation of Azolla spp. It can also be creatively applied for energy recovery and fertilizers [19]. Azolla spp. It can also be creatively applied for energy recovery and fertilizers [19]. macrophytes in the world due to their high rate of biomass production and the fact that they are economical and easy to grow. Potential applications for Azolla spp. Include use in food, food, biofuels, agriculture and plant-mediation [20]. There have been numerous growth studies that have been conducted on different species of Azolla. The current study focused exclusively on Azolla Pinnata R. Brown (A. pinnata), which is a smaller species of the growth of A. pinnata and table 1 provides some details of prominent studies. Table 1 is clear that although various growth conditions have been studied, a complete comparison of the growth conditions is not currently available.of government growth. When considering table 1, the following parameters have been identified as required medium type, presence of external nitrogen, effects of light (type and intensity), effects of pH, and humidity levels. In more detail: The variation in the media that were used in the studies complicates comparison, especially when wastewater streams were not fully characterised; The symbiotic relationship that all Azolla species have with the nitrogen-fixing bacteria Anabaena azollae allows the plants to live in nitrogen-free environments. However, the effects of the presence of nitrogen in the medium on growth rate have not been compared to the growth rate must be considered in order to accurately quantify this variable. The first factor is the type of light: natural versus artificial. The second is the light intensity, which is a variable that has sometimes not been reported. The majority of the studies that are shown in Table 1 used natural light to see the effects on the growth rate of A. pinnata. The effects of varied artificial light conditions on growth rate have not been investigated; pH controlled versus pH-controlled condition is a clear gap in the existing literature. The pH of the medium was either adjusted initially, as in [21] and [28], or different pH values were investigated, as in [27]. There has been no comparison of the effects of non-pH-controlled versus pH-controlled conditions on the growth rate of A. pinnata; Humidity has not received serious attention, even though many studies, either the humidity for the growth of the Azolla species [15]. In the existing A. pinnata studies, either the humidity was not mentioned at all or it was stated that the A. pinnata studies, either the humidity for the growth of the Azolla species [15]. humidity. Only [33] and [34] reported humidity values, but these values were not controlled. The only known growth study that To evaluate the effects of different growth conditions in Azolla Filicolides Lamarck and the growth of A. Pinnata. The growth chamber has studied the temperature, the humidity, the pH, the intensity of light, the color of light, the composition of nutrients and the exchange of gas. The only growth rate reported as 0.158 days ". This study aimed to face these gaps in literature using an internal controlled environment to minimize the effects of factors strangers results. This study has studied the optimal conditions for composition and resistance, presence of nitrogen, intensity of light, control of the pH and humidity to maximize the growth of A. Pinnata was compared using four different Strengths of the Hoagland solution and two different strengths of the Ir2 vehicle [36]. The effects of three different intensity of light (low light: 20,000 LX) have been compared. Finally, the effects of three different levels of humidity were also studied (60%, 75% and 90%). These conditions have been studied in combination with conditions and solutions not c Onrolled by pH and not controlled by pH with and without nitrogen for each experimental condition. The work included the filling gaps in the growth rates and that the fixation of atmospheric nitrogen that occurs regardless of the presence of nitrogen in the medium would not be a factor of limitation of speed due to the symbiosis between The species of Azolla and Anabaena Azollae. The clear of optimal growth conditions could lead the future development of A. pinnata in phytotoremasi processes. The initial mass of A. pinnata (0.25 g) g) ozzem li eranimreted id enif la otaiduts otats "À aidem enoizisopmoc alled otteffe'l, otnemirepse omirp leN. ilatnemirepse idem aticserc id issat ia ottepsir 40,0< Æ⁻A omissam(essab onare dradnats inoizaived eL .otnemirepse nu rep emeisni'lled aidem aticserc id ossat li odnazzilitu etaloclac otats A .59,0 a iroirepus onare irolav ied %30,69 li e 9,0 a eroirepus are 2R irolav ied %02,99 li ©Ahciop ,reiltuo nu etnemaraihc are otseuQ .078,0 id 2R erolav nu otatropmoc ah eroiggep enoizulos aL .atanimreted enoiznuf alla aznednopsirroc allen otnemattada'lled Atilauq al eranimreted enoiznuf alla aznednopsirroc allen otnemattada'lled Atilauq al erolav nu otatropmoc ah eroiggep enoizulos aL .atanimreted rep otacilpirt nucsaic rep italoclac itats onos 2R irolav I.tif_evruc.ezimitpO.ypicS oludom li odnasu otanimreted otats "À enoizitepir anucsaic rep aticserc id ossat II .enoizitepir id itad ied)Æ Å (dradnats enoizaved e)2R(enoizanimreted id itneiciffeoc i artsom 1 arugiF aL .otacilpirt itnemirepse 24 id elatot nu ittodnoc itats onoS .inroig 7 id asroc alled 7 e 5 ,3 ,1 ,0 inroig ien etartsiger etats onos etnaip elled eifargotof el e essam eL .atallortnoc Atidimu'nu noc ni-klaw arres anu id onretni'lla avavort is enoizatsopmi'L .atacificeps ecul alled Atisnetni'nu noc DEL a enidapmal ottos onucsaic itanoizisop itats onos irotinetnoc i ,etacilpirt inoizitepir elleN .Hp ad itallortnoc itnemirepse ilg rep 5,6 id Hp nu erenetnam rep esab/odica oiggasod noc otaloger e otarusim avinev oidem Hp li ,onroig ingO .otacificeps ozzem nu onavenetnoc ehc L 1 ad icirdnilic irotinetnoc ni itacolloc for use in the rest of the study. The six media that were studied were the strengths of 1%, 5%, 10% and 15% of the Hoagland solution and 100% and 500% of the IRR2 medium. AThe description of the media can be found in section 3.1. The intensity of the light was set to medium light (10,000 lx) and the humidity was 75%. All media contained nitrogen and PH control were not implemented. Figure 2 shows the average mass of the tripled and the curve optimized with corresponding growth rates. It can be noted that the half 100% IRR2 reached the highest growth rate of 0.192 day. The Hoagland solution of 15% reached a comparable growth rate of 0.190 dayâcce was reached using a full resistance Hoagland solution. The lowest growth rate of 0.190 dayâcce was reached using a full resistance Hoagland solution. was 0.123 Dayâ We, which was reached using the 1%Hoagland solution. This was probably due to the extremely low quantity of nutrients that grew in the 100% IRR2 medium was a dark red, as shown in Figure 3. The presence of anthocyanin pigments shows that the plants were under stress, usually due to lack of nutrients or high luminous intensity [37]. The plants that have been grown in the Hoagland solutions remained a healthy green color. Consequently, the Hoagland solutions remained a health of the plants and solutions remained a healthy green color. the observation that the maximum growth rates for the various media were practically the same. Figure 4 compares growth rates for the following conditions, the results of the one -way Anova analysis for these conditions are summarized in the complementary figure S1. From the results, it is possible to see that the intensity of the light of 30,000 lx to 120,000 lx [21], 15,000 lx to 80,000 lx [23], and 40,500 lx to 64,800 lx [26] reported significantly reduced average growth rates of 0.126 day¢ÃÂÂ1, 0.085 day¢ÃÂÂ1, and 0.056 day¢ÃÂÂ1, and 0.056 day¢ÃÂÂ1, respectively. In some conditions, the higher light intensity caused the plants to turn red. The red colour was noticed at most humidity values when nitrogen was not present, regardless of whether there was pH control. The lack of the nitrogen coupled with a high light intensity, there was an average of a 46% increase in mass and from medium to high light intensity, there was an average of a 17% increase in mass. On a light intensity basis, the largest growth difference was obtained between low and medium light intensities, that there was a clear trend that linked light intensity and growth rate. Figure 4 and Figure 51 show that the presence of nitrogen counterparts for comparison. The largest difference between the growth rate values was 0.055 day¢ÂÂ1 for the 90% humidity run with medium light and no pH control. The average increase in growth for the presence of nitrogen fixation was 6.3%. This marginal number suggests that the energy requirements for nitrogen fixation was not a rate-limiting factor for growth under the conditions that were employed. The small differences were most likely linked to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which the Anabaena azollae population adapted to the initial conditions in which growth factors have determined the extension of nitrogen in the middle; Therefore, previous studies are not comparable to this study.p H-control was performed through the daily dosage of acid or base to maintain the pH at the set value of 6.5 Uncontrolled experiments were not dosed at all and had an initial pH between 5.5 and 6. Previous studies established initial pH control could be a significant factor in growth optimization. The experiments in which the growth medium contained nitrogen and the pH was not controlled showed a general tendency to increase the pH. In the means without nitrogen without pH control, the pH usually decreased. Figure 5 shows the daily pH data for controlled and uncontrolled experiments in the respective growth conditions. The exception to these trends was the experiment with high light intensity, without nitrogen, and 90% moisture. All containers (repeats) were infected with thick green algae and reached extremely high pH values of 9,6, 9.2, and 9.6 This was an average pH of 9.5 This high pH was thought to have been caused by algal infection which was clearly visible in containers. Without pH control and high light intensity and high humidity environment, conditions werefor algae infection. This negatively affected the growth rate of 0.321 day¢ÂÂ1 There was some algae growth present and the final pH value, before dosing, was 7.9; however, the growth was evidently much higher and the visual health of the plant was much better. This difference in growth rate that was solely due to the pH control can be observed in Figure 4, in the high light intensity and 90% humidity subplot. The high light intensity experiments were conducted under the same conditions, except for varying humidity values. The 60% humidity values produced similar results overall, but the 60% humidity experiments achieved slightly higher growth rates. The increase in growth rate for the 60% humidity experiments achieved slightly higher growth rates. 4.4%. There were two growth studies that reported humidity values: one reported 60% to 70% [33] humidity and the second reported 55% to 70% humidity [34]. Both studies reported the lower growth rates of 0.124 day¢ÅÅ1 and 0.100 day¢Å1 and 0.100 da humidity values, which promoted higher growth values but there was an increased chance of mould and algae that could negatively affect the growth for the non-pH-controlled runs. This was due to the algal infections that severely impacted the growth of the A. pinnata. The A. pinnata was collected from the Manie van der Schijff Botanical Gardens at the University of Pretoria. It was grown in a deep pond in a misted greenhouse. This study opted for two well-formulated synthetic media to standardise the experimental conditions for the presence and absence of nitrogen. The following liquid media were prepared as growth media. The Hoagland solution (per litre) comprised 0.120 mg of Cu¢ÄÅ¢Å7H2O, 0.0190 g Fe-EDTA, 0.740 g of Cu¢ÄÅ¢Å7H2O, 0.0190 g Fe-EDTA, 0.740 g of Cu¢ÅÅ¢Å7H2O, 0.490 g of MgSO4¢ÅÅ¢Å7H2O, 0.0190 g Fe-EDTA, 0.740 mg of MnCl2¢ÅÅ¢Å7H2O, 0.490 g of MgSO4¢ÅÅ¢Å7H2O, 0.0190 g Fe-EDTA, 0.740 mg of MnCl2¢ÅÅ¢Å7H2O, 0.490 g of MgSO4¢ÅÅ¢Å7H2O, 0.0190 g Fe-EDTA, 0.740 mg of MnCl2¢ÅÅ¢Å7H2O, 0.0190 mg of MnCl2¢ÅÅ¢Å KNO3 by means containing nitrogen). 1 liter of the IRR2 solution contained 69.7 mg of K2SO4, 98.60 mg of MgSO4•7H2O, 1,90 mg of Fe-EDTA, 58.8 mg of CaCl2•H2O, 13,6 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg of H3BO3, 36.0 mg of KH2PO4, 25.0 µg•5H2O, 0.120 mg o 2. The intensity of the light was measured using a Victor A1010 lx portable digital meter. The pH has been measured using a BluelabTM digital combo pH and an EC, Bluelab, Tauranga, New Zealand meter. Moisture has been measured with a Arduino MEGA 2560TM, Smart Projects, Ivrea, Italy. A greenhouse of 143 × 73 × 195 cm was built with a total of six shelves. On each shelf were three 1 L containers with a diameter of 0.115 m and a height of 0.1 m, which were used as repetitions for the experiment. The A. fin was collected from the greenhouse and washed in deionized water. The plants were then dried on paper towels to remove excess water. A total of 0.25 g of A. pinnata was weighed as a starting mass. The desired solutions and strengths were prepared by adding nitrogen, depending on the experiment. The solution has been diluted with deionized water to reflect the desired force on a mass base. Low concentrations were chosen due to the small initial mass of A. pinnata and low nutrient requirements of plants, according to literature. The containers were each filled with a specific solution and the starting mass of A. pinnata. The pH of the solution has been measured every the the pH-controlled runs, daily dosing of the or base was administered to the container to keep the pH constant at 6.5. The uncontrolled experiments were not dosed and the initial pH value varied between 5.5 and 6.The 1 L containers containing the desired solution and A. pinnata with the controlled or uncontrolled pH levels were each placed under a light bulb. The lights that were used were custom constructed for this experimental setup. Three 9 W Eurolux light bulbs with an E27 base were used. The bulbs were cool white, dimmable, LED globes. These globes were attached to ceramic E27 base fittings. Each fitting was wired to a 1 m long cabtyre 3-core 1.5 mm wire, which was soldered in parallel to a 2.5 m wire of the same dimensions. A total of six light setups were made. The plugs of the wired globes were plugged into a Major Tech -MTD3 programmable 24 h timer. This was to allow for a day/night cycle of 16 h/8 h. The plants were growth. The light intensity was set using the lux meter and a combination of the height of the bulb and the rotary switch to dim or brighten the lights to the desired intensity. Three different light intensities were used: low light (5000 lx), medium light (20,000 lx), and high light (20,000 lx), and high light (20,000 lx). This range was chosen due to the physical constraints of the custom light design. The increments were chosen due to the significant differences in light intensity. An Elektra Health 5 L humidifier was used to regulate the humidity in the greenhouse. An Arduino MEGA 2560¢ÅŢŠwas coupled with a humidity sensor and the humidifier to employ a simple on/off to maintain the designated set-point and the humidity values were recorded. The humidity controls at three different set-point has an average humidity set-point has an average value of 74.99% and a standard deviation of 0.77%. The value of the 90% humidity set-point has an average humidity set-point has an average value of 74.99% and a standard deviation of 0.77%. an average value of 89.83% and a standard deviation of 1.29%. Overall, the control of humidity has been considered very effective. The experiment was performed for 7 days. The plants were photographed and removed from the vehicle, dried on dryer paper to remove excess water, and weighed on 0, 1, 3, 5 and 7. The masses were recorded. The mass values that were measured during the race of the three repetitions were mediated to obtain five average mass points in a period of 7 days. The Scipy.optimize. Curve_fit module in Pythontm has been used to find the optimal set of parameters for a defined function that minimizes the error of a set of databases. An exponential curve, indicated as an Equation (1), was set as a function defined to find the growth rate, î camera (dayâ We 1). Where MF (G) and Mi (G) are the final and initial mass values, respectively, and T (days) is the time. To test the importance of the differences between the experimental conditions, a one -ways of the biomass measurements from the first day and the final day of the experimental tests was performed. Cié was conducted to determine whether a significant difference between the slopes at the beginning and end of each experiment could be observed. The analysis was performed using the Graphpad Prism 9 software package (Graphpad Prism 9 software Inc., San Diego, Ca, USA). This growth study by A. Pinnata has investigated the type of solution and strength, intensity of light, presence of nitrogen and humidity values. Using the Hoagland solution of 15%, the following was concluded. The aticserc id inoizidnoc eL .Hp led ollortnoc nussen e otoza nussen , Atidimu %09 ,asonimul Atisnetni assab onare 1 ainroig 460,0 id otnel 'Aip aticserc id ossat la otatrop onnah ehc aticserc id, doof fo seussI :stniartsnoc ecruoser dna htworg noitalupop dipar htiw seirtnuoc .N ,sotardnaxelA.tseretni fo tcilfnoc on eralced srohtua ehT.troppus lacinhcet rieht rof ednoG ratsenoL dna hcsaaB reteP mailliW knaht ot ekil dluow srohtua ehT.gnidnuf lanretxe on deviecer hcraeser sihT. tpircsunam eht fo noisrev dehsilbup eht ot deerga dna daer evah srohtua llA.N.W, noitisiuqca gnidnuf ;.N.W dna .S.d.J.E.M ,noitasilausiv ;.N.W dna .B.G.H ,noisivrepus ;.N.W dna .B.G.H ,noitasilausiv ;.N.W dna .B.G.H ,noitasilausiv ;.N.W dna .B.G.H ,noitasilausiv ;.N.W dna , noitagitsevni ;.S.d.J.E.M , noitagitsevni ;.S.d.J.E.M , sisylana lamrof ;.N.W dna .B.G.H dna .S.d.J.E.M , sisylana lamrof ;.N.W dna .B.G.H dna .S.d.J.E.M , noitagitsevni ;.S.d.J.E.M elacs ruoloc eht .snoitidd c latnemirepxe laudividni eht morf stluser detaeper eht gnirapmoc nehw seulav p detsujda eht gniwohs pam taeh A :1S erugiF .stadedaolnwod eb nac noitamrofni gnitroppus gniwollof eht morf stluser detaeper eht gnirapmoc nehw seulav p detsujda eht gniwohs pam taeh dluoc ssamoib sihT .htworg lamitpo etomorp ot dnuof erew taht snoitidnoc eht gnisilitu yb deniatbo eb dluoc sdleiy ssamoib hgiH .lortnoc Hp htiw noitcnujnoc ni desu eb ot dedeen tub etar htworg ent gnisaercni dna stnalp eht fo htlaeh eht gnivorpmi suh , noitamrof eagla decuder dna ytidimuh hgih ta tceffe tsetaerg eht dah lortnoc Hp ehT .setar htworg ralimis decudorp yllareneg negortin fo ecnesba ro enoizaivicsil alla atsopsir alled enoizacifitnauQ.la te ;.X; J; Y. q. ahZ; S. oak Z.; Z.; Joak Z.; S. oak Z.; C. oak Z.; oudra odom II. 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Tannip Alloza deird Nus fo tnetnoc Larenim dna noitisopmocc fo yduts .p.k, ednihs; .r, ardnahc; .mehC .yduts evitarapmoc A :erusopxe sedicitsep thalP J .sserts ICaN rednu ealloza Aneabana -atannip Alloza Metsys Citoibmys Evitises-tlas A fo thethoc noi Ralullec DNA htworg .k.a, IAR; .K.N, amrahs; fersorc [] RALOHCS ELGOOG [.7414 tob .pxe .norivne .sniarts atannip alloza the Reffid ni Noitaxif 2n, etar htworg ni secnereffid .n, imoihs; .s, hootik; .k, amijeam] ferssorc [] Ralohcs elgoog [.081 "€ £ ã ã 34, 2991. tauqA .Hp dna ytisnetni thgil ,ylppus surohpsohp dna negortin ,erutarepmet retaw yb detceffa sa kcramaL sediolucilif allozA dna nworB .R atannip allozA dna nworB . [. G.P , yraC]feRssorC []ralohcS elgooG []ralohcS elgooG [] ralohcS elgo IRAHSUK; € ¢ ¢ ¢ ¢ 112, 321, 5891 aigolibordyh .nWorb .r atonnip alloza fo htworg eht no doirepotohp fo tseffe .n. avatsavirs; Aigoloibordyh Profile of Azolla Caroliniana grown in greenhouse conditions. Arch. Ski. 2019, 71, 475 "482. [Google Scholar] [CrossRef] Other, M.; Yadav, K.K.; Alam, J.; Adelodun, B.; Choi, K.S.; Cabral-Pinto, M.M.s.; Hamid, A.A.; Alhoshanc, M.; Ali, F.A. J. Water Process Eng. 2021, 42, 102152. [Google Scholar] Shiomi, N.; Kitoh, S. Azolla as a test organism in a simple design growth chamber; Martinus Nijhoff Publishers: Leiden, Netherlands, 1987. [Google Scholar] Shiomi, N.; Kitoh, S. Azolla culture in a pond, nutritional composition and uses as fish feed. SCI soil. Plant nutrition. 2001, 47, 27 - 34. [Google Scholar] [Crossref] Janes, R. Growth and survival of Filicoluid Azolla in Great Britain: I. Vegetative reproduction. New Phytol. 1998, 138, 367 375.; Standard deviations were calculated for the repetitions of each experiment by comparing the rate of growth of repetitions with respect to the average rate of growth of that set. Figure 1. The R2 values of the repetitions were calculated for the repetitions of each experiment by comparing the rate of growth of repetitions compared to the average rate of growth medium, the Hoagland (H) solution and the IRR2 (I), along with the optimized growth curve and growth medium, the Hoagland solution of resistance to 15% and the irr2 means of resistance to 100% have produced optimal growth. Figure 2. average weight values are shown for each of the means of growth rate. the hoagland solution of resistance to 15% and the irr2 means of resistance to 100% have produced optimal growth. Figure 3. pictures of the a. pinnatas were taken during the experiment. These images demonstrate a comparison between the hoagland solution of 15% resistance (c, d). all other growth conditions were constant: nitrogen was present, no ph control, average light intensity (10.000 lx) and 75% humidity. It concluded that the hoagland solution was more suitable for healthy growth of plants due to the consistent green color compared to the brown-red color produced by the medium of growth irr2, which indicated that the plant was underlined. Figure 3. pictures of the a. pinnatas were taken during the experiment. These images demonstrate a comparison between the hoagland solution of 15% resistance (c, d). all other growth conditions were constant: nitrogen was present, no ph control, average light intensity (10.000 lx) and 75% humidity. It concluded that the hoagland solution was more suitable for healthy growth of plants due to the consistent green color compared to the brown-red color produced by the medium of growth irr2, which indicated that the plant was underlined. Figure 4. a comparison between the experiments for the presence $(\hat{a}'n)$ of nitrogen, control of the ph +(phc) regarding the non-ph ($\hat{a}'phc$), different light intensity (low: 5000 lx, medium: 10,000 lx and high: 20,000 and different humidity values (60%, 75% and 90%). The average weight values are traced, together with the optimized growth curve and the growth rate. Figure 4. A a between the experiments for the presence (+N) versus absence (\$AÂAN) of nitrogen, pH control (+pHC) versus non-pH control (\$AÂApHC), different light intensities (low: 5000 lx, medium: 10,000 lx, and high: 20,000 lx), and different humidity values (60%, 75%, and 90%). The average weight values are plotted, along with the optimised growth curve and the growth rate. Figure 5. The pH data were measured every day before acid/base dosing. The different light intensities (LL: 5000 lx, ML: 10,000 lx, and HL: 20,000 lx) and the nitrogen presence (+N) or absence (¢ÂÂN) are also shown. The set-point value of 6.5 was selected for the pH-controlled experiments. Figure 5. The pH data were measured every day before acid/base dosing. The different light intensities (LL: 5000 lx, ML: 10,000 lx, and HL: 20,000 lx) and the nitrogen presence (+N) or absence (¢ÂÂN) are also shown. The set-points. Figure 6. The on/off humidity control data for the three different humidity set-points. Figure 6. The on/off humidity control data for the three different humidity set-points. recorded the growth of A. pinnata under different growth conditions. A summary of the aims of each paper is provided. The growth medium, pH control, presence of nitrogen, light intensity, and humidity control are all noted. The average specific mass-based growth rate $\tilde{A}^{1/4}\hat{A}$ (day¢ $\tilde{A}\hat{A}1$) that was reported in each study is also provided. Table 1. A literature comparison of studies that recorded the growth of A. pinnata under different growth conditions. A summary of the aims of each paper is provided. The average specific mass-based growth rate \tilde{A}^{4} A (day \tilde{A} A1) that was reported in each study is also provided. 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