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Optimizing Nutrients Formulation and Spray Schedule for Aeroponically Grown Potato

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ABSTRACT

Aeroponics system is an efficient and alternate technique to produce quality and disease free mini-tubers of potato. Aeroponics, a soil less culture has a main feature comprising root system enclosed in a dark chamber and the water and nutrients are supplied to the roots through misting. Since the roots are hanging inside the dark chamber, water and nutrients are provided through mist or a fine spray. A modular aeroponics system was designed with water and nutrient delivery system with an option of regulating misting or spraying time during the day and night with the help of cyclic timers. In the present study, we have optimized the misting cycles and composition of nutrients solution for optimum growth and development of potato for initial 45 days. Accordingly, the misting cycle of 30 seconds *on* with 6 minutes *off* during the day and 30 seconds *on* with 12 minutes *off* during night time was found to be the best misting cycle for effective growth of potato plants with higher shoot and root length, number of nodes per plant, leaf area and biomass. Similarly, the modified Hoagland's nutrient solution with higher amount of N and K was found to be very effective for good growth and productivity of aeroponically grown potato plants. As compared to normal Hoagland's nutrient solution, our new formulations (modified Hoagland's solution) with altered nutrients composition has significantly improved the growth and mini-tuber number and total yield in aerponically grown potato.

Keywords : Nutrient formulation, Aeroponics, Potato

POTATO (*Solanum tuberosum* L.) is one of the world's most important non-cereal high yielding horticultural food crop. Being largely a vegetatively propagated crop, it is subjected to a number of seed borne diseases leading to degeneration of seed stocks over the years. It is therefore imperative to use good quality seeds for economic production of potato. However, availability of quality seed material is a major constraint for potato production especially in developing countries (Upadhya, 1979 and Trivedi & Gadewar, 1990). Thus, farmers are often forced to use locally grown seed material despite severe yield losses as the degenerated seeds are known to lower the productivity by around 40 per cent (Salazar, 1996 and Raveesha, 2014). In a country like India, the major cause for low productivity of potato has been the use of poor quality seed material (Singh, 2003) and at present, the state and the central seed production agencies of the country are able to meet only 20 - 25 per cent of the total seed requirement (Kumar *et al*., 2007). In this regard, aeroponics technology is emerging as a potential option to produce virus free / disease free mini-tubers as planting material. Mini-tubers produced in aeroponics systems are subsequently multiplied under net house for about 3-4 generations before supplying the seed material to the farmers.

Aeroponics technology is a soil less culture where the plants are grown in air with the assistance of an artificial support. It is an air water cultivation system where the roots are hung inside a container under darkness, while the shoot system grows above the container exposed to the outside environmental condition. Nutrients and water are sprayed through atomization nozzles or misters. The nozzles create a fine spray or mist of different droplet sizes intermittently or continuously and the nutrient-mist system uses a minimum amount of water and provides an excellent environment for plant's growth (Mbiyu *et al*., 2012 and Rykaczewska, 2016). Aeroponics system is therefore, an incredible system that uses a very little amount of water compared with the other plants growing systems (Lakhiar *et al*., 2018). This system offers lot of benefits as it saves water up to 95 per cent, nutrients up to 60 per cent and shown to maximize crop yield by 45 to 75 per cent over either hydroponics or soil grown systems (Spinoff, 2006). The aeroponics system is therefore considered as a safe and environmentally friendly plant cultivation method.

In aeroponics system, as the root is enclosed in a dark chamber with roots hanging not contacting with any media to supplement the water and nutrients requirement of the growing plants, the required water and nutrients are to be provided to the roots in the form of spray or a mist. As water and nutrients requirement of each crop is different, it is necessary to standardize the nutrients formulations and concentration as well as nutrients spray schedule for effective growth of aeroponically grown plants. Frequency of misting of nutrients solution is an essential factor for successful plant cultivation and therefore, it is necessary to fix the atomization spray time and the interval time based on the plants requirement (Lakhiar *et al.*, 2018). Many studies in the past have standardized the spray schedule for different crop plants and accordingly, Biddinger *et al.* (1998) have reported a spray schedule of three seconds on and 10 minutes off for tomato. Similarly, in another study, Osvald *et al.* (2001) found a good response with a spray schedule of 60 seconds on and five minutes off for tomato. Likewise, spray schedule has been standardized for various crops which include cucumber with seven seconds on and 10 minutes off (Peterson and Krueger, 1988); lettuce with 1.5 - 2.0 minutes on and 5.0 - 7.0 minutes off (Kacjan-Marsic and Osvald, 2002); peas with 3 seconds on and 10 minutes off (Rao *et al.*, 1995); onion with 7 seconds on and 90 seconds off (Jarstfer *et al.*, 1998). However, not many studies were made to systematically analyse the spray scheduling for day and night period as the water and nutrients requirement of plants differ during day and night period.

Apart from the misting cycles, aeroponics systems use nutrients solution for effective growth of plants. This technique has been applied successfully for cultivation of leafy and root vegetables, aromatic and medicinal plants, because of their higher nutritional quality and properties of aeroponically grown plants compared to the other soil less plants and soil grown plants (Kumari and Kumar, 2019). In soil less cultures like aeroponics, nutrient optimization is the most critical factor to produce high quality and high yields. Although aeroponics system is highly effective, several aspects of the system are to be scientifically proved, such as the proper selection of atomizers (droplets), spraying time, spraying interval, root-zone temperature, humidity. In addition, the best nutrient solutions for different crops and varieties need to be identified and standardized (Otazu, 2010; Buckseth *et al.*, 2016 and Sumarni *et al.*, 2019). Therefore, in the present study, an attempt was made to optimize the nutrients composition and concentration as well as spray scheduling of the nutrients solution for effective growth of aeroponically grown potato.

Material and Methods

Experiments were conducted at the greenhouse facility of the Department of Crop Physiology, University of Agricultural Sciences, GKVK. Bengaluru. The potato variety, *Kufri Jyoti* was selected for the study mainly because of the fact that, this variety is extensively grown in hills, plains and plateaus as it is highly suitable to all the conditions. This variety occupies more than 60 per cent area under potato cultivation in India and in Karnataka, it occupies more than 90 per cent. Wide adaptability, early bulking and slow rate of degeneration, floury texture and mild flavour, free from discoloration after cooking are the major quality features of *Kufri Jyoti*. Further, it is moderately resistant to early and late blight diseases and shows immunity to wart and its yield potential is up to 2.5 to 3.0 tons/ha.

Nursery Preparation : Early generation certified potato tubers of *Kufri Jyoti* was procured from certified source of ICAR-CPRS (ICAR- Central Potato Research Station), Ooty and the seed tubers were treated with a fungicide, carbendazim @ 2 g^{-1} litre of water for 10 minutes. After fungicide treatment, tubers were cut into 2 to 3 pieces with each piece contained a minimum of two buds and the cut pieces were treated again with same fungicide. Cut pieces were sown in portrays containing sterilized coco-peat and the portrays were watered regularly. The 21 days old, healthy, uniform, vigorous potato seedlings were removed from the trays and used for planting in aeroponics chambers after washing the roots in fresh water to remove the adhered media and other material. Before transplanting in aeroponics chambers, roots of seedlings were dipped again in 0.2 per cent carbendazim solution for 10 minutes.

Design of Mini Aeroponics Chambers : To achieve the effective growth of potato crop under aeroponics system, standardization of misting period (misting cycles) and nutrients composition is important. A novel and low cost mini aeroponics chambers were designed initially to standardize the misting cycles for aeroponics potato cultivation and to optimize the nutrients composition for efficient cultivation of potato (Fig. 1). Mini modular aeroponics chambers were designed and fabricated using commercial fibre boxes / crates (dimension of 3.5 ft. x 2 ft. x 3.5 ft). Inside the chambers, a 2 inch CPVC pipe was fixed horizontally near the base of the fibre boxes / crates to which, misters were mounted each facing upward. The inlet of the pipe was connected to a motor having a discharge capacity of 3 litres per minute. Cyclic timers were fixed to these motors to regulate the misting cycle. Nutrients solution of 20 litres per chamber was used for misting to the hanging root zone inside the chamber and the dripped solution was collected and stored in the bottom of the aeroponics chamber. Nutrients solution stored at the bottom of the chamber were pumped again and supplied through misting units fixed on CPVC pipe. The chamber was covered with a high density polystyrene sheet and on which, small holes were made to plant the young potato seedlings. The polystyrene sheet acts as a plant holder which holds the plants during the entire experimental period. Young, uniform and even aged potato plants were transplanted in the holes made on polystyrene using the rubber cork (Fig. 1).

Fig. 1: Mini-modular aeroponic chambers designed to standardize the misting cycle and nutrients composition for aeroponically grown potato

Standardization of Misting Cycles : Fine droplets of nutrients solution through misters mounted at the bottom of the aeroponics chamber facing upward was achieved by pumping nutrients solution through a feeding pipe at high pressure. Through the timer, schedule of spray can be regulated and as shown in Table 1, different spray schedule was attempted with altered spray schedule during day and night time. Based on the healthiness, leaf turgor and the growth performance of the plants grown on aeroponics chambers, the best spray schedule was selected for further experiments.

TABLE 1

Different misting cycles attempted for standardizing the optimum misting cycle for aerponically grown potato

Treatments	Day		Night	
	on (Seconds)	*off* (Seconds)	*on* (Seconds)	*off* (Seconds)
T1	15	3	15	6
T2	30	3	30	6
T3	45	3	45	6
T4	15	6	15	12
T5	30	6	30	12
T6	45	6	45	12

Standardization of Nutrients Composition : Normal Hoagland's solution was used while standardizing the nutrients spray schedule for potato. However, this may not really be the nutrients composition required for the efficient growth and tuberization of potato. Therefore, standardization of nutrients compositions and concentration is equally important for potato cultivation under aeroponics system. Therefore, it is highly relevant to standardize the nutrients composition and concentrations for effective growth and productivity of potato plants grown on aeroponics chambers. Towards this, several nutrients formulations and concentrations were tried (Table 2) and based on the best results, effective nutrient formulations were standardized. Besides normal Hoagland's nutrients solution, a few other nutrients formulations reported in the literature were tested for the growth response of potato. These formulations include,

A. Standard Hoagland's solution

B. Modified Hoagland's solutions

C. USDA potato nutrients formulation from Peru by Otazu (2010)

D. Nutrients formulations from Karnataka State Horticulture Department

E. Ethiopian nutrients formulation by Tessema *et al.* (2017)

While all other formulations were retained as it is as reported in the literature, the Hoagland's solution was rather modified with our own formulations keeping the base nutrients of Hoagland's solution constant. In the modified Hoagland's solution, we have increased the N and K and a few other nutrients to examine whether such modifications have any significant positive effect on growth of potato plants in aeroponics chambers. To prepare the nutrients solutions, stock solution of each salt were prepared in deionized water separately using laboratory grade nutrients salts. Later, according to the treatments, required quantity of stock solution was diluted to make 20 litres of nutrients solution using deionised water. Once diluted, the pH and EC was checked and adjusted. While the pH was maintained at 6.5 to 7, the electrical conductivity (EC) was made to lie between 1.2 to 1.6 dsm^{-1}. However, over a period of time, the pH and EC of the nutrients solution inside the aeroponics chambers altered due to release of certain compounds from the root as well as continuous use by the plants growing on the aeroponics chambers. Therefore, the fresh nutrients solutions are to be replaced very often. In this regard, the time required to replace the old and used nutrients solutions with freshly prepared nutrients solution was standardized based on the deviation in pH and EC of the nutrients solution. When the pH goes beyond the neutral range and EC reduced to less than 1 dsm^{-1} (Fig. 2), the nutrients solutions were changed and replaced with freshly prepared solutions.

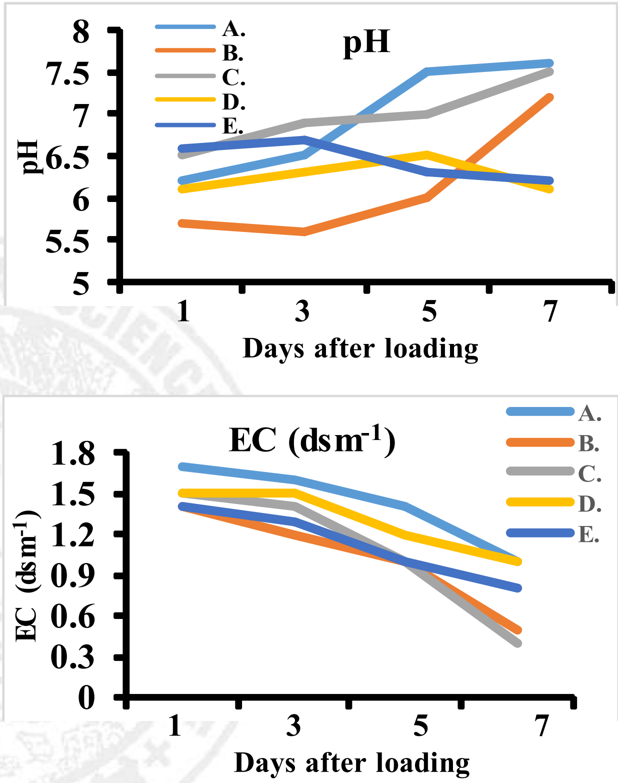

Fig. 2: Graphical representation of pH (A) and Electrical conductivity (EC; B) of different nutrient formulations altered with time inside the aeroponics chambers

A: Standard Hoagland's solution; B: Modified Hoagland's solution; C: USDA potato nutrients formulation from Peru by Otazu, (2010); D: Nutrients formulations from Karnataka state Horticulture Department and E: Ethiopian nutrients formulation from Tessema *et al*., (2017).

Assessing the Mini-tuber Yield in the Best Nutrients Solution under Aeroponics Systems : The nutrients solutions standardized for aeroponically grown potato should not only help the plants to grow effectively on the chambers, but also be productive. In this regard, the best nutrients solution (modified Hoagland's solution) was used to assess its efficacy in inducing the mini-tubers in aerponically grown potato. For comparison, normal Hoagland's solution was also used

TABLE 2

Different nutrient formulations and their concentrations used for standardizing the nutrients composition for aeroponically grown potato

Nutrient elements	Hoagland's Solution (mg/l)	Modified Hoagland's solution (mg/l)	Nutrients formulations of USDA (mg/l)	Nutrients formulations of State Horticulture Dept. (mg/l)	Nutrients formulations of Ethiopian group (mg/l)
N	210.00	251.83	197.02	343.58	85.00
P	31.00	15.49	72.80	53.90	30.87
K	235.00	409.50	205.00	759.60	232.58
Ca	200.00	119.32	47.50	63.85	40.00
Mg	48.00	48.31	48.11	33.81	20.00
S	64.00	64.14	63.26	45.57	36.00
Zn	0.05	0.07	0.48	0.46	0.48
Fe	1.30	2.50	0.43	0.48	0.93
B	0.50	0.24	0.06	0.24	0.06
Cu	0.02	0.06	0.18	0.20	0.18
Mn	0.50	0.50	0.47	0.30	0.47
Mo	0.05	0.06	1.19	0.01	0.01
Na	0.02	23.03	0.57	29.64	0.57
Cl	0.63	35.67	-	45.61	-
Co	-	0.02	-	0.01	-

which served as check. Healthy potato plants were planted on the modular aeroponics chambers and provided with normal and modified (our new formulations) Hoagland's solutions separately with the standardized misting cycle and monitored for their growth, days taken to tuber initiation and also for tuberization. When the tubers reach to a size of approximately 4 to 5 g, they were harvested from each plant and harvesting continued till the end of the crop cycle which lasts for about six weeks. Immediately after harvest of the tubers from each plant, number of mini-tubers per plant, individual mini-tuber weight and the total tuber weight was measured and the tubers were stored in air tight boxes.

Data Collection and Statistical Analysis : Data on different plant growth and morphological attributes were recorded from the selected tagged plants in each experimental unit. To find out the significance of experimental results, the recorded data on different parameters were analysed statistically using CRD programme. The mean for all the treatments were calculated and analysis of variance for each parameter was performed by DMRT (Duncan's Multiple Range Test). The mean separation was done by DMRT at 5 per cent level of probability.

RESULTS AND DISCUSSION

The basic principle in aeroponics technique is to enclose the root system in a dark chamber and supplying the nutrients in the form of a mist of desired droplet size with an appropriate misting cycles using specialized timers. As the aeroponics system is performed without soil, it is essential for the growers to fix the atomization spray time or interval time of misting based on the plants requirement. The wrong and inappropriate spray scheduling could affect the plants growth and productivity. Therefore, while growing the plants under aeroponics systems, it is highly essential that the proper nutrients formulations coupled with spray scheduling has to be optimized and standardized for the crop in question. In this regard, in the present study, misting cycle and the nutrients formulation was optimized and standardized for the production of healthy and vigorous plantlets leading to increased productivity of potato.

Misting Cycles : Aeroponics, a soil less, water-based crop production system using nutrients-rich solutions has been gaining popularity in recent years due to water and nutrients savings, quick growth, high yields and low rates of root-borne diseases (Pignata *et al*., 2017). Among the different types of aeroponics crop production systems, periodic spray of nutrients water is an improved technique that saves a substantial amount of water and nutrients by spraying a mixed nutrients solution directly onto the plants root zone (Sumarni *et al*., 2013). In the present study, with different misting cycles, a significant difference in number of nodes, shoot length, root length, leaf area and biomass was observed. The T_5 treatment which had 30 seconds *on* with 6 minutes *off* during the day; and 30 seconds *on* with 12 minutes *off* during the night was found to be the best among the different misting cycles examined (Table 3). Although the number of nodes per plant was significantly higher in T_5 and T_3 treatments, the shoot and root length was significantly higher in T_5 treatment compared to T_3 treatment. Interestingly, the leaf area increased proportionately with spray time and was higher in T_5 treatment. The higher biomass (leaves + stem + root) was observed in T_5 treatment followed by T_6 and T_2 treatments and among all the misting cycles tried, T5 treatment was found to be the best. This treatment of 30 seconds *on* throughout and 6 minutes and 12 minutes *off* during day and night time, respectively, was taken forward for the nutrients composition standardization (Table 3).

Although the reports on misting cycle are available, most of them have same fixed cycles for day and night despite the fact that the plants water and nutrients requirement is rather less during night time. For instance, Tunio *et al*. (2022) have given a spraying intervals of 30, 45 and 60 minutes with 5 minutes on for lettuce crop and found that, 30 minutes off and 5 minutes on gave best results. Similarly, Biddinger *et al*. (1998) and Osvald *et al*. (2001) have successfully cultivated the tomato under the atomization spray time and interval time of 3 seconds on and 10 minutes off and 60 seconds on and 5 minutes off, respectively. In cucumber, 7 seconds on and 10 minutes off showed the best results (Peterson and Krueger, 1988) while in potato, 20 seconds on and 5 minutes off has given higher biomass with improved mini-tuber yield under aeroponics system (Farran and Mingo-Castal, 2006). These studies however have not emphasised the need

TABLE 3

Effect of different misting cycles on growth parameters of potato

Treatments	No. of nodes per plant	Shoot length (cm)	Root length (cm)	Leaf area (cm^2)	Biomass (g)
T1	8.10 ^{c}	9.50 ^{b}	15.00 ^{d}	45.97 ^{f}	4.60 ^{d}
T2	7.60 ^{d}	7.90 ^{d}	24.30 ^{b}	75.53 ^{d}	5.90 ^{b}
T3	8.60 ^{b}	9.60 ^{ab}	25.00 ^{b}	51.65 ^{e}	3.20 ^{e}
T4	7.50 ^{d}	8.90 ^{c}	18.40 ^{c}	82.91 ^{c}	5.60 ^{c}
T5	9.10 ^{a}	10.10 ^{a}	26.70 ^{a}	103.98 ^{a}	7.40 ^{a}
T6	8.30 ^{bc}	9.70 ^{ab}	19.10 ^{c}	90.68 ^{b}	5.90 ^{b}
CD (P<0.05)	0.42 **	0.48 **	1.17 **	4.02 **	0.26 **
SE (m)	0.14	0.16	0.40	1.37	0.09
SE (d)	0.20	0.23	0.56	1.94	0.12
CV (%)	3.91	3.94	4.19	3.74	3.75

*Significant at 5% level; **significant at 1% level for altering the day and night spray schedule. However, Tsoka *et al*. (2012) showed the importance of different spray schedule for day and night period separately and found its relevance. They found 15-minutes on and 15 minutes off during day time and 15 minutes on and one hour off during night time gave significantly higher number of potato mini-tubers under aeroponics system. However, in our study, we have reduced the spray *on* time significantly saving the power and the pressure on the motor and achieved not only the vigorous growth of plants but also increased mini-tubers in potato.

Nutrients Formulation Standardization : The aeroponics system is the best system for producing mini-tubers as planting material (Buckseth *et al*., 2016). Using this approach, plant roots can be quickly nourished under controlled conditions (Factor *et al*., 2007). These conditions include uniform nutrient concentrations, pH, EC, humidity, atomization spray time, atomization interval, atomization frequency, oxygen availability, temperature and light intensity (Lakhiar *et al*., 2018). However, the plants grow rapidly in the aeroponics chambers due to the disinfected environment and the availability of sufficient oxygen that improves potato growth and development (Calori *et al*., 2017). The biggest advantage of aeroponics is that, roots are exposed to air, thus there is never an issue of insufficient oxygen. Therefore, besides standardizing the spray schedule, it is also equally important to come out with nutrients formulations and concentrations for aerponically grown plants. Since the aeroponically grown plants are not in contact with any nutrients holding media or nutrients supplying media like soil, they need to be given the required nutrients externally through a fine mist or a fog for their effective growth and productivity. In this regard, four nutrients formulations were examined with some modifications in Hoagland's solution which is called as modified Hoagland's formulation for potato. When the nutrients are being used by the growing plants in the aeroponics chambers, the pH and EC will undoubtedly alter over a period of time. The EC reflects the total ions concentration in the nutritive solution which affects the absorption of nutrients, plant growth, productivity and tubers quality (Chang *et al*., 2011), while, the pH reflects the availability of nutrients for plants absorption.

A significant difference in plants growth was observed among the different nutrients formulations used (Fig. 3). Among the different nutrients formulation used, modified Hoagland's solutions showed significantly higher plant height, root length and root volume compared to the other nutrients formulation (Table 4). Leaf area (cm^2) and biomass (leaves + stem + root) increased significantly under modified Hoagland's solution which may be because of the increased nitrogen and potassium content which probably influenced the growth and development of potato crop under aeroponics system. Among the mineral nutrients, nitrogen and potassium are the two major elements which are required in higher quantity for the potato crop for its initial vegetative growth (Savitha *et al*., 2000). However, later during the tuberization stage, N plays a negative role where it inhibits tuberization. Therefore, nutrients management for initial growth of potato is essential for maximising nutrients uptake efficiency, survival, seedling establishment followed by growth and development including tuber yield of potato plants under aeroponics

Fig. 3: Growth response of potato plants grown under different nutrients solutions

A: Standard Hoagland's solution; B: Modified Hoagland's solution; C: USDA potato nutrients formulation from Peru by Otazu, (2010); D: Nutrients formulations from Karnataka State Horticulture Department and E: Ethiopian nutrients formulation by Tessema *et al.* (2017).

TABLE 4

Growth parameters of potato plants grown with different nutrients formulations under aeroponics system

Treatments	Plant height (cm)	Root length (cm)	Root volume (cc)	Leaf area (cm^2)	Biomass (g)
T1	70.98 [b]	60.24 [b]	7.30 [b]	963.40 [ab]	16.20 [c]
T2	78.99 [a]	67.60 [a]	8.80 [a]	1026.30 [a]	23.00 [a]
T3	69.40 [b]	60.20 [b]	6.11 [c]	767.23 [cd]	12.60 [d]
T4	73.65 [ab]	61.25 [b]	7.13 [b]	875.60 [bc]	20.00 [b]
T5	60.65 [c]	46.68 [c]	7.04 [b]	737.1 [d]	19.58 [b]
CD (P<0.05)	6.15 **	3.58 **	0.72 **	125.38 **	0.97 **
SE (m)	2.07	1.20	0.24	42.20	0.32
SE (d)	2.93	1.70	0.34	59.68	0.46
CV (%)	6.55	4.56	7.45	10.80	4.01

*: Significant at 5% level; **: Significant at 1% level

condition. A correct balance between macronutrients and micronutrients is essential to obtain the best results possible from the potato plants grown under soil less cultures. A deficiency of any single nutrient is enough to limit the crop yield and the availability of each nutrient needs to be related to the crop requirements. In this regard, several nutrients formulations were examined and found that, the modified Hoagland's solution with increased N and K was found to yield best results for potato. Here, the nutrients formulation with 59 g $CaNO_3$, 126 g KNO_3, 68 g KH_2PO_4 and 100 g $MgSO_4$ along with 2.2 g of Fe EDTA and 6 g of Fetrilon has given maximum plant growth and higher mini tubers number. In the present study, EC and pH of the nutrients formulations were regularly monitored and replaced the nutrients solution on a weekly basis or whenever, the EC and pH were altered too much. While the pH of the nutrients solution was maintained between 6.5 to 7, the electrical conductivity was maintained between 1.2 to 1.6 dsm^{-1}. The highest productivity of seed potato mini tubers was observed when EC was at 1.2 dS^{-1} (Calori *et al*., 2017). The results also showed that, not only the concentration of nutrients, but maintaining the required pH and EC is also equally important for better nutrient uptake and utilization.

Mini-tuber Yield as Influenced by Composition of Nutrients Solution : Based on the previous results, the misting cycle of 30 seconds *on* throughout and 6 minutes and 12 minutes *off* during day and night time respectively, along with the normal Hoagland's

Fig. 4: Potato mini-tubers production under Hoagland's and Modified Hoagland's solutions

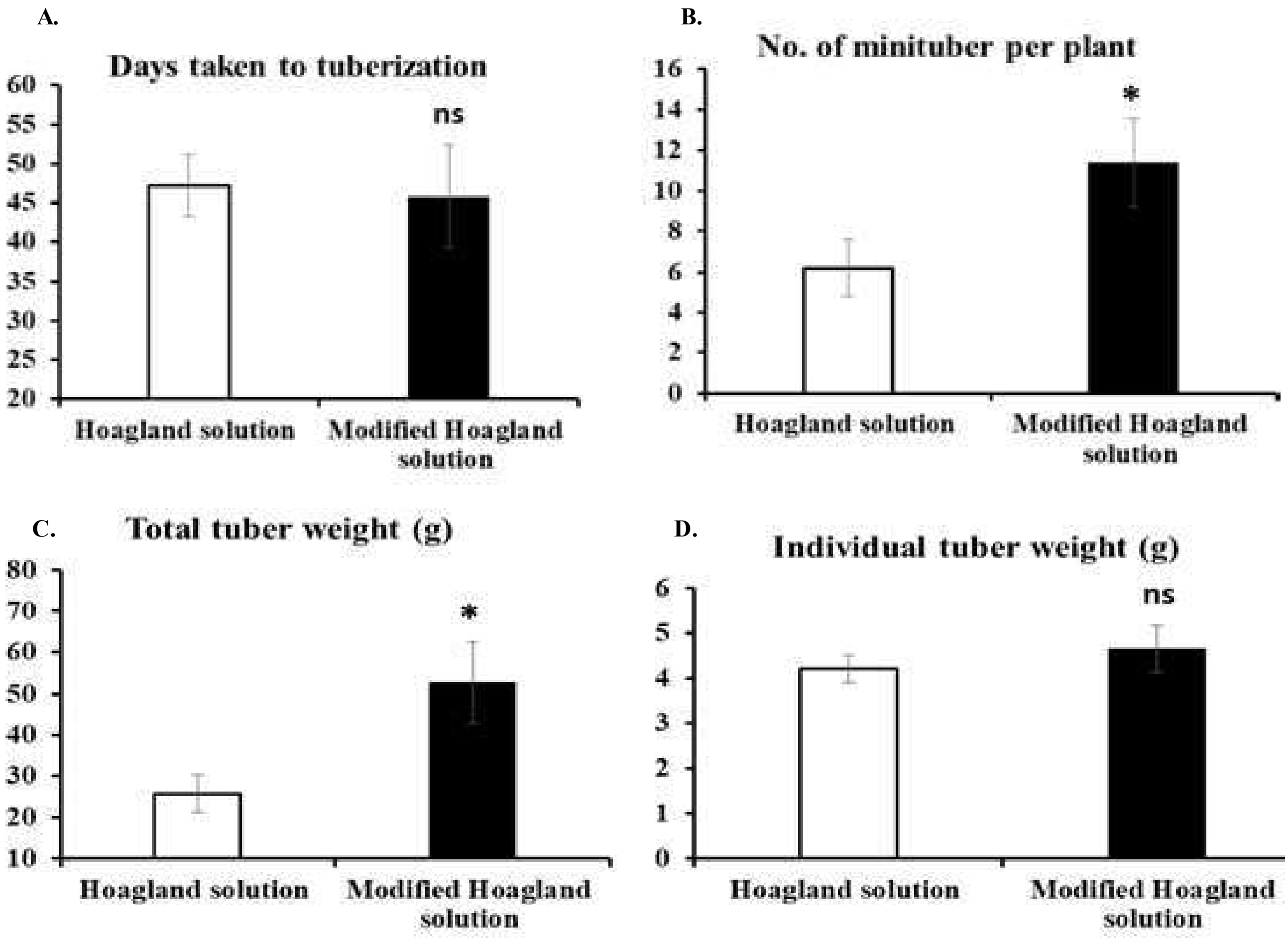

Fig. 5 : Effect of Hoagland's and modified Hoagland's solution on mini-tuber production in aeroponically grown potato plants

(control / check) and the best performed modified Hoagland's solution was examined for mini-tuber production and productivity (Fig. 4). Accordingly, the modified Hoagland's solution yielded 83.41 per cent more mini tubers per plant over normal Hoagland's solution. Further, the total tuber weight per plant was also significantly higher in modified Hoagland's solution (52.78 g) compared to normal Hoagland's solution (25.80 g). However, no significant difference was observed for days taken to tuberize as well as individual tuber weight (as we have consciously harvested the same sized tubers from the plants). Although the N and K was increased in the modified Hoagland's solution as it influenced the plants growth effectively in the vegetative stage, the N was reduced at tuberization as higher N has negative effect on tuberization. Overall, the study infers that, it is necessary to standardize the nutrients formulations and concentrations besides the spray schedule for effective growth and productivity of plants grown under aeroponics systems.

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