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Preface

We would like to present, with great pleasure, the inaugural volume-7, Issue-4, April 2021, of a scholarly journal, *International Journal of Environmental & Agriculture Research*. This journal is part of the AD Publications series *in the field of Environmental & Agriculture Research Development,* and is devoted to the gamut of Environmental & Agriculture issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Environmental & Agriculture as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical investigations. Its mission is to become a voice of the Environmental & Agriculture community, addressing researchers and practitioners in below areas.

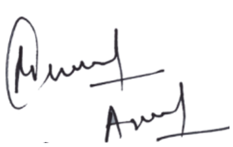
Environmental Research:

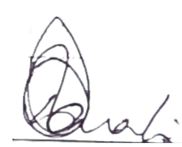
Environmental science and regulation, Ecotoxicology, Environmental health issues, Atmosphere and climate, Terrestric ecosystems, Aquatic ecosystems, Energy and environment, Marine research, Biodiversity, Pharmaceuticals in the environment, Genetically modified organisms, Biotechnology, Risk assessment, Environment society, Agricultural engineering, Animal science, Agronomy, including plant science, theoretical production ecology, horticulture, plant, breeding, plant fertilization, soil science and all field related to Environmental Research.

Agriculture Research:

Agriculture, Biological engineering, including genetic engineering, microbiology, Environmental impacts of agriculture, forestry, Food science, Husbandry, Irrigation and water management, Land use, Waste management and all fields related to Agriculture.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IJOEAR*. We are certain that this issue will be followed by many others, reporting new developments in the Environment and Agriculture Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IJOEAR* readers and will stimulate further research into the vibrant area of Environmental & Agriculture Research.





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Agricultural Sciences	
Soil Science	Plant Science
Animal Science	Agricultural Economics
Agricultural Chemistry	Basic biology concepts
Sustainable Natural Resource Utilisation	Management of the Environment
Agricultural Management Practices	Agricultural Technology
Natural Resources	Basic Horticulture
Food System	Irrigation and water management
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Vegetable crops or Olericulture: Crops utilized fresh or whole (wholefood crop, no or limited processing, i.e., fresh cut salad); (Lettuce, Cabbage, Carrots, Potatoes, Tomatoes, Herbs, etc.)	Tree Fruit crops: apples, oranges, stone fruit (i.e., peaches, plums, cherries)
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Mr. Muhammad Farooq

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Standardization of the Appropriate Doses of GA_3 and Ag-Nanoparticle in Green Gram for Quality Seed Production

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Abstract— *One of the most important pulse crops in India is green gram (Vigna radiata L.). Pre-sowing seed priming is a promising strategy to provide value-added solutions that influence the yield and quality of the seed. For selecting the appropriate doses of Ag-nanoparticle and GA_3, three doses were taken for each chemical and eight genotypes of green gram were selected. The doses of Ag-nanoparticle were 10 ppm, 20 ppm and 50 ppm and for GA_3 50 ppm, 100 ppm, 150 ppm. Eight genotypes of green gram were soaked with three doses each of GA_3 and Ag-nanoparticle solution for 6 hours. The laboratory experiment was conducted in seed testing laboratory, BCKV, West Bengal during 2019. Germination percentage and vigor were observed to determine the changes in seed quality after priming with different doses GA_3 and Ag-Nanoparticle. While considering treatments over genotypes for GA_3, significantly highest germination percentage (99.16) and vigour index (2017.937) were observed when it was primed with 50 ppm GA_3. In case of Ag-nanoparticle significantly highest germination percentage (99.31) and vigour index (2102.632) were recorded for 20 ppm, when the average was made over genotypes. So, Ag-Nanoparticle @ 20 ppm and GA_3 @ 50 ppm were proved to be appropriate dose in green gram for quality seed production.*

***Keywords*— Green gram, Ag-Nanoparticle, GA_3, Seed priming.**

I. INTRODUCTION

The mung bean (*Vigna radiata* L.) is a food legume mainly grown in South and South-East Asia commonly known as green gram is an economically important crop belonging to the family Fabaceae. The crop is known to be first originated and domesticated in India several thousand years ago and then spread to China and other parts of South-East Asia (Vavilov. 1926). This crop can be grown successfully in extreme environmental conditions like low rain fall, high temperatures, and poor soils with few economic inputs. Nair *et al*., 2013 reported that mung bean seeds are a rich source of high quality protein (24%), carbohydrates (63%), iron (0.03-0.06 mg g^{-1}) and zinc (0.02-0.04 mg g^{-1}). Despite various good qualities of mungbean, the global average productivity is staggeringly low at 0.5 t ha^{-1} which is far below than the estimated yield potential, i.e. 2.5-3.0 t ha^{-1} of the crop (Nair *et al*., 2019). India grows 65% (3.0 million ha) of total mungbean acreage and provides 54% (1.5 million tonnes) of the global production (AICRP on MULLaRP: http://www.aicrpmullarp.res.in/crop_profile.html).

The growth in the human population has outpaced the production of pulses in the country which has led to gradual decrease in per capita pulse consumption. Seed priming prior to sowing is a promising strategy to provide value-added solutions that enhance the yield and quality potential of high-value crops. Priming instigates an increase in the activity of enzymes such as amylases, proteases, and lipases that break down macromolecules for growth and development of the embryo. Priming also reduces stress at the germination stage and ultimately results in higher rates of seedling emergence and successful seedling establishment. These biological consequences ultimately benefit farmers because it reduces the time, expense of re-seeding, additional irrigation, fertilization, and weed management on weak plants. Several chemicals including synthetic plant hormones have been used for seed priming. Plant hormones are vital members of the signal cascade complicated in the induction of plant stress responses. Moreover in recent years, nanotechnology has emerged as an advanced seed priming technology for smart agriculture. Important and unique aspects of nanoparticles, such as their surface to mass ratio, which is much greater than that of other particles and materials, allows them to efficiently increase catalysis, as well as to adsorb and deliver substances of interest. Nanoparticles derived from metals or their compounds have been evolved and utilized as carriers for biological systems. In this study, the effect of priming with a plant growth regulator (GA_3) and silver nanoparticles on seed germination and early seedling growth has been demonstrated. Application of Gibberellic Acid (GA_3)

has been reported to increase germination percentage and seedling growth of crop plants under salt stress (Tsegay and Andargie, 2018, Biswas *et al.*, 2020a). GA_3 was found to influence the spikelet fertility and seed yield significantly (Biswas *et al.*, 2020b). The influence of GA_3 has been found to enhance seed yield plant^{-1}and all the seed yield attribute characters. (Ray and Bordolui, 2020). Consequently, nano-priming enhances the rate of emergence and subsequent growth, yield, and quality of the crop. Recent studies have reported that a plant's response to Ag-nanoparticles, enhancement or inhibition of growth, depends on the Ag-nanoparticle dosage. Exposure to specific concentrations of Ag-nanoparticles could enhance plant growth compared with non-exposed plants, whereas higher and lower concentrations could affect plant growth negatively. Objective of this study was to standardize the appropriate doses of Ag-nanoparticle and GA_3 for quality seed production of green gram.

II. RESEARCH METHODS

For standardization the appropriate doses of Ag-nanoparticle and GA_3 in green gram, we selected three doses each of Ag-nanoparticle and GA_3 and eight genotypes of green gram. In case of Ag-nanoparticle the doses were 10 ppm, 20 ppm and 50 ppm and for GA_3 50 ppm, 100 ppm, 150 ppm. Eight genotypes of green gram were Pusa Vishal (G_1), PM-11-9 (G_2), IPM-2-3 (G_3), Meha (IPM 99-125) (G_4), Samrat (G_5), IPM-512-1 (G_6), TMB-37 (G_7), SML-1822 (G_8), which were soaked with three doses each of GA_3 and Ag-nanoparticle solution separately for 6 hours to determine the best suitable dose each for GA_3 and Ag-nanoparticle. The laboratory experiment was conducted in Seed Testing Laboratory, BCKV, and West Bengal during 2019. The different seed quality parameters such as root length, shoot length, seedling dry weight, fresh weight, germination percentage and vigor index were recorded. Germination test was carried out using glassplate and petri-plate method (ISTA, 1985) and calculated as

Germination (%) = No. of normal seedlings germinated × 100/ Total no. of seeds placed for germination.

Root length and shoot length test was carried out by glassplate method. Vigor Index was also calculated by Abdul-Baki and Anderson (1973) as

Vigor index = Germination (%) × Seedling length (cm).

III. RESULTS AND DISCUSSIONS

3.1 Root Length (cm) of genotypes after priming with GA_3

Significantly highest root lengths (13.038 cm) were observed for G_5 (Samrat) followed by G_2 (PM-11-9) when the average was made over the treatments, while shortest root lengths (6.953 cm) were recognized for G_7 (TMB-37) preceded by G_1 (Pusa Vishal). The influence of T_1 (50 ppm GA_3) over all genotypes was significantly superior to that of 100 ppm and 150 ppm GA_3 for the exhibition of root length. While considering the interaction between treatments and genotypes, a significantly maximum root length (14.427 cm) was recorded for G_5 (Samrat) followed by G_3 (IPM-2-3) after application of 50 ppm GA_3, and shortest root length (5.013 cm) was recorded for G_7 (TMB-37) preceded by G_3 (IPM-2-3) when treated with 150 ppm of GA_3.

When the ranking is made amongst the genotypes over treatments about its root length, it could be noted as $G_5 > G_2 > G_3 > G_4 = G_6 > G_8 > G_1 > G_7$.

TABLE 1
MEAN VALUE OF ROOT LENGTH OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF GA_3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	8.023	12.827	13.217	9.623	14.427	10.047	8.407	8.853	10.678
T_2	7.210	8.820	6.650	6.247	12.863	6.630	7.440	6.623	7.810
T_3	7.193	9.783	6.227	9.040	11.823	8.233	5.013	7.040	8.044
Mean G	7.476	10.477	8.698	8.303	13.038	8.303	6.953	7.506	
	T	**G**	**TXG**						
SEm(±)	**0.005**	**0.008**	**0.014**						
LSD	**0.014**	**0.023**	**0.040**						

T= GA_3, T_1= 50 ppm, T_2= 100 ppm, T_3= 150 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_1G_1 T_1G_2 T_1G_3 T_1G_4

FIGURE 1: Images of germination and vigour test of green gram genotypes after priming with dose of 50 ppm GA_3 (T_1).

3.2 Shoot Length (cm) of genotypes after priming with GA_3

Highest shoot lengths (9.896 cm) were observed for G_1 (Pusa Vishal) followed by G_5 (Samrat), while shortest shoot lengths (5.949 cm) were recognized for G_3 (IPM-2-3) preceded by G_6 (IPM-512-1) when the average was made over the treatments. The influence of T_2 i.e. 100 ppm and T_3 i.e. 150 ppm GA_3 was significantly inferior to that of T_1 (50 ppm GA_3) for the exhibition of shoot length when the average was made over genotypes. A significantly maximum shoot length (12.627 cm) was recorded for G_1 (Pusa Vishal) followed by G_2 (PM-11-9) after application of 50 ppm GA_3, and shortest shoot length (4.200 cm) was recorded for G_3 (IPM-2-3) preceded by G_8 (SML-1822) when treated with 150 ppm of GA_3 when the interaction between treatments and genotypes was considered.

$G_1 > G_5 > G_2 > G_4 > G_8 > G_7 > G_6 > G_3$ is the ranking amongst the genotypes about its shoot length over treatments.

TABLE 2
MEAN VALUE OF SHOOT LENGTH OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF GA_3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	12.627	11.620	8.223	8.627	11.333	6.620	8.633	9.613	9.662
T_2	8.623	6.840	5.423	5.430	10.627	4.860	7.423	7.230	7.057
T_3	8.437	9.017	4.200	7.427	7.020	7.617	4.613	4.430	6.595
Mean G	9.896	9.159	5.949	7.161	9.660	6.366	6.890	7.091	
	T	**G**	**TXG**						
SEm(±)	**0.008**	**0.012**	**0.022**						
LSD	**0.022**	**0.035**	**0.061**						

T= GA_3, T_1= 50 ppm, T_2= 100 ppm, T_3= 150 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_1G_5 T_1G_6 T_1G_7 T_1G_8

FIGURE 2: Images of germination and vigour test of green gram genotypes after priming with dose of 50 ppm GA_3(T_1).

3.3 Fresh weight (g) of genotypes after priming with GA_3

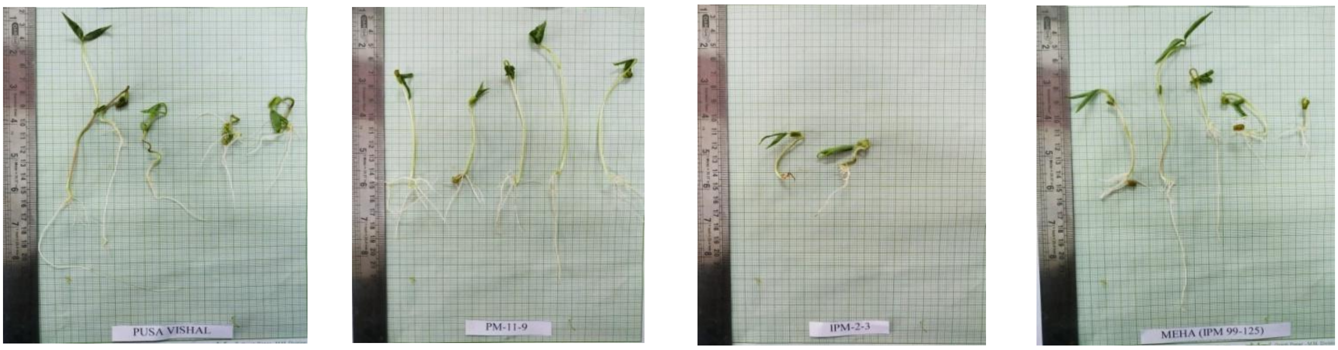
Significantly lowest fresh weight (0.631 g) were recognized for G_2 (PM-11-9) preceded by G_8 (SML-1822) while highest fresh weight (0.866 g) were observed for G_6 (IPM-512-1) followed by G_4 (Meha) when the average was made over the treatments. Influence of T_1 (50 ppm GA_3) was significantly superior to that of 100 ppm and 150 ppm GA_3 for the exhibition of fresh weight when the average was made over genotypes. In case of the interaction between treatments and genotypes, a significantly maximum fresh weight (1.047 g) was recorded for G_7 (TMB-37) followed by G_6 (IPM-512-1) after application of 50 ppm GA_3, and lowest fresh weight (0.257 g) was observed for G_7 (TMB-37) preceded by G_3 (IPM-2-3) when treated with 100 ppm of GA_3.

Ranking amongst the genotypes about its fresh weight over treatments is, $G_6 > G_4 > G_1 > G_7 > G_5 > G_3 > G_8 > G_2$.

TABLE 3
MEAN VALUE OF FRESH WEIGHT OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF GA_3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	0.987	0.437	0.863	0.923	0.863	1.010	1.047	0.837	0.871
T_2	0.940	0.867	0.410	0.813	0.640	0.660	0.257	0.640	0.653
T_3	0.557	0.590	0.823	0.820	0.647	0.927	0.970	0.613	0.743
Mean G	0.828	0.631	0.699	0.852	0.717	0.866	0.758	0.697	
	T	**G**	**TXG**						
SEm(±)	**0.024**	**0.039**	**0.068**						
LSD	**0.069**	**0.112**	**0.195**						

T= GA_3, T_1= 50 ppm, T_2= 100 ppm, T_3= 150 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.



T_2G_1 T_2G_2 T_2G_3 T_2G_4

FIGURE 3: Images of germination and vigour test of green gram genotypes after priming with dose of 100 ppm GA_3 (T_2).

3.4 Dry weight (g) of genotypes after priming with GA_3

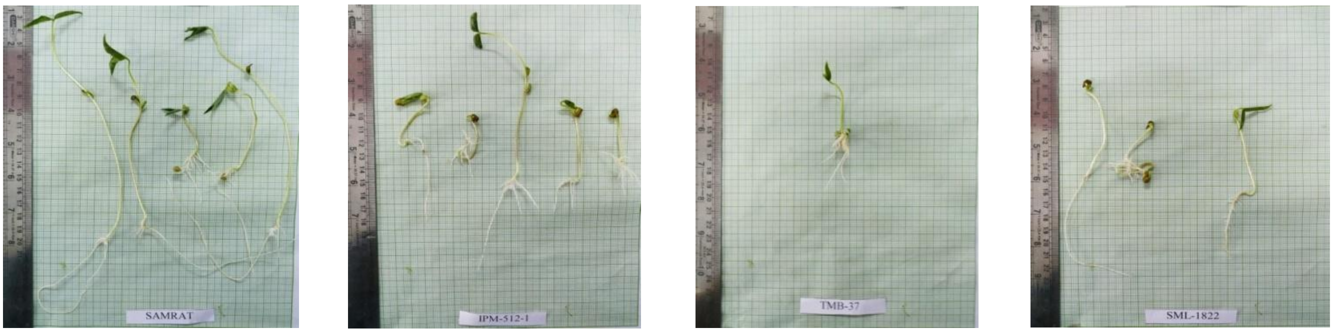
Significantly highest dry weight (0.108 g) were recorded for G_2 (PM-11-9) followed by G_1 (Pusa Vishal), while lowest dry weight (0.069 g) were recognized for G_8 (SML-1822) preceded by G_3 (IPM-2-3) when the average was made over the treatments. The influence of T_1 (50 ppm GA_3) was significantly superior to that of 100 ppm and 150 ppm GA_3 for the exhibition of dry weight when the average was made over genotypes. While considering the interaction between treatments and genotypes, a significantly maximum dry weight (0.120 g) was recorded for G_2 (PM-11-9), G_6 (IPM-512-1) and G_4 (Meha) followed by G_7 (TMB-37) after application of 50 ppm GA_3, and lowest dry weight (0.040 g) was recorded for G_8 (SML-1822) when treated with 150 ppm of GA_3 and G_3 (IPM-2-3) when treated with 100 ppm of GA_3 preceded by G_7 (TMB-37) when treated with 150 ppm of GA_3 and G_6 (IPM-512-1) when treated with 100 ppm of GA_3.

If ranking is made amongst the genotypes over treatments about its dry weight, it could be recorded as $G_2 > G_1 > G_7 > G_4 > G_6 > G_5 > G_3 > G_8$.

TABLE 4
MEAN VALUE OF DRY WEIGHT OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF GA_3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	0.113	0.120	0.093	0.120	0.080	0.120	0.117	0.100	0.108
T_2	0.110	0.093	0.040	0.087	0.080	0.063	0.113	0.067	0.082
T_3	0.093	0.110	0.077	0.083	0.087	0.087	0.063	0.040	0.080
Mean G	0.106	0.108	0.070	0.097	0.082	0.090	0.098	0.069	
	T	**G**	**TXG**						
SEm(±)	**0.002**	**0.003**	**0.005**						
LSD	**0.005**	**0.008**	**0.014**						

T= GA_3, T_1= 50 ppm, T_2= 100 ppm, T_3= 150 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.



T_2G_5 **T_2G_6** **T_2G_7** **T_2G_8**

FIGURE 4: Images of germination and vigour test of green gram genotypes after priming with dose of 100 ppm GA_3 (T_2).

3.5 Germination percentage of genotypes after priming with GA_3

When the average was made over the treatments, highest germination percentage (95.02 %) were noted for G_5 (Samrat) followed by G_4 (Meha), while lowest germination percentage (93.86 %) were recognized for G_7 (TMB-37) preceded by G_8 (SML-1822). The germination percentage of T_1 (50 ppm GA_3) was significantly superior to that of 100 ppm and 150 ppm GA_3 when average was made over genotypes. In case of interaction between treatments and genotypes, maximum germination percentage (99.58 %) was recorded for G_4 (Meha) followed by G_5 (Samrat) after application of 50 ppm GA_3, and lowest germination percentage (87.91 %) was recorded for G_6 (IPM-512-1) preceded by G_7 (TMB-37) when treated with 150 ppm of GA_3.

Ranking amongst the genotypes about its germination percentage over treatments is, $G_5 > G_4 > G_2 > G_1 > G_3 > G_6 > G_8 > G_7$.

TABLE 5
MEAN VALUE OF GERMINATION PERCENTAGE OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF GA_3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	99.25 (85.045)	99.25 (85.045)	99 (84.257)	99.58 (86.399)	99.5 (86.002)	98.91 (84.130)	98.83 (83.825)	99 (84.356)	99.16 (84.882)
T_2	94.66 (76.622)	94.5 (76.426)	94.91 (76.945)	95.41 (77.614)	95 (77.051)	95.66 (77.968)	94.58 (76.526)	94.83 (76.837)	94.94 (76.998)
T_3	89.41 (70.988)	90.33 (71.859)	89.16 (70.758)	89.91 (71.459)	90.58 (72.103)	87.91 (69.632)	88.16 (69.856)	88.58 (70.225)	89.26 (70.860)
Mean G	94.44 (77.552)	94.69 (77.777)	94.36 (77.320)	94.97 (78.490)	95.02 (78.385)	94.16 (77.243)	93.86 (76.736)	94.13 (77.139)	
	T	**G**	**TXG**						
SEm(±)	**0.161**	**0.262**	**0.454**						
LSD	**0.458**	**0.748**	**1.296**						

T= GA_3, T_1= 50 ppm, T_2= 100 ppm, T_3= 150 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_3G_1 T_3G_2 T_3G_3 T_3G_4

FIGURE 5: Images of germination and vigour test of green gram genotypes after priming with dose of 150 ppm GA_3 (T_3).

3.6 Vigor Index of genotypes after priming with GA_3

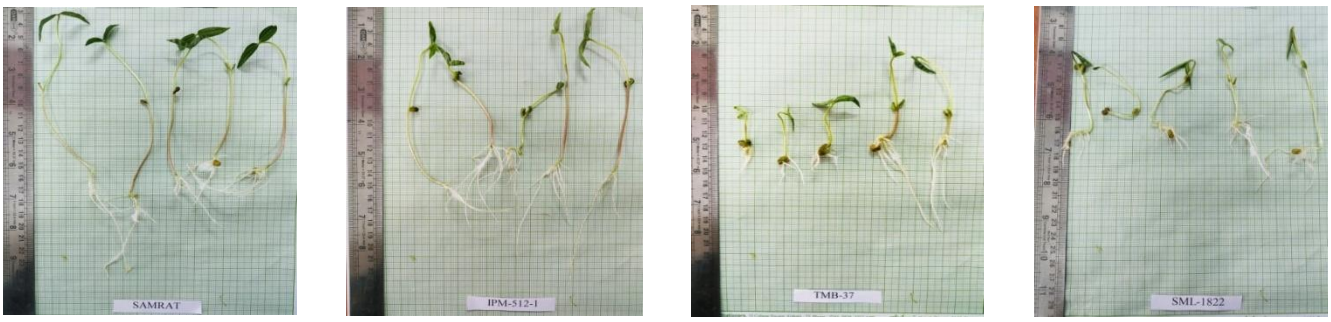
Maximum vigor index (2,167.894) were observed for G_5 (Samrat) followed by G_2 (PM-11-9), while lowest vigor index (1,312.901) were recognized for G_7 (TMB-37) preceded by G_6 (IPM-512-1) when the average was made over the treatments. The average influence of T_2 i.e. 100 ppm and T_3 i.e. 150 ppm GA_3 was significantly inferior to that of T_1 (50 ppm GA_3) for the exhibition of vigor index when the average was made over the genotypes. When the interaction between treatments and genotypes was considered, a significantly maximum vigor index (2,565.244) was recorded for G_5 (Samrat) followed by G_2 (PM-11-9) after application of 50 ppm GA_3, while lowest vigor index (848.756) was recorded for G_7 (TMB-37) preceded by G_3 (IPM-2-3) when treated with 150 ppm of GA_3.

$G_5 > G_2 > G_1 > G_4 > G_3 > G_8 > G_6 > G_7$ is the ranking amongst the genotypes about its vigor index over treatments.

TABLE 6
MEAN VALUE OF VIGOR INDEX OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF GA_3

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	2,049.508	2,426.335	2,122.565	1,818.915	2,565.244	1,648.607	1,684.125	1,828.197	2,017.937
T_2	1,498.882	1,479.868	1,145.967	1,114.152	2,231.549	1,099.220	1,405.823	1,313.752	1,411.151
T_3	1,397.586	1,698.267	929.724	1,480.634	1,706.888	1,393.473	848.756	1,016.055	1,308.923
Mean G	1,648.658	1,868.157	1,399.419	1,471.234	2,167.894	1,380.433	1,312.901	1,386.001	
	T	**G**	**TXG**						
SEm(±)	**1.601**	**2.614**	**4.528**						
LSD	**4.566**	**7.456**	**12.914**						

T= GA_3, T_1= 50 ppm, T_2= 100 ppm, T_3= 150 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.



T_3G_5 T_3G_6 T_3G_7 T_3G_8

FIGURE 6: Images of germination and vigour test of green gram genotypes after priming with dose of 150 ppm GA_3 (T_3).

3.7 Root length (cm) of genotypes after priming with Ag-Nanoparticle

Highest root lengths (8.691 cm) were observed for G_7 (TMB-37) followed by G_5 (Samrat), while shortest root lengths (5.222 cm) were recognized for G_1 (Pusa Vishal) preceded by G_2 (PM-11-9) when the average was made over the treatments. The influence of T_1 i.e. 10 ppm and T_3 i.e. 50 ppm Ag-Nanoparticle was significantly inferior to that of T_2 (20 ppm Ag-Nanoparticle) for the exhibition of root length when the average was made over the genotypes. While considering the interaction between treatments and genotypes, a significantly maximum root length (14.217 cm) was recorded for G_3 (IPM-2-3) followed by G_4 (Meha) after application of 20 ppm Ag-Nanoparticle, and shortest root length (3.017 cm) was recorded for G_3 (IPM-2-3) preceded by G_4 (Meha) when treated with 50 ppm of Ag-Nanoparticle.

$G_7 > G_5 > G_4 > G_3 > G_8 > G_6 > G_2 > G_1$ is the ranking amongst the genotypes about its root length over treatments.

TABLE 7
MEAN VALUE OF ROOT LENGTH OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF Ag-NANOPARTICLE

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	5.623	6.823	6.830	10.013	7.820	8.423	9.827	9.223	8.073
T_2	6.223	11.027	14.217	11.420	11.030	9.423	10.820	9.820	10.498
T_3	3.820	3.640	3.017	3.223	6.030	3.823	5.427	3.320	4.038
Mean G	5.222	7.163	8.021	8.219	8.293	7.223	8.691	7.454	
	T	**G**	**TXG**						
SEm(±)	**0.005**	**0.008**	**0.014**						
LSD	**0.014**	**0.022**	**0.039**						

T= Ag-Nanoparticle, T_1= 10 ppm, T_2= 20 ppm, T_3= 50 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_1G_1 T_1G_2 T_1G_3 T_1G_4

FIGURE 7: Images of germination and vigour test of green gram genotypes after priming with dose of 10 ppm Ag-nanoparticle (T_1).

3.8 Shoot Length (cm) of genotypes after priming with Ag-Nanoparticle

Shortest shoot lengths (6.617 cm) were recognized for G_4 (Meha) preceded by G_6 (IPM-512-1) whereas highest shoot lengths (9.554 cm) were observed for G_1 (Pusa Vishal) followed by G_7 (TMB-37) when the average was made over the treatments. When the average was made over the genotypes, the influence of T_2 (20 ppm Ag-Nanoparticle) was significantly superior to that of 10 ppm and 50 ppm Ag-Nanoparticle for the exhibition of shoot length. When the interaction between treatments and genotypes was considered, a significantly maximum shoot length (13.817 cm) was recorded for G_1 (Pusa Vishal) followed by G_3 (IPM-2-3) after application of 20 ppm Ag-Nanoparticle, and shortest shoot length (2.210 cm) was recorded for G_4 (Meha) preceded by G_2 (PM-11-9) when treated with 50 ppm of Ag-Nanoparticle.

If ranking is made amongst the genotypes about its shoot length over treatments, it could be noted as $G_1 > G_7 > G_5 > G_2 > G_3 > G_8 > G_6 > G_4$.

TABLE 8
MEAN VALUE OF SHOOT LENGTH OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF Ag-NANOPARTICLE

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	10.620	8.010	6.423	7.627	6.617	7.650	10.250	7.013	8.026
T_2	13.817	11.037	11.623	10.013	10.423	8.223	10.827	9.420	10.673
T_3	4.227	2.830	3.423	2.210	5.620	4.033	4.430	4.630	3.925
Mean G	9.554	7.292	7.157	6.617	7.553	6.636	8.502	7.021	
	T	**G**	**TXG**						
SEm(±)	**0.005**	**0.008**	**0.014**						
LSD	**0.014**	**0.024**	**0.041**						

T= Ag-Nanoparticle, T_1= 10 ppm, T_2= 20 ppm, T_3= 50 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_1G_5 **T_1G_6** **T_1G_7** **T_1G_8**

FIGURE 8: Images of germination and vigour test of green gram genotypes after priming with dose of 10 ppm Ag-nanoparticle (T_1).

3.9 Fresh weight (g) of genotypes after priming with Ag-Nanoparticle

Significantly highest fresh weight (0.921 g) were observed for G_1 (Pusa Vishal) followed by G_7 (TMB-37), while lowest fresh weight (0.214 g) were recognized for G_6 (IPM-512-1) preceded by G_4 (Meha) when the average was made over the treatments. The average influence of T_2 (20 ppm Ag-Nanoparticle) was significantly superior to that of 10 ppm and 50 ppm Ag-Nanoparticle for the exhibition of fresh weight when the average was made over the genotypes. While considering the interaction between treatments and genotypes, a significantly maximum fresh weight (1.170 g) was recorded for G_1 (Pusa Vishal) followed by G_3 (IPM-2-3) after application of 20 ppm Ag-Nanoparticle, and lowest fresh weight (0.110 g) was recorded for G_6 (IPM-512-1) treated with 50 ppm of Ag-Nanoparticle preceded by the same genotype when treated with 10 ppm of Ag-Nanoparticle.

$G_1 > G_7 > G_3 > G_5 > G_2 > G_8 > G_4 > G_6$ is the ranking about its fresh weight over treatments amongst the genotypes.

TABLE 9
MEAN VALUE OF FRESH WEIGHT OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF AG-NANOPARTICLE

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	0.990	0.760	0.860	0.340	0.700	0.217	0.910	0.403	0.648
T_2	1.170	0.880	1.040	1.030	1.013	0.317	0.980	0.880	0.914
T_3	0.603	0.270	0.527	0.330	0.507	0.110	0.663	0.577	0.448
Mean G	0.921	0.637	0.809	0.567	0.740	0.214	0.851	0.620	
	T	**G**	**TXG**						
SEm(±)	**0.002**	**0.003**	**0.005**						
LSD	**0.005**	**0.008**	**0.014**						

T= Ag-Nanoparticle, T_1= 10 ppm, T_2= 20 ppm, T_3= 50 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_2G_1 T_2G_2 T_2G_3 T_2G_4

FIGURE 9: Images of germination and vigour test of green gram genotypes after priming with dose of 20 ppm Ag-nanoparticle (T_2).

3.10 Dry weight (g) of genotypes after priming with Ag-Nanoparticle

Highest dry weight (0.081 g) were observed for G_3 (IPM-2-3) followed by G_7 (TMB-37) when the average was made over the treatments, while lowest dry weight (0.043 g) were recognized for G_6 (IPM-512-1) preceded by G_4 (Meha). While considering the interaction between treatments and genotypes, lowest dry weight (0.027 g) was recorded for G_4 (Meha) preceded by G_6 (IPM-512-1) when treated with 50 ppm of Ag-Nanoparticle and a significantly maximum dry weight (0.117 g) was recorded for G_2 (PM-11-9) followed by G_3 (IPM-2-3) after application of 20 ppm Ag-Nanoparticle. When the average was made over the genotypes, the influence of T_2 (20 ppm Ag-Nanoparticle) was significantly superior to that of 10 ppm and 50 ppm Ag-Nanoparticle for the exhibition of dry weight.

When the ranking is made amongst the genotypes about its dry weight over treatments, it could be observed as $G_3 > G_7 > G_1 = G_2 > G_8 > G_5 > G_4 > G_6$.

TABLE 10
MEAN VALUE OF DRY WEIGHT OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF AG-NANOPARTICLE

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	0.080	0.053	0.083	0.040	0.043	0.040	0.087	0.040	0.058
T_2	0.040	0.117	0.093	0.077	0.087	0.060	0.073	0.090	0.080
T_3	0.083	0.033	0.067	0.027	0.037	0.030	0.080	0.060	0.052
Mean G	0.068	0.068	0.081	0.048	0.056	0.043	0.080	0.063	
	T	**G**	**TXG**						
SEm(±)	**0.002**	**0.003**	**0.005**						
LSD	**0.005**	**0.007**	**0.013**						

T= Ag-Nanoparticle, T_1= 10 ppm, T_2= 20 ppm, T_3= 50 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.

T_2G_5 T_2G_6 T_2G_7 T_2G_8

FIGURE 10: Images of germination and vigour test of green gram genotypes after priming with dose of 20 ppm Ag-nanoparticle (T_2).

3.11 Germination ercentage of genotypes after priming with Ag-Nanoparticle

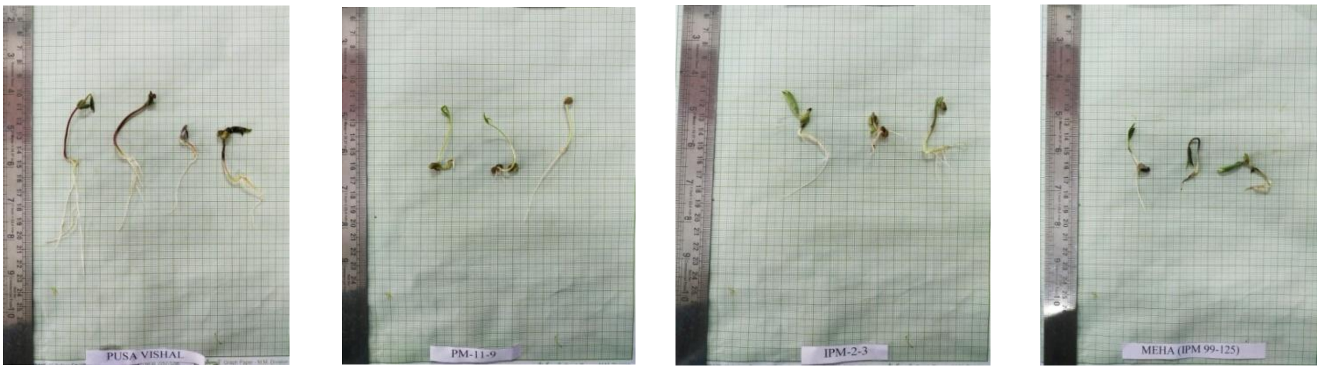
The influence of T_2 (20 ppm Ag-Nanoparticle) was significantly superior to that of 10 ppm and 50 ppm Ag-Nanoparticle for the exhibition of germination percentage when the average was made over the genotypes. Highest germination percentage (90.55 %) were observed for G_2 (PM-11-9) followed by G_5 (Samrat), while lowest germination percentage (89.19 %) were recognized for G_3 (IPM-2-3) preceded by G_7 (TMB-37) when the average was made over the treatments. When the interaction between treatments and genotypes was considered, highest germination percentage (99.5 %) was recorded for G_1 (Pusa Vishal) and G_2 (PM-11-9) followed by G_6 (IPM-512-1) after application of 20 ppm Ag-Nanoparticle, and lowest germination percentage (78.91 %) was recorded for G_7 (TMB-37) and G_3 (IPM-2-3) preceded by G_4 (Meha) when treated with 50 ppm of Ag-Nanoparticle.

$G_2 > G_5 > G_8 > G_6 > G_1 > G_4 > G_7 > G_3$ is the ranking about its germination percentage over treatments amongst the genotypes.

TABLE 11
MEAN VALUE OF GERMINATION PERCENTAGE OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF AG-NANOPARTICLE

T_1	90.33 (71.859)	91 (72.517)	89.41 (70.988)	90.33 (71.859)	90.83 (72.350)	88.91 (70.529)	89.83 (71.381)	91.25 (72.772)	90.23 (71.782)
T_2	99.5 (86.002)	99.5 (86.002)	99.25 (85.045)	99.25 (85.215)	99.08 (84.613)	99.41 (85.746)	99.25 (85.045)	99.25 (85.045)	99.31 (85.339)
T_3	80.08 (63.470)	81.16 (64.255)	78.91 (62.643)	79.66 (63.173)	81.58 (64.563)	81.83 (64.747)	78.91 (62.643)	80.08 (63.470)	80.28 (63.620)
Mean G	89.97 (73.777)	90.55 (74.258)	89.19 (72.892)	89.75 (73.416)	90.5 (73.842)	90.05 (73.674)	89.33 (73.023)	90.19 (73.763)	
	T	**G**	**TXG**						
SEm(±)	**0.160**	**0.262**	**0.453**						
LSD	**0.457**	**0.746**	**1.292**						

T= Ag-Nanoparticle, T_1= 10 ppm, T_2= 20 ppm, T_3= 50 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.



T_3G_1 T_3G_2 T_3G_3 T_3G_4

FIGURE 11: Images of germination and vigour test of green gram genotypes after priming with dose of 50 ppm Ag-nanoparticle (T_3).

3.12 Vigor Index of genotypes after priming with Ag-Nanoparticle

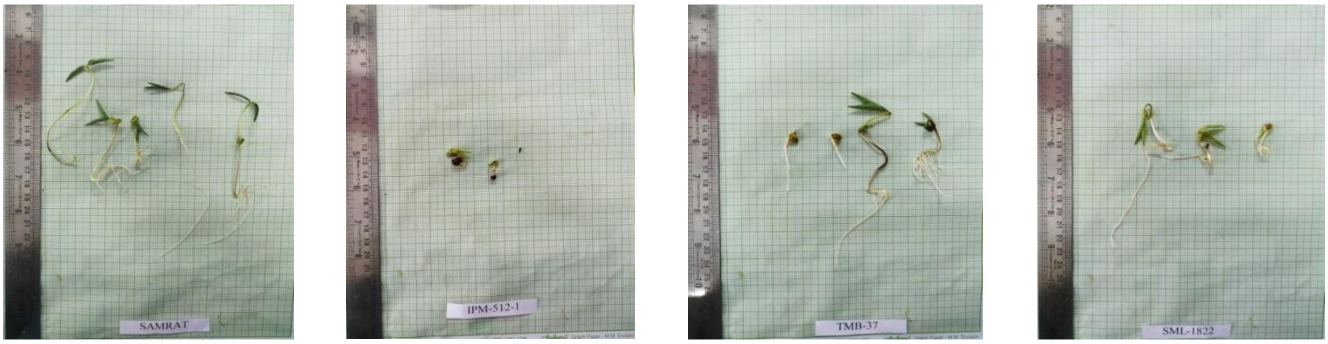
In case of considering the interaction between treatments and genotypes, a significantly maximum vigor index (2,564.625) was recorded for G_3 (IPM-2-3) followed by G_2 (PM-11-9) after application of 20 ppm Ag-Nanoparticle, and minimum vigor index (432.854) was recorded for G_4 (Meha) preceded by G_3 (IPM-2-3) when treated with 50 ppm of Ag-Nanoparticle. Significantly maximum vigor index (1,576.616) were observed for G_7 (TMB-37) followed by G_5 (Samrat), while lowest vigor index (1,275.502) were recognized for G_6 (IPM-512-1) preceded by G_8 (SML-1822) when the average was made over the treatments. The influence of T_2 (20 ppm Ag-Nanoparticle) was significantly superior to that of T_1 i.e. 10 ppm and T_3 i.e. 50 ppm Ag-Nanoparticle for the exhibition of vigor index when the average was made over the genotypes.

Ranking amongst the genotypes about its vigor index over treatments is $G_7 > G_5 > G_1 > G_3 > G_4 > G_2 > G_8 > G_6$.

TABLE 12
MEAN VALUE OF VIGOR INDEX OF DIFFERENT GREEN GRAM GENOTYPES AFTER TREATED WITH DIFFERENT DOSES OF AG-NANOPARTICLE

	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	Mean T
T_1	1,647.989	1,349.837	1,185.080	1,593.469	1,311.331	1,429.190	1,803.558	1,481.616	1,475.259
T_2	1,993.978	2,197.150	2,564.625	2,127.255	2,125.683	1,754.363	2,148.427	1,909.576	2,102.632
T_3	644.396	525.144	508.209	432.854	950.459	642.954	777.862	636.658	639.817
Mean G	1,428.788	1,357.377	1,419.305	1,384.526	1,462.491	1,275.502	1,576.616	1,342.617	
	T	**G**	**TXG**						
SEm(±)	**1.769**	**2.889**	**5.004**						
LSD	**5.046**	**8.240**	**14.273**						

T= Ag-Nanoparticle, T_1= 10 ppm, T_2= 20 ppm, T_3= 50 ppm
G= Genotypes, G_1= Pusa Vishal, G_2= PM-11-9, G_3= IPM-2-3, G_4= Meha (IPM 99-125), G_5= Samrat, G_6= IPM-512-1, G_7= TMB-37, G_8= SML-1822.



T_3G_5 **T_3G_6** **T_3G_7** **T_3G_8**

FIGURE 12: Images of germination and vigour test of green gram genotypes after priming with dose of 50 ppm Ag-nanoparticle (T_3).

IV. CONCLUSION

The various seed quality parameters such as root length, shoot length, seedling dry weight, fresh weight, germination percentage and vigor index were highest when priming with 50 ppm of GA_3 and 20 ppm of Ag-nanoparticle was done. So, it can be concluded that 50 ppm of GA_3 and 20 ppm of Ag-nanoparticle doses are appropriate for quality seed production.

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Greenhouse Conditioning using Internet of Things and Solar Panel

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Abstract— *The conditioning in a greenhouse is one of the efforts in the development of biotechnology-based plant products, thus enabling the growth of a plant to be controlled. In the current era of the industrial revolution 4.0, control technology leads to the use of information and communication technology. Internet of Things based devices can be used to build control systems. One of the most popular IoT devices today is the ESP8266, a microcontroller module that can connect to WiFi and TCP / IP. In the other side, the abundant sunlight is a potential use as an alternative sources of electrical energy to conditioning of greenhouse. In this research, the development of the solar energy as source of power of electrical energy in greenhouses and contolled using internet of thing is the main problem.*

Keywords— ***greenhouse, internet of things, solar energy, conditioning, control.***

I. INTRODUCTION

As a country with a tropical climate, Indonesia has a fairly high fertility rate. But fertility is not enough, it is necessary to develop agriculture by utilizing biotechnology, especially in order to increase agricultural production. The use of biotechnology is also needed, because with the increasingly rapid developments in the industrial sector, the area of agricultural land in Indonesia is also getting smaller. The shrinking of agricultural land is also caused by the large number of land changes to residential areas.

One of the biotechnologies that have developed quite rapidly is the use of a greenhouse. A greenhouse is a building made of glass or polyethylene which plays an important role in protecting the survival of plants. The gases contained in the greenhouse, such as carbon dioxide and methane and water vapors are conditioned in a balanced condition, so that they can withstand the sun's heat energy which affects the conditions or temperature therein.

Greenhouse also has weather engineering capabilities, which include temperature, watering duration and air circulation (Alwi, 2011). Sometimes unpredictable weather changes and limited land have led to the choice of greenhouse technology as an alternative solution to these problems (Abbas et al, 2015).

Conditioning in the greenhouse is also an effort to develop plant products through biotechnology so that the growth of a plant can be controlled to accelerate plant growth. However, so far, control in greenhouses is generally still done manually or in traditional ways, so that the effectiveness of growth in plants is lacking. Therefore, an automatic control system is needed in the greenhouse to make it easier to use the greenhouse.

In the current era of the Industrial Revolution 4.0, control technology (automatic control) leads to the use of ICT (information and communication technology). The control system is connected to the internet so that observation data storage, control decisions, and monitoring can be carried out through cloud computing. This allows the owner / operator to access the control system via a mobile device such as a smartphone, tablet or laptop.

Is an IoT (Internet of Things) based device that can be used to build an ICT-based control system? One of the most popular IoT devices today is the ESP8266, a microcontroller module that can connect to Wi-Fi and TCP / IP connections. As a microcontroller, this device has a processor, memory, input / output lines, and can be programmed according to the needs of the application.

In addition, the existing greenhouses still use conventional sources of electricity (PLN), which sources come from coal, fuel oil, natural gas, and others. Dependence on conventional energy sources of course has a bad impact, such as the increasing demand for energy is not accompanied by availability in nature. So that efforts to use renewable energy from alternative energy sources need to be pursued. Indonesia is a country that is exposed to the sun all year round, so the potential for solar energy is enormous as an alternative energy. Therefore, the development of the potential for solar energy as an alternative energy source must be done properly.

Conditioning a greenhouse that is in accordance with what is expected will be able to increase agricultural productivity and it is hoped that plants will continue to produce throughout the year without depending on the season. Automatic control will also make it easier for farmers to apply the availability of water, nutrients and light intensity needed by plants and is expected to be able to control plants from various kinds of pest and disease attacks.

The availability of abundant sunlight is a potential use of alternative sources of electrical energy. Therefore, the development of the potential for solar energy as a solar power plant which is a provider of electrical energy in greenhouses needs to be investigated. So it is hoped that the Greenhouse can have its own energy supply without depending on electrical energy.

II. MATERIAL AND METHOD

2.1 Operational Design

The greenhouse control system is intended to maintain the temperature and humidity (RH) of the room at the desired level. Temperature and RH are detected by special sensors that can be read by the system. The desired level can be adjusted by inputting numbers on the interface in the form of a computer screen (laptop, tablet, or smartphone).

The system then sends a digital signal to the relay which functions to switch (turn ON and OFF) the space cooling actuator and humidifier actuator devices.

The control system is planned to use a hybrid electric power source, namely solar power (using solar panels / photo-voltaic) and the electricity grid. For this reason, a control is needed to switch sources automatically based on the ability of the solar panel unit at any time (depending on the brightness of the sun). This capability is detected by a voltage sensor that is read by the system. If the voltage from the solar panels is less than required, the control system will switch to the PLN network using a relay / contactor.

In general, the control system receives information from the sensor in the form of temperature, RH, and voltage. The system also has a set point regarding the three parameters which are input by the operator. If the temperature exceeds the set point, the cooling actuator must be ON. Conversely, if the temperature is below the set point, the coolant must be OFF. Humidifier ON if RH is less than set point, and OFF if above set point. If the voltage generated by the solar panels is less than required, the power source must be switched to the power grid, conversely, if the solar panel voltage is sufficient, the power must be switched back to the solar panels.

The control system is designed to be able to communicate with computer devices (laptop/tablet/smartphone) via a wireless/WiFi network with internet protocol (IP). Therefore, it will be possible for the control system to be monitored and controlled remotely via the internet (Internet of Things/IoT system).

2.2 System Design

Based on the working principles that have been formulated in the operational design, a system design can be made as shown in Fig. 1. Broadly speaking, the components of the control system consist of (1) sensors, (2) IoT-based Microcontollers, (3) Programs, (4) Actuators, (5) Power supply, (6) Internet, (7) User interfaces, (8) Solar Panel and Power source.

The sensor functions as a detector for the amount of temperature, RH, and voltage that produces information that can be read by the microcontroller. The temperature and RH sensors are a single unit of the DHT22 type sensor. This sensor directly sends digital data that can be read directly by the microcontroller in the form of calibrated temperature and RH values. Voltage is detected using a voltage divider circuit to avoid voltage above the supply voltage from the microcontroller (3.3 V). The output voltage is then connected to the microcontroller ADC input to be converted into a digital value.

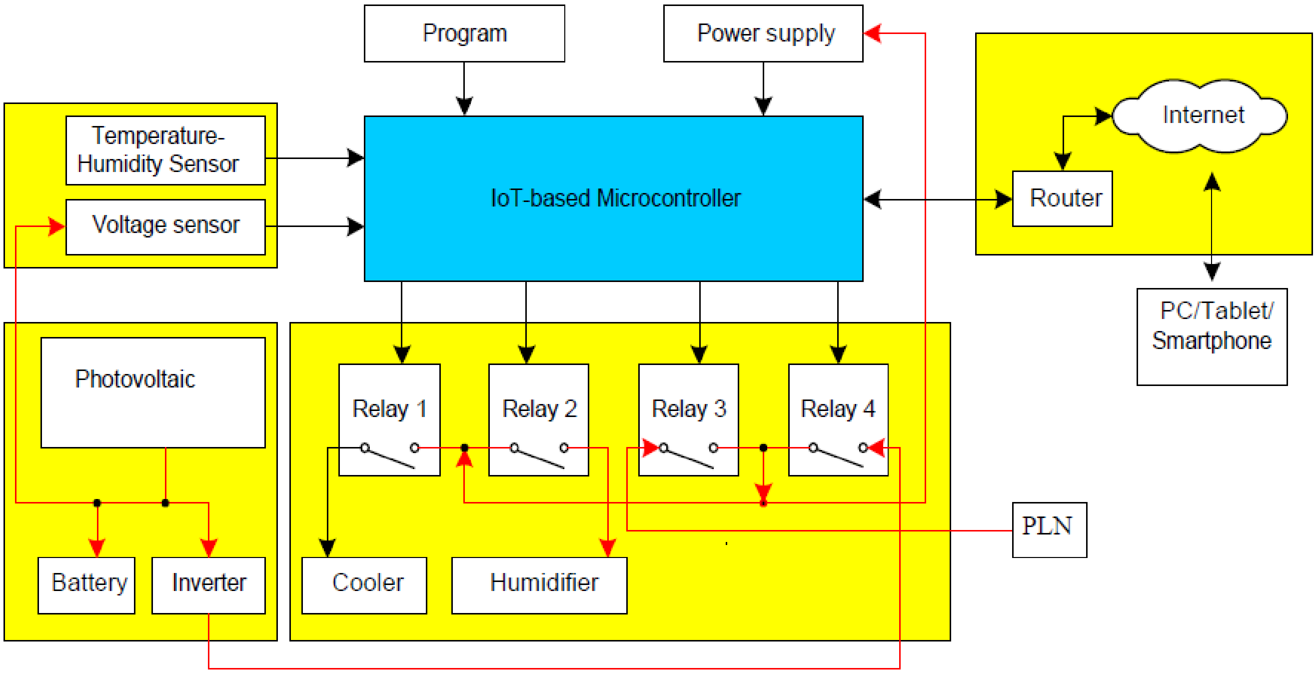


FIGURE 1: System design of the greenhouse control system

The microcontroller is the brain of this control system. The main function of this component is to process the information read / received to decide the operation of the actuator when to ON and when to OFF. Decision making is based on the comparison of the actual value obtained from the sensor with the set point value inputted by the user / operator.

In addition, this unit facilitates connection to the internet network via WiFi media. By using a PC / Smartphone device, the user / operator can access the interface via a web browser at a recognized IP-address. The control web display and the control algorithm are determined through the preparation of the microcontroller program. The program is a sequence of instructions stored in the microcontroller memory which will be executed every time the microcontroller is turned on. The program is structured using a microcontroller programming language, namely ESP8266 Basic (Molinari, 2015). The functions of this microcontroller program include reading sensors, reading set points, displaying temperature, RH and voltage values, displaying control functions on the web, sending digital signals to relays, and others.

Actuators are electrically powered devices that can affect parameters such as temperature and RH. The temperature actuator functions as an air conditioner such as a fan or evaporative cooler. While RH can be increased with an actuator in the form of a humidifier or sprayer. The actuator that can move the power source line is a relay or contactor.

A power supply or power supply is a unit that provides the DC voltage required by electronic circuits. This unit is an adapter that converts AC 220V to 5V DC voltage.

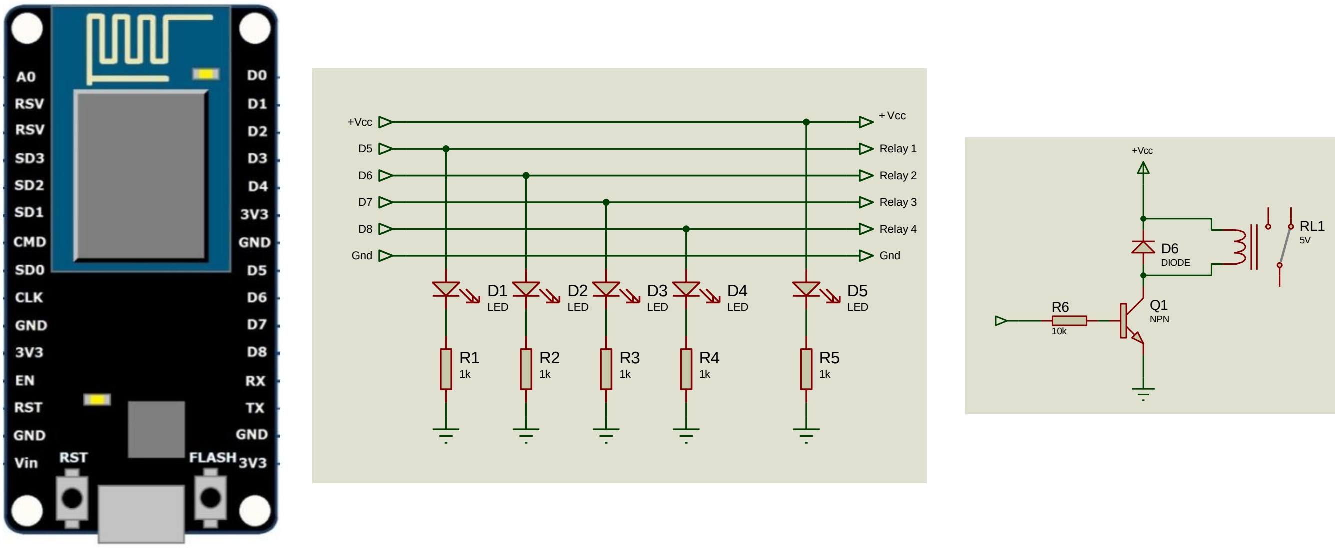
This unit is a wireless router connected to the internet network. The function of this unit is to connect the microcontroller to the internet by providing an IP address to the microcontroller device, so that it can be accessed via that IP address.

The user interface unit is a mobile device such as a laptop, tablet or smartphone. The function of this unit is as an interface device between the user / operator and the control system. Applications used are web browsers such as Mozilla, Chrome, and so on.

The source of electricity used in the greenhouse control system functions as a power source for the power supply and actuator unit. The source of electricity comes from the solar panel unit and the electricity network that works in a hybrid manner.

2.3 Electronic Circuit

The electronic circuit consists of the ESP8266 microcontroller circuit module, a series of indicator lights, and a relay-board circuit module. Schematic diagrams of electronic circuits are presented in Figures 2(a), 2(b), and 2(c). The electronic circuit is arranged based on the schematic diagram above. Between circuits connected by jumpers and connectors.



(a) (b) (c)

FIGURE 2(a): NodeMCU version of the ESP8266 microcontroller module, 2(b): Schematic diagram of indicator lights, and 2(c): Schematic diagram of a 1 channel relay circuit

2.4 Software Development

The microcontroller program is prepared in BASIC language using the ESP8266 BASIC compiler based on hardware design and control algorithms. The programming step begins by uploading (flash) the BASIC firmware to the ESP8266 microcontroller as follows:

1) Installing the ESP_Basic_Flasher application on a PC computer;

2) connecting the ESP8266 microcontroller module (NodeMCU) using a USB cable;

3) run the ESP_Basic_Flasher application program (see Fig. 3(a));

4) enter the parameter COM Port number and memory size (Flash Size);

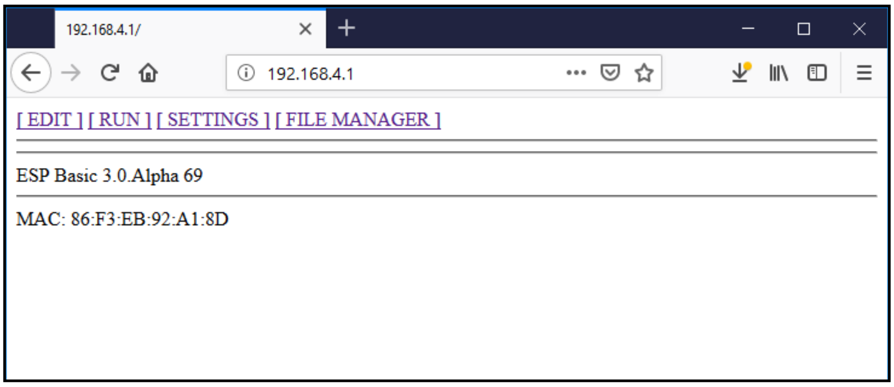
5) click Firmware Flash;

6) wait a while for the flashing process to complete;

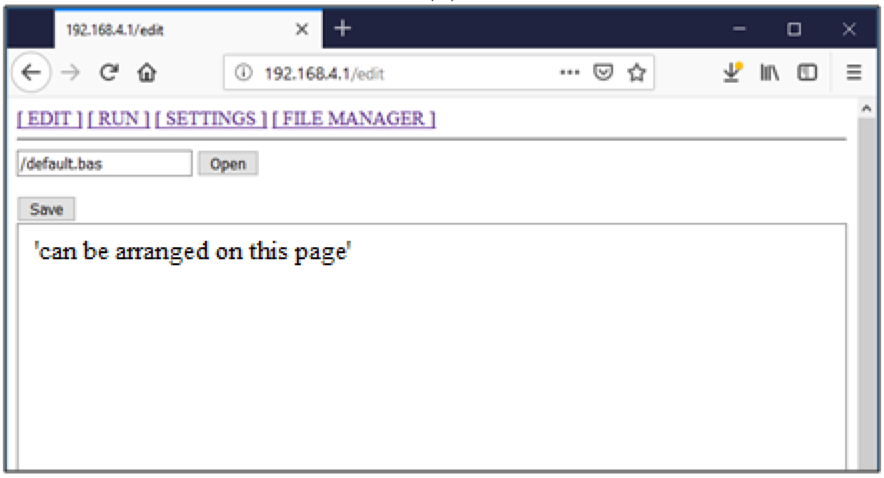
The next step is to connect the PC WiFi with the SSID emitted by the NodeMCU device. Default SSID name contains MAC ADDRESS. Furthermore, using a browser opens the web with the URL address: http://198.162.4.1/ so that a display like Fig.3 (b) is obtained. From this figure, information about the mac address of the device is obtained.

To write / compile a program click "EDIT" and a page will be displayed with the provided writing area (Fig. 3(c)). Press "Save" to save the program, and click "RUN" to run the program.

(a)



(b)



(c)

FIGURE 3: (a) Flasher ESP8266 Basic Interface, 3(b) Web programming interface, 3(c) Program writing area

Apart from being based on a series of hardware and control algorithms, program design also refers to the web appearance, component layout, aesthetics and others. Some of the required web components include a button, textbox, text, dropdown, and so on. Button is used to switch ON / OFF of each actuator when set in manual mode. Text and text-boxes are used to display measurement values and input set points. Dropdown is used to select "Manual" and "Auto" mode options for each actuator. The “Manual” mode will allow control of the actuator by clicking the ON or OFF button. While the "Auto" mode automatically turns on or off based on the set point value and actual parameters.

The program simulation is carried out by observing the changes in the indicator light which is connected to the NodeMCU module when the ON / OFF button is clicked. Sensors are also installed on the module, then observed the display of temperature, RH and voltage values provided on the web. The choice of “Manual” and “Auto” mode is also tested on each actuator which is simulated with an indicator light. If an error occurs and the function mismatches, then the program will be repaired immediately until a solution is found.

2.5 Calibration

Calibration is carried out to obtain the appropriate measurement value. In this study, three parameters were measured, namely temperature, RH and voltage. As previously described, temperature and RH were measured using a calibrated DHT22 sensor. Therefore, only voltage measurements will be calibrated in this study. While the temperature and RH will be compared with the measurement results with a thermohygrometer to get the average deviation which is the absolute value of the difference.

Voltage calibration is intended so that the voltage value displayed on the control web is the actual value in volts. Voltage measurement in this system involves a conversion process from an analog to digital quantity (ADC) where the ADC output value is the conversion value of a 10-bit binary number (0 - 1023). This is in accordance with the ADC characteristics of the ESP8266 microcontroller, which has an output of 10 bits (Espressif System, 2015).

The calibration stage is to provide input to the ADC pin (A0) of the NodeMCU module in the form of an analog voltage ranging from 0 Volts to a maximum that can produce an output of 1023. To generate an analog voltage, a multi-turn potentiometer is used which is assembled as a voltage divider. Furthermore, by turning the potentiometer gradually the ADC input voltage varies. Each voltage variation is measured with a voltmeter and the ADC output is recorded on the web.

The data pairs obtained are then processed with linear regression techniques to produce an equation for the relationship between the ADC output value and the voltage. This equation will then be used to convert the ADC value into the voltage value displayed on the web.

III. RESULT AND DISCUSSION

3.1 Hardware

The hardware design consists of: a microcontroller module, relay unit, DHT22 sensor, power supply, and voltage sensor. This design can be seen in Fig. 4 below. The microcontroller module uses NodeMCU, a type of module based on the ESP8266 which is widely sold in the on-line shop market. This module has several GPIO (general purpose input output) lines that can be used to family digital "1" or "0" signals. In this design, four GPIO lines are used to drive the relay and indicator lights, namely D5, D6, D7, and D8. Line D5 for Fan, D6 for humidifier, D7 for mains power source (solar panels or PLN), and D8 reserved for irrigation pumps.

The microcontroller module is powered by 5 V via the micro-USB connector from the power supply or HP charger. A PC power bank and USB port can also be used for this purpose.

The indicator light board consists of 5 red LEDs. The five LEDs respectively from top to bottom (Figure 4.1) are used as indicators: Relay 1, Relay 2, Relay 3, Relay 4, and Power-on. This board is equipped with a male connector which is used to connect the 4 channel relay board.

The DHT22 sensor is connected by a 3 line cable to the microcontroller. In its application in miniature greenhouses and real greenhouses, these connector cables can be replaced with lengths of up to 10 m. This sensor will be placed in the middle of the room and put in a special box as a protection. The voltage sensor uses a potentiometer to limit the voltage source that is measured to exceed the ADC capability limit, which is 3.3 volts. This sensor must be calibrated first to get the appropriate voltage value.

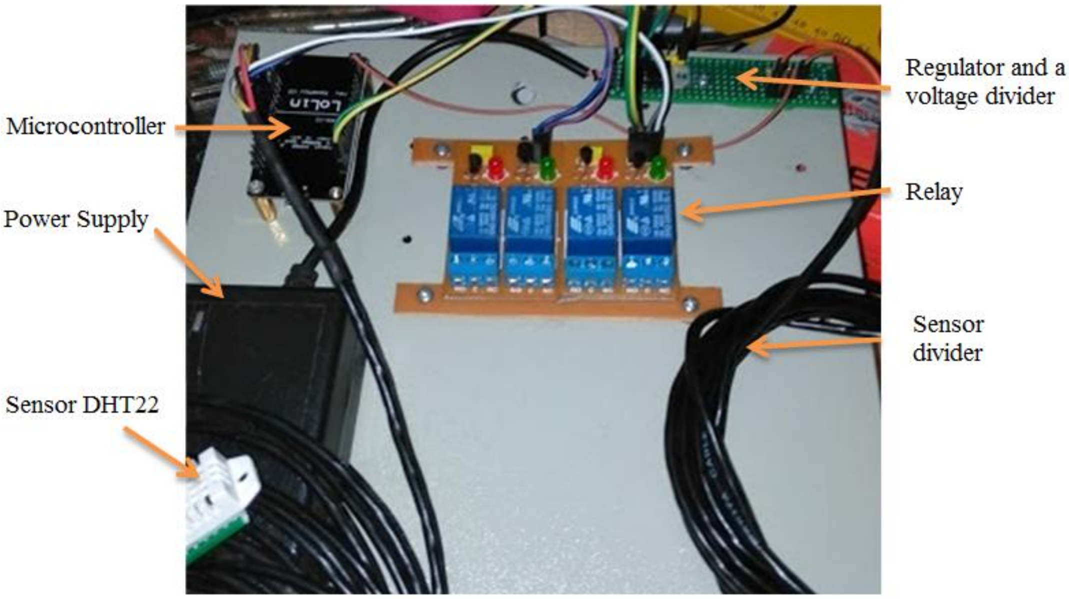


FIGURE 4: The result of the control system design

3.2 Software

The design of the software produces a web-based display of the greenhouse controller program as shown in Fig.5. The web controller can be accessed via a web browser with Android (using a smartphone) or Windows (using a laptop). The device to access must first be connected to WiFi with the SSID name: ESP86: F3: EB: B6: F8: F8 emitted by the ESP8266 module.

The SSID name of each ESP8266 device by default takes from its mac-address. The URL address that must be accessed is http://192.168.4.1. Furthermore, obtained a display like Fig. 5.

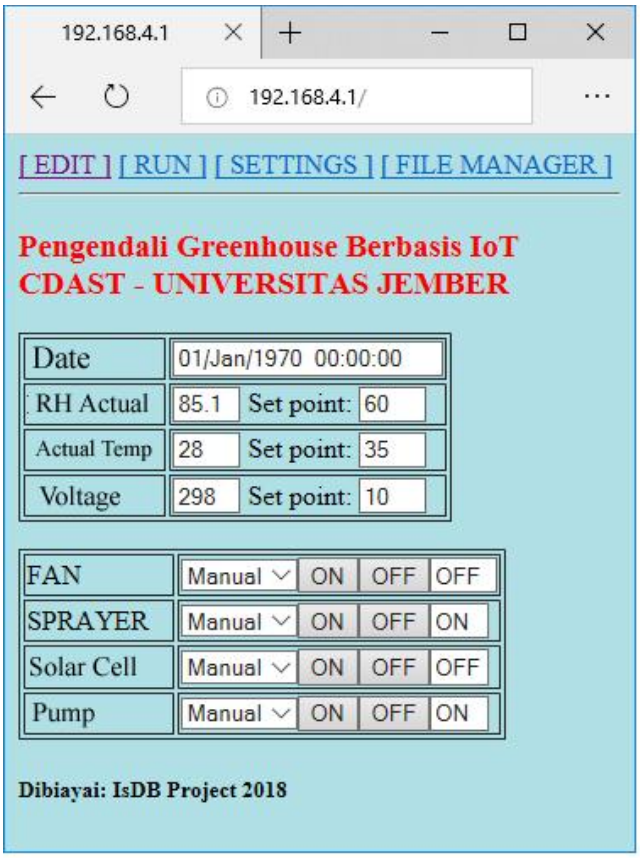


FIGURE 5: Web interface for greenhouse controllers

3.3 Tempereture Measurement Performance

The results of temperature observations at the same object and time using the control unit and digital thermohygrometer are presented in Table 1. Based on the table, the average deviation between measurements using the control unit and the thermohygrometer is 0.5^{o}C.

TABLE 1
TEMPERATURE MEASUREMENT

Unit Control	Thermohigrometer	d	d^2	|d|
28.4	27.8	0.6	0.36	0.6
27.2	26.6	0.6	0.36	0.6
28.6	28.1	0.5	0.25	0.5
26.4	26.8	-0.4	0.16	0.4
28.4	27.8	0.6	0.36	0.6
27.7	27.2	0.5	0.25	0.5
27.8	27.3	0.5	0.25	0.5
27.9	28.4	-0.5	0.25	0.5
29.0	28.5	0.5	0.25	0.5
29.0	28.5	0.5	0.25	0.5
29.0	28.5	0.5	0.25	0.5
28.2	27.8	0.4	0.16	0.4
Avarage				0.5

3.4 Relative Humidity (RH) Measurement Performance

RH is measured using the same sensor, namely DHT22. So this calibration of RH only produces an average deviation between the RH readings by the control unit and the thermohygrometer. The results of RH observations with both tools can be seen in Table 2. The average deviation value was 0.6%.

TABLE 2
RELATIVE HUMIDITY MEASUREMENT

Unit Control	Thermohigrometer	d	d^2	|d|
77.1	78	-0.9	0.81	0.9
85.5	85	0.5	0.25	0.5
76.2	77	-0.8	0.64	0.8
79.9	80	-0.1	0.01	0.1
82.1	82	0.1	0.01	0.1
80.7	82	-1.3	1.69	1.3
79.6	81	-1.4	1.96	1.4
73.8	75	-1.2	1.44	1.2
74.1	74	0.1	0.01	0.1
73.8	74	-0.2	0.04	0.2
74.2	74	0.2	0.04	0.2
75.5	76	-0.5	0.25	0.5
Avarage				0.6

3.5 Solar Panel Performance

In the experiment, the energy from solar panels needed for conditioning the greenhouse is very dynamic. The existence of sunlight intensity which is influenced by the time of day and night and the presence of clouds is very influential in the fulfillment of electrical energy. Meanwhile, the weather outside the greenhouse greatly affects the electrical energy used. To meet the electrical energy from solar panels for a greenhouse, further research is still needed.

3.6 Green House Conditioning

In principle, the greenhouse system has been implemented and is able to provide a good temperature and relative humidity. However, for performance related to plant growth, further research is still needed.

IV. CONCLUSION

In this research, the temperature and humidity control systems in greenhouses with energy from solar panels have been discussed and can be controlled by Internet of Things. The system can provide an ideal environment with controllable temperature and humidity that allows plants to experience perfect growth. This research focuses on the control system structure, hardware, software design, and system control strategy. The control system has a simple hardware structure, is cost-effective, easy to use and maintain, and provides good temperature and humidity stability.

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Socio-Economic Determinants of the Adoption of Improved Maize Varieties by Farmers in Shongom Local Government Area of Gombe State

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Abstract— *This study was designed to determine the socio-economic determinants of the adoption of improved maize varieties by farmers in Shongom Local Government Area of Gombe State, Nigeria. The study specifically described the socio-economic characteristics of maize farmers in Shongom LGA, determined the socio-economic factors influencing the adoption of maize varieties introduced to farmers and identified the constraints faced by farmers in the adoption of the maize varieties. Data were collected through structured questionnaire and focus group discussion and analyzed using descriptive and inferential statistics. The findings revealed that majority of the respondents were male (84.96%), the mean age of respondents involved in maize farming was 36 yearsand46.90% of maize farmers had secondary school education. Also, above average (61.36%) of the respondents were married and the mean household size of the respondents was 8. The binary logit regression output shows that education, years of farming experience and extension contacts had positive and significant relationship with adoption of improved maize varieties; education, years of farming experience and extension contacts were all significant at P≤0.01.Years of residence and credit received were significant but had negative coefficients; credit received was significant at P≤0.01 while years of residence was significant at P≤0.05. The most common constraints to adoption of maize were high cost of fertilizer (97.80%), inadequate credit (74.73%), weeds (57.14%), pest and diseases (41.76%) and late arrival of inputs (33.52%). It is recommended that the cost of education be reduced to the barest minimum so that farmers can afford to educate themselves and their children. Also, more emphases should be made by ADPs and other extension agencies on regular visits by their agents to farmers.*

Keywords— Adoption, Maize, Farmers, Improved variety.

I. INTRODUCTION

Maize is a major cereal and one of the most important food crops in Nigeria. Its genetic plasticity has made it the most widely cultivated crop in the country from the wet evergreen climate of the forest zone to the dry ecology of the Sudan savanna (Kamara *et al*., 2020). Over the years, maize has become an important crop, taking over acreages from traditional crops such as millet and sorghum. In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018).

Soil fertility in the savannas has progressively declined due to increased pressure on land resources arising from rapid population expansion combined with low use of fertilizers. The soil is deficient both in macronutrients, such as N, P, and K, and key micronutrients, such as copper and zinc. Therefore, the soil cannot support meaningful maize yields without proper fertilization. Yields as low as less than 1 t ha-1 can be obtained without the addition of fertilizer (Kamara *et al*., 2020). Research efforts by plant breeders and agronomists have led to the production of many technologies including the breeding of high yielding varieties that are tolerant to drought, diseases, low nitrogen, and striga infestation (Kamara *et al*., 2014).

Maize being a major staple crop in Nigeria is of vital concern to agricultural policy decisions. FAO (2017) reported that Nigeria produced 10.5 Million metric tons of maize in the year 2017. Maize production in Nigeria for the 2019/20 season is estimate at about 10.5 Million metric tons (Foreign Agriculture Service (FAS) Lagos, 2019). Local maize farmers in Nigeria can raise yield to about 4.2 tonnes/ha and national production could hit 20 million tonnes (International Institute of Tropical Agriculture (IITA), 2009). The average yield of maize in Nigeria for the year 2019 was recorded to be 1.69 tonnes/ha (IITA, 2020). When compared to other African countries such as Egypt and Mauritius with average yields of 7.1 tonnes/ha and 5.8 tonnes/ha respectively, Nigerian maize farmers can be said to be producing far below expectation (Food Agriculture Organization Corporation Statistic Database, 2009). In Shongom LGA, maize farmers do not realize up to the expected average yield of 4.2 tonnes/ha despite the availability of new maize varieties and other improved agronomic practices, the reason for this anomaly is what the study sort to reveal. This study is motivated by the important position of maize production in the Nigerian economy. Maize production does not only serves as a major staple food to a majority of the citizens of Nigeria but also a good source of revenue to both farm households and the nation at large.

The study therefore assessed the socio-economic determinants of the adoption of improved maize varieties by farmers in Shongom Local Government Area of Gombe State, Nigeria. The study objectives were to: describe the socio-economic characteristics of maize farmers in Shongom LGA, determine the socio-economic factors influencing the adoption of maize varieties introduced to farmers and identify the constraints faced by farmers in the adoption of the maize varieties. The research hypothesis is:

H_0^1: Socio-economic factors of maize farmers have no significant influence on adoption of improved maize variety.

H_A^1: Socio-economic factors of maize farmers have significant influence on adoption of improved maize variety.

II. METHODOLOGY

2.1 The Study Area

The study was conducted in Shongom LGA of Gombe State. Gombe State is located in the northeastern part of Nigeria. The state covers an area of 20,265 km² and from the 2006 census has a population of about 2,365,000 people (National Population Commission, 2007). At 3.2% growth rate, the year 2020 projected population of the state is 3,585,104. Shongom LGA has its headquarters in the town of Boh in the north of the Area. The town of Shongom lies between Latitude 9^o 40^I 25^{II}N and Longitude 11^o 15^I 24^{II}E. The LGA covers an area of 922 km² and has a population of 151,520 (National Population Commission, 2007). At 3.2% growth rate, the year 2020 projected population of the LGA is 229,689. Shongom has an annual rainfall of 560 - 740 mm (July - October) and lies 300 - 400m above sea level (Anon, 1987). The area is bounded to the north by Akko LGA and to the west by Kaltungo LGA, the south is bound by Billiri LGA while, Karin-Lamido and Alkaleri LGA in both Taraba and Bauchi state forms the eastern boundaries of the local government area (Dede *et al.*, 2005). The area falls within the Sudan Guinea savannah, at the boundaries of the Sahel savannah belt; that separate the forest zone from the savannah areas. It has sparse vegetation and enjoys hot weather climate most part of the year (Shamaki *et al.*, 2009). The major spoken language is Tangale, other languages spoken are English and Hausa. Majority of the residents are mainly farmers, but during the dry season they involve in other activities as carpentry, welding, blacksmith etc. A total of seven villages in the LGA including Boh, Lapan, Lalaipido, Filiya, kulishen, Gwandom were selected for the purpose of this research.

Sample Size and Sampling Technique

Multi-stage sampling technique was employed in selecting the farmers for this study. In the first stage, out of all the Northeast States in Nigeria, Gombe was purposively selected because it was the first State in Northeast to witness the pilot trial of Agricultural Development Programmes (ADPs) in Nigeria. In the second stage, out of the 11 Local Government Areas(LGAs) in the State, Shongom LGA was purposively selected. The Local Government Area was selected because it has a high proportion of maize growers. In the third stage, a total of seven villages were purposively selected; these villages were selected based on the fact that high proportions of maize growers are found in them. In the fourth stage, simple random sampling technique was employed in selecting farmers from these villages to avoid being bias. Out of a sample frame of 2200 maize growers, 339 respondents were randomly selected as the sample size. See Table 1.

TABLE 1
POPULATION AND SAMPLE SIZE OF MAIZE FARMERS

State	LGA's	Villages	**Sample frame	Sample size
Gombe	Shongom	Lapan Boh Lalaipido Filiya Kushi Kulishin Gwandum	400 400 350 300 200 300 250	62 62 54 46 31 46 38
Total		**7**	**2200**	**339**

*****Source: Gombe State Agricultural Development Programme***

Yamane (1967) formula was used to calculate the sample size with 95% confidence level and 5% sampling error assumption.

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where,

n= Sample size (Total sample size)

N= Population size (Total sample frame)

e= Level of significance (set at 0.05 for this study)

To determine further the proportion of the respondents (sample size per village), Yamane (1967) sampling method for determining of respondents was used i.e:

$$\text{Sample size of village} = \frac{\text{Sample frame of village} \times \text{Total sample size of all villages}}{\text{Total sample frame of all villages}} \quad (2)$$

2.2 Data Type and Source

Primary data and secondary sources of information were used for this work. Primary data was achieved via structured questionnaires and focus group discussion while the internet, journals, textbooks, conference papers etc were used as secondary sources of information.

2.3 Tool of Analysis

In this study, the descriptive and inferential statistics was used to achieve the specific objectives. The descriptive statistics such as frequency count, table, percentage, range and mean are some of the mathematical tools were used and the Binary Logit Regression Model was used to determine the socio-economic factors influencing the adoption of improved maize varieties.

The empirical model is specified as follows:

$$Y = \ln\left(\frac{p}{1-p}\right) = \beta0 + \beta1X1i + \beta2X2i + \beta3X3i + \beta4X4i + \beta5X5i + \beta6X6i + \beta7X7i + \beta8X8i + \beta9X9i + + e \quad (3)$$

Where;

In = natural logarithm

P= probability

Y = practice of ADP services ($Y_=$ 1 when "yes", $Y_=$ 0 when "no")

β_0 = constant term

β_1- β_9 =regression coefficients

X_1 = age of farmer (years)

X_2 = household size (number)

X_3 = educational status (years)

X_4 = numbers of extension contact (number of extension contact/period)

X_5 = farm size (hectares)

X_6 = farming experience (years)

X_7=extension contact

X_8= credit

X_9= income of farmers

III. RESULTS AND DISCUSSION

3.1 Socio-economic Characteristics

The results in Table 2 show that majority of the respondents were male (84.96%) while the rest were females (15.04%) This indicates that male dominated maize farming in the study area. This finding is in agreement to that of Idrisa *et al*. (2012) who worked on Influence of Farmers Socio-economic and Technology Characteristics on Soybean Seeds Technology Adoption in Southern Borno and revealed male respondents to be 87.7%. Also the Table reveals that the mean age of respondents involved in maize farming was 36 years. This shows that the farmers were young, in their active stage and expected to have more energy to practice maize farming. This result is similar to the findings of Olaniyi and Adewale (2010) and Jamilu *et al.* (2014) who found that maize farmers were between 30-35 years. Similar to this finding, Onyedicachi (2015) found a mean age of 40.79 among rural farming household in Abia State, Nigeria. The table further shows that 6.49% of respondents in the study area had no formal education, 0.59% attended adult education, 10.91% had primary education, 46.90% had secondary education, 19.17% had NCE/OND and 15.93% of the respondents had bachelor’s degree education level. Majority (46.90%) of maize farmers having secondary school education shows that farmers in the study area possess the basic education to understand the implications of adopting new technologies which have been introduced to them by the (Agricultural Development Programmes (ADPs). This result contradicts the finding of Jamilu *et al*. (2014) who found low level of education among maize farmers but agrees with the studies by Okunlola and Akinwalere (2011) on adoption of new technologies by fish farmers and Ajewole (2010) on adoption of organic fertilizers which revealed that the level of education had a positive and significant influence on adoption of the technologies introduced to farmers. Higher education influences respondents’ attitudes and thoughts, making them more open, rational and able to analyze the benefits of the new technology.

For marital status of the respondents, Table 2 further revealed that majority (61.36%) of the farmers were married; this implies that married people concentrate on maize farming probably to provide food for their family members. This finding is similar to that of Umar *et al.* (2014) who found that majority of the farmers were married. Also, 37.46 % were never married, 0.29% were divorced or separated and 0.88% were widowed.

The result also shows that the mean household size of the respondents was 8 with 82.89% of the respondents having a household size of 1-10, 15.63% of the respondents had 11-20 household size, 0.88% had a household size of 21-30 and 0.59% had household size of 31-40. Household size could be an important factor in the adoption of new practices in maize production considering the tasks involved in agronomic activities on the field such as method of planting and seemingly fertilizer application methods, weeding, harvest, processing, among others . It will therefore be easier for a relatively larger household size to adopt the technology and practices. This is in agreement with the report of Motuma *et al.* (2010) that increase in family size positively influences the decision to adopt improved maize varieties.

TABLE 2
SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS (n=339)

Variables	Frequency.	Percent	Mean
Sex			
Male	288	84.96	
Female	51	15.04	
Age			
11-20	19	5.60	36
21-30	99	29.20	
31-40	117	34.51	
41-50	74	21.83	
51-60	19	5.60	
Above 60	11	3.24	
Education			
No formal education	22	6.49	
Adult Education	2	0.59	
Primary Education	37	10.91	
Secondary Education	159	46.90	
NCE/OND	65	19.17	
University	54	15.93	
Marital Status			
Never Married	127	37.46	
Married	208	61.36	
Widowed	3	0.88	
Divorced	1	0.29	
Household Size			
1-10	281	82.89	8
11-20	53	15.63	
21-30	3	0.88	
31-40	2	0.59	

Source: Field Survey, 2020

Results from Table 3 revealed the mean cultivated land in the study area to be 2.9 with most farmers (77.88%) in the study area cultivating between 0.5-2.5ha of land. About 18% of the respondents cultivated farm sizes ranging from 2.6-4.6ha. Only 0.29% of the respondents cultivated farm sizes ranging from 15.2-17.2ha. of land. This confirms the report of the Nation Newspaper that few of the problems associated with maize farmers to a greater extent in Bauchi state are small farm size and low income earning (The Nation, 2009). This may be a result of problem of land tenure which ravaged the state in general. Also this implies that maize farming is dominated by small scale farmers. This finding corroborates that of Jamilu *et al*. (2014) who found that maize farmers operate on small scale.

The table further shows that 43.07% of respondents had 1-10 years of farming experience in the study area. About 32.50% of the respondents had 11-20 years of experience, 18.88% had 21-30 years of experience and only 0.58% had 51-70 years of farming experience. This indicated that most respondents had acquired some experience, knowledge and skills to varying degrees in farming. Experience, knowledge and skills increase with increase in years of farming. This finding is similar to that of Komolafe *et al*. (2014) who found high farming experience among farmers.

Table 3 also shows that 88.50% of the respondents have had 0-3 contacts with extension agents, 9.44% had 4-7 contacts with the agents, 1.47% of the respondents had 8-11 contacts and 0.59% of the respondents have had 12-15 contact with extension agents. It can therefore be deduced from the result that extension agents' services are lacking in the study area. According to Obinne (1991), the role of the extension agent in technological transfer is of great importance to the sustenance of viable technology. The result further indicated that 88.27% of the respondents received 0-20,000 naira worth of credit, 7.3% received 21,000-50,000 naira worth of credit, 3.23% received 51,000-100,000 naira worth of credit and only 0.29% received

152,000-200,000 naira worth of credit. This finding is supported by the study of Kudi *et al*. (2010) which revealed that inadequate capital was a major constraint to adoption of technology.

TABLE 3
SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS (n=339)

Variables	Frequency.	Percent	Mean
Size of Land Cultivated			
0.5-2.5	264	77.88	
2.6-4.6	60	17.7	
4.7-6.7	10	2.95	2.9
6.8-8.8	2	0.59	
13.1-15.1	2	0.59	
Years of Farming Experience			
01.-10	146	43.07	
11-20	110	32.45	
21-30	64	18.88	
31-40	13	3.83	
41-50	4	1.18	
51-60	1	0.29	
61-70	1	0.29	
Extension Contacts			
0-3	300	88.5	
4-7	32	9.44	
8-11	5	1.47	
12-15	2	0.59	
Credit Received			
0-20000	301	88.27	
21-50000	25	7.33	
51-100000	11	3.23	
101000-151000	3	0.88	
152000-200000	1	0.29	

Source: Field Survey, 2020

3.2 Socio-economic Determinants of Adoption of Improved Maize Varieties

The results of the logit regression output can be interpreted using log odds or odds ratio. For this work, the interpretation was done using odds ratio. Table 4 shows that education; years of farming experience and extension contacts were significant and positive while years of residence and credit received had a negative relationship with adoption of practices. The table further shows that education was significant at 1% and had odds ratio of 1.667, years of farming experience was significant at 1% with odds ratio of 3.218, extension contact was significant at 1% and had odds ratio of 3.291. This implies that every unit increase in education, years of farming experience and extension contacts will more likely increase the adoption rates by 66.7% 221% and 229.1% respectively. This result agrees with komolafe *et al*. (2014) who found that farmers with high level of education adopt new technologies easily and use them effectively while farmers with more years of farming experiences will be more efficient in farm production. Also the result is in line with previous studies from Lawal and Oluloye 2008 and Bamire *et al*., 2010 which showed that farmers' education and access to extension services exert positive and significant influence on adoption of improved maize varieties.

Furthermore, Table 4 revealed that year of residence was significant at 5% and had an odds ratio of 0.952 and credit received was significant at 1% with odd ratio of 0.165. This means every unit increase in years of residence and amount of credit received will make the adoption of improved maize varieties less likely by 4.8% and 83.5% respectively.

TABLE 4
SOCIO-ECONOMIC DETERMINANTS OF ADOPTION

Adoption of practices	Coefficient (odds ratio)	Standard Error	t-value	p-value	[95% Conf	Interval]	Sig
Sex	1.898	1.002	1.21	0.225	0.675	5.343	
Age	1.243	0.326	0.83	0.407	0.743	2.077	
Education	1.667	0.320	2.66	0.008	1.144	2.430	***
Marital	1.719	0.859	1.08	0.278	0.646	4.576	
Residence yrs.	0.952	0.019	-2.45	0.014	0.915	0.990	**
HH Size	1.513	0.552	1.13	0.257	0.740	3.095	
Farm Size cult.	1.143	0.313	0.49	0.625	0.668	1.956	
Farming exp.	3.218	0.795	4.73	0.000	1.982	5.224	***
Ext. contact	3.291	1.432	2.74	0.006	1.403	7.722	***
Credit received	0.165	0.100	-2.98	0.003	0.050	0.538	***
Constant	0.008	0.014	-2.76	0.006	0.000	0.245	***
Mean dependent var		0.566	SD dependent var			0.497	
Pseudo r-squared		0.254	Number of obs			182.000	
Chi-square		63.212	Prob> chi2			0.000	

Source: Field Survey, 2020
****** p<0.01, ** p<0.05, * p<0.1***

3.3 Testing of Hypothesis

The hypothesis 1 of the study which assumes that socio-economic factors of maize farmers have no significant influence on adoption of improved maize varieties was tested and the result in Table 5 shows that the value of F-calculated (6.51) was greater than F-critical value (2.43). This implies that the socio-economic factors influenced the adoption of practices introduced. The null hypothesis is therefore rejected and the alternative hypothesis accepted.

TABLE 5
ANALYSIS OF STUDY HYPOTHESIS

Hypothesis	F-Calculated	F-Tabulated (f-critical) at 1% significance level
Hypothesis 1	6.51	2.43

Source: Field Survey, 2020

3.4 Constraints by Farmers in the Adoption of Improved Maize Varieties in Shongom LGA

Table 6 shows that the most common constraints to adoption of practices were high cost of fertilizer (97.80%), inadequate credit (74.73%), weeds (57.14%), pest and diseases (41.76%) and late arrival of inputs (33.52%).This finding is supported by the study of Kudi *et al*. (2010) which found that major constraints to adoption was lack of adequate capitals and high cost of inputs. Umar *et al*. (2014) also found that unavailability of seed and high costs of fertilizer were the major constraint of maize production to maize farmers. The study is also in agreement with the study done by Makokha *et al*. 2001 on determinants of fertilizer and manure in maize production in Kiambu county Kenya, he reported high cost of labor and other inputs, unavailability of demanded packages and late arrival of inputs as the main constraints to fertilizer adoption.

TABLE 6
CONSTRAINTS BY FARMERS IN THE ADOPTION OF IMPROVED MAIZE VARIETIES (n=182)

Constraints	Frequency	Percent of response	Percent of cases
Late arrival of inputs	61	10.99	33.52
High cost of fertilizer	178	32.07	97.8
Weeds	104	18.74	57.14
Pests and diseases	76	13.69	41.76
Inadequate credit	136	24.5	74.73
Total	**555***	**100**	**304.95**

Source: Field Survey, 2020
****Multiple Responses***

IV. CONCLUSION AND RECOMMENDATION

The mean age of farmers in the study area was 36, this indicates that most people engaged in farming in the study area were still in their active stage and therefore have more energy to engage in maize production. Also, the mean household size was 8, this implies that they had adequate man power to carry out farm activities. Education, years of farming experience and number of extension contacts had positive and significant relationships with adoption of improved maize varieties. This implies that more formal education and visits by extension agents have the capacity to increase the adoption rates of technologies introduced to farmers. Some of the major constraints faced by farmers in adoption of the practices introduced were late arrival of inputs, high cost of fertilizer, weeds, pest and disease and inadequate credit. If these constraints are given proper consideration by appropriate bodies, maize production in the study area would be boosted.

Education and extension contacts were significant and positively influenced the adoption of practices introduced. It is recommended that the cost of education be reduced to the barest minimum so that farmers can afford to educate themselves and their children. Also, more emphases should be made by ADPs and other extension agencies on regular visits by their agents to farmers. One of the major constraints faced by farmers in the adoption of practiced introduced was high cost of fertilizer, therefore, proper monitoring and strengthening of the on-going fertilizer subsidy intervention in order to block leakages and ensure timely disbursement to farmers should be put in place.

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Use of Cobalt Nitroprusside Nanoparticles in the detection of Sulphites in Sugar

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***Abstract*—** *Sulphite detection and removal is currently an important process in the manufacture of sugar. Our objective in this review paper is to explore the methods of detection of sulphites using Cobalt Nitroprusside nanoparticles.*

Cobalt Nitroprusside, also known as cobalt pentacyanonitrosylferrate has proved to be an excellent coordinate compound for the manufacture of its nanoparticles and usage of those nanoparticles in the detection of sulphite. The method proposed in our review paper involves using a carbon paste electrode modified with Cobalt Nitroprusside nanoparticles. Cobalt Nitroprusside being a transitional element complex and is used for the quantification of analytes, provides the industry with a wide potential window.

Sulphites in foods and most commonly in sugar, pose a threat to the health of individuals who consume processed foods regularly. Sulphites are known to cause allergic reactions on the face and eyes and vomiting, diarrhoea and cramps, it is essential to remove the sulphites in ingestible items.

Hence, it is an important process to detect the sulphites present in the sugar making process and taking the necessary steps to eliminate them from the sugar-manufacturing process.

***Keywords*— Sulphites; processed foods; sugar; cobalt nitroprusside nanoparticles.**

I. INTRODUCTION

The sugar that is largely consumed across India is called,' Plantation White Sugar'. This 'Plantation White Sugar' is manufactured after operations such as affination, filtration and carbonation. It is because of these operations, the market gets flooded with the extra white, refined sugar. Most commonly, sulphur dioxide is used by sugar mills to lighten the colour of the molasses and extend its shelf life. This leads to residual sulphur remaining in the sugar in the form of sulphite, which is considered to be risky for human consumption and may cause health hazards towards sensitive individuals such as:

1. Dermatitis
2. Urticaria
3. Flushing
4. Hypotension
5. Abdominal Pain
6. Diarrhoea
7. Anaphylactic reactions

The sugar mills in India follow a process of double sulphitation for the plantation of white sugar. This causes the residual sulphur to be left behind in the manufactured sugar, which can be harmful to the human body. Traditionally, residual sulphur is removed by the method of evaporation and double distillation. This method leads to loss of yield and becomes uneconomical for the production of sugar. Moreover, the presence of residual sulphurous acid in the sugar, which is formed due to the reaction of excess sulphur dioxide with water after re-sulphitation of the unsulphured syrup obtained from the evaporator, increases the sulphur dioxide content of the sugar.

Hence, because of the health hazards being posed by the presence of sulphites in sugar, The Bureau of Indian Standard: 5982-1970, has kept the maximum sulphur dioxide content limit as 70 ppm, within the safe tolerance limit. For 'Plantation White Sugar' the safety limit has been fixed for 70 ppm and for refined sugar it has been fixed as 20 ppm. International Standard has fixed the safety tolerance limit at 10 ppm for refined sugar.

II. CRYSTAL STRUCTURE OF COBALT NITROPRUSSIDE.

The structure of Cobalt Nitroprusside, or as its chemical term refers to Cobalt Pentacyanonitrosylferrate, can be described as; the iron nucleus of the complex, octahedrally coordinated to five cyanide ligands and a nitrosyl group and the cobalt nucleus of the complex coordinated to 5 cyanide ligands and one water molecule. The cyanide ligands create a bridge (Fe-C≡N-Co) and link the metal centres. This provides a cubic framework and uncoordinated water molecules are held in position in crystallographically distinct environments by hydrogen bonding or van der Waals forces. This cubic framework characterizes unique vacancies and a high degree of disorder.

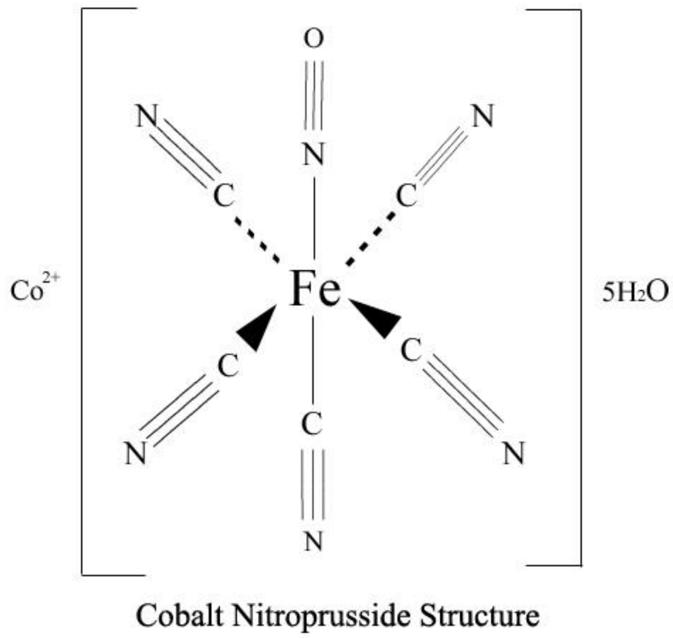

FIGURE 1: Properties of Nanoparticles Used

Recent globalization trends show that nanoscale metallic particles are being considered for their intriguing properties and potential application across various industries. Due to the large surface-to-volume ratio and superior properties of the nano-sized metal particles, these prove to be very useful candidates for electrochemical, food safety and catalytic studies than their bulk counterparts. The application of these nano-sized metallic particles involves the idea of carbon paste electrodes (CPE) being modified with nanoparticles. This method provides a considerably improved basis for the electrochemical behaviour in the respective compound.

In our case, Cobalt Nitroprusside nanoparticles (chemically referred to as Cobalt Pentacyanonitrosylferrate.). The ligand that forms the molecule mentioned above ([Fe(CN)5NO]2−) is an important one because of its ability to form complexes with most of the transitional metal ions. The advantage of nanoscale sizes factors in the improvement of dispersibility of Metal Nitroprussides in solvents.

The metal nitroprusside as stated above has to be modified into electrochemical sensors. This can be achieved by electrochemically coating the metal nitroprusside on the rigid electrode surface. According to some recent approaches, the CoNP nanoparticles have been used as a modifier in designing an electrochemical nanosensor for the quantification of sulphur. In this case, this CoNP nanosensor is used extensively for the detection of sulphites in sugar.

III. SYNTHESIS OF COBALT NITROPRUSSIDE

Cobalt nitroprusside synthesis can be achieved by three different procedures: 1. Drop-by-drop method, 2.sonication method, 3. bulk mixing method. This synthesized cobalt nitroprusside then has to be modified into catalytically oxidisable electrodes for the detection of sulphites. Out of the 3 methods mentioned above, according to Mr.S.Devaramani and Mr.P. Malingappa, drop-by-drop method shows the best catalytic activity.

The Cobalt Nitroprusside samples that are formed by the drop-by-drop method, sonication method and bulk mixing method have been designated as n-CoNP, s-CoNP, b-CoNP.

3.1 Drop By Drop Method

Through experiments conducted by Mr Devaramani and Mr Malingappa, the drop-by-drop method is initiated by using 10 m of the aqueous solution of 0.01 M sodium nitroprusside and added dropwise to 10 ml of 0.02 M aqueous solution of cobalt chloride. The thermostated beaker maintained at 5-10◦C, under vigorous stirring forms the turbid solution of cobalt nitroprusside complex. This turbid solution has to be then maintained in acidic condition and left untouched for 24 hrs. The supernatant liquid is then decanted and made to go through a routine process of centrifugation. The centrifuged compound of CoNP particles is then washed with water then alcohol and is now ready to be used as a modifying agent in carbon paste electrodes (CPE).

3.2 Electrode Preparation

The electrode preparation method specified by Mr Devaramani and Mr Malingappa proceeds by manually mixing dispersed graphite powder with the prepared n-CoNP at a 15:1 mass ratio. To this 38 % (m/m) of mineral oil has to be added. The resultant mixture has to be ground in an agate mortar for 10-15 minutes. This paste then has to be packed in a capillary tube and a copper wire has to be inserted from the opposite end to create an electrical contact. After being kept aside for 24 hrs, the electrodes would be ready for electrochemical sensing.

IV. MODIFIED CPE DETECTION OF SULPHITES

The n-CoNP CPE has to be tested for the detection of sulphite in a sample sulphite containing solution. According to the tests done previously, a solution of 0.5 KNO3 with the presence of 3.4 mM sulphite can be used for the detection of sulphite with the modified CPE. The CoNP nanoparticle here significantly improves the anodic current of the modified electrode in presence of sulphite. Hence, these CoNP nanoparticles are essential for the detection of sulphites in any sulphite containing solution.

V. USE OF THE N-CONP CPE IN THE DETECTION OF SULPHITE IN SUGAR

Sulphur dioxide remains an important constituent for sugar manufacture. It avoids browning of the raw sugar during the crystallization and evaporation process. It even prevents the enzymic oxidation of polyphenols and precipitation of calcium ions as calcium sulphite. This makes it important to the industries to take steps towards detection of sulphites in the sugar so that it does not exceed the parameters stated by National Legislations and adhere to the safety regulations set by the standard body of food safety in India, FSSAI (Food Safety and Standard Authority of India).

The steps towards the synthesis of sugar proceed as follows:

1. Obtaining a suitable carbohydrate source for extraction of its juice, eg. sugarcane, beet sugar, palm sap, etc.
2. Extraction of juice of the suitable carbohydrate source.
3. Sulphitation of the juice.
4. Post-sulphitation, the juice has to be settled to obtain clarity in the liquid.
5. Concentration of the juice to obtain syrup for the processing of crystallized sugar.

Here, the steps involved do not detect the sulphur content of the sulphitation undergone juice. The industries need to know the content of sulphur before concentration so that the sulphite content in it does not exceed the standard regulated 70 ppm for plantation white sugar or 20 ppm for refined sugar. Hence, the use of the n-CoNP CPE can be made to detect the amount of sulphite in sugar to ensure its treatment before being sent for concentration to syrup form.

The proposed reaction for the same will be given as follows:

$$2Co[Fe^{III}(CN)_5NO] + 2Ca^{2+} + HSO_3^{-} + H_2O \rightarrow 2KCo[Fe^{II}(CN)_5NO] + SO_4^{2-} + 3H^+$$

Steps for the desulphitation are proposed as follows:

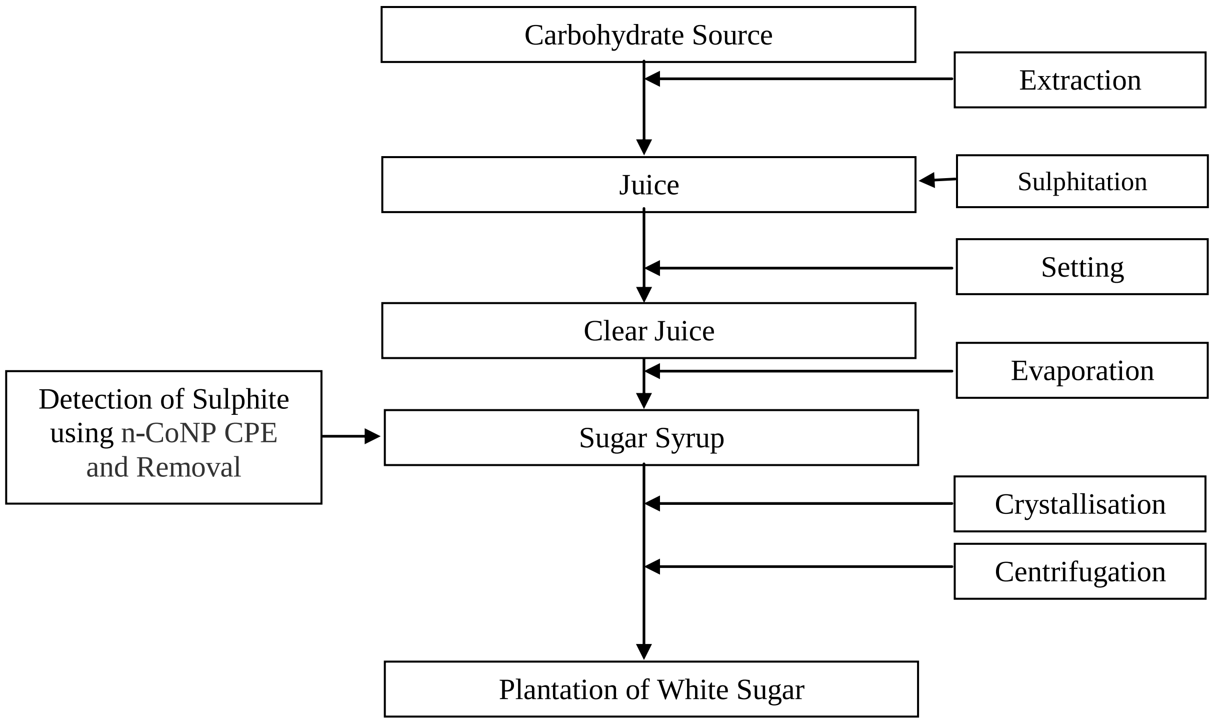

FIGURE 2: Steps for the desulphitation

Hence, using this methodology, the n-CoNP CPE can be effectively used for the detection of sulphur in sugar.

VI. CONCLUSION

Cobalt Nitroprusside is an important complex in the field of upcoming nanotechnology and nanoparticles. It is an extremely useful complex for the detection of compounds; sulphites, for instance. It has been used as a modifier in carbon paste electrode which in turn affects its electrochemical activity drastically. Even though the short term effects of sulphites are not usually an area of concern for the human body, its long term effects can be harmful. Alternate solutions like using the sonication method or bulk mixing method provide an insight on how the usage of Cobalt Nitroprusside nanoparticles in the detection of sugar can be modified. Having a low catalytic activity can even be preferable over a high catalytic activity producing CPE since the control over the process is more. The continued research in the removal of nanosensors and nanoparticles may also bring a change in the direction of our consumption of various products. Our review paper shall hopefully provide some knowledge to the researchers having an interest in the use of nanosensors and cobalt nitroprusside nanoparticles.

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