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Effect of sources and doses of Sulphur and Boron application on Yield, nutrient content and nutrient uptake of Groundnut (*Arachis hypogea L.*)

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Abstract— The field experiment was carried out at Regional Research and Technology Transfer Station (OUAT), Mahisapat of Dhenkanal district during kharif season of 2014 and 2015 to study the "Effect of different sources and doses of Sulphur and Boron application on Yield, nutrient content and nutrient uptake of Groundnut under Mid Central Table Land zone of Odisha". The experiment was laid out in randomized block design with three replications comprising of seven treatments T_1 - Soil Test Based Fertilizer Recommendation (STBFR), T_2 - STBFR + Sulphur @ 20kg /ha from Gypsum Source, T_3 – STBFR + Sulphur @ 40kg /ha from Gypsum Source, T_4 - STBFR + Sulphur @ 20kg /ha from Gypsum Source + spraying of Borax @ 0.3% twice before and after flowering, T_5 - STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source, T_6 - STBFR + Sulphur @ 40kg /ha from Bentonite Sulphur Source, T_7 - STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering. It was revealed that T_7 recorded significantly higher pod yield (17.14 q ha^{-1}), 100 kernel weight (38.93 g) and shelling percent (66.00) followed by T_4 with pod yield (15.80 q ha^{-1}), 100 kernel weight (37.60 g) and shelling percent (65.10). T_7 was superior over T_1 with the yield advantage of 24.2 % and B: C (2.10). The Concentration of nutrient N, P, K, S and B in the harvested pod was also found highest in T_7 i.e. 4.34 %, 0.70% , 0.88 %, 0.39% and 17.77 $mgkg^{-1}$ followed by T_4 having concentration of 4.26% ,0.66 % , 0.83 %, 0.35% and 17.23 $mgkg^{-1}$ respectively. The same treatment T_7 also recorded higher uptake of N, P ,K, S and B in pod with 79.47, 9.20 ,19.83,6.23 kg ha^{-1} and 31.43 g ha^{-1} respectively.

Key words: Sulphur, Boron, foliar spray, nutrient content, nutrient uptake

I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the important edible oil seed crop in the world belongs to Leguminoceae (Fabaceae) family. It is classified both as a grain legume and an oilseed crop, because of its high oil content. It is an unpredictable heavy feeder legume and is cultivated worldwide on almost all types of soil. It contains about 50% oil, 25-30% protein, 20% carbohydrate and 5% fibre and ash which make groundnut a rich source of nutrition (Fageria et al., 1997). It is also a valuable source of vitamins E, K and B. It is the richest plant source of thiamine and is also rich in niacin, which is low in cereals. It is a valuable cash crop cultivated by millions of small farmers throughout the world, because of its economic and nutritional value. In spite of recommended application of fertilizer (NPK – nitrogen, phosphorus, potassium) the yield does not reach the potential level (Sahu et al., 1999). One of the major constraints for low yield of groundnut relates to deficiency of micronutrients. Intensification of agriculture, usage of straight fertilizers, rising crop requirements due to increasing productivity levels have heightened the micronutrients demand in soil fertility management and are becoming major constraints to achieve agricultural production.

Sulphur is the fourth major nutrient and plays an important role in the nutrition of oil-seed crop and as a constituent of sulphur containing amino acids (Gangadhara *et al.*, 1990). They considered that the oil-seeds require more sulphur than other crops; its concentration and uptake vary with the availability of sulphur in soil. Singh (1999) reported that the application of sulphur increased the uptake of various macro and micro nutrients in groundnut. Non-application of sulphur in sulphur deficient soils has often resulted in low yield. Sulphur deficient plants have poor utilization of N, P, K and a significant reduction in sulphur content.

The role of S in plants is to help in the formation of plant proteins and essential for the formation of chlorophyll and improves root growth. Sulphur is involved in the formation of vitamins and enzymes required for the plant to conduct its biochemical processes (Scherer *et al.,* 2008).

Micronutrients often act as cofactors in enzyme systems and participate in redox reactions, in addition to several other vital functions in plants. Most importantly, micronutrients are involved in the key physiological processes of photosynthesis and respiration (Marschner, 2012). However, micronutrient deficiencies can result in great deal of limitation in the physiological and metabolic processes even if the plants need only small amount of micronutrient for satisfactory crop growth and production, (Nasiri *et al.*, 2010). Boron is the important micronutrient required by the plant for their growth and development. Boron has the ability to increase photosynthetic and enzymatic activity in plant; moreover, it causes pollen grain germination, pollen tube growth and viability of pollen grains. It was evident that application of B enhanced the seed and oil yields/ha and protein percentage in groundnut (Ramaprasad et al.,2020) Additionally, foliar spray enables plants to absorb the applied nutrients from the solution through their leaf surface and thus, may result in the economic use of fertilizer (Helmy et al.,2008). Keeping these in view, current study was carried out to evaluate the effect of sulphur application, foliar spray, B on groundnut yield, yield components, pod and haulm nutrient composition, as well as uptake of nutrient in Groundnut.

II Materials and methods:

A field experiment was conducted at Regional Research and Technology Transfer Station situated at Mahisapat of Dhenkanal district in Mid Central Table Land Zone of Odisha under Odisha University of Agriculture and Technology during *kharif* season of 2014 & 2015. The farm is located in the geographical parallels between 20^0-3'and 21^0-16' North latitudes and 84^0 and 86^0-6' East longitude. The important soil groups of the zone are alluvial (Entisol), black (Vertisol), red-laterite (Alfisol) and lateritic (Oxisol). The soil of experimental site was red, sandy loam in texture & acidic in reaction (pH=5.58), Organic carbon (0.60%) with available N (250 kg ha^{-1}), available P_2O_5 (16.0 kg ha^{-1}), available K_2O (180 kg ha^{-1}), available B- 0.2mg/kg & available Sulphur-16.0 kg/ha. The experiment was laid out in RBD with seven treatments and three replications. The detailed of the treatments are as follows. T_1 - Soil Test Based Fertilizer Recommendation (STBFR), T_2 - STBFR + Sulphur @ 20kg /ha from Gypsum Source, T_3 – STBFR + Sulphur @ 40kg /ha from Gypsum Source, T_4 - STBFR + Sulphur @ 20kg /ha from Gypsum Source + spraying of Borax @ 0.3% twice before and after flowering, T_5 - STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source, T_6 - STBFR + Sulphur @ 40kg /ha from Bentonite Sulphur Source, T_7 - STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering. The crop was sown with seed rate of 150 kg ha^{-1} with a row spacing of 30 cm. The intra-row spacing of 10 cm was maintained by thinning operation. The thinning & weeding operations were carried out on 15 & 21 days after sowing. The soil test dose (30:40:40 N, P_2O_5 & K_2O kg ha^{-1}) was applied to the crop as per treatment. Full dose of P, K & ½ N in form of DAP, MOP & Urea respectively were applied as basal and rest ½ N after three weeks of sowing. The crop was harvested at physiological maturity.

Five plants were randomly selected from each plot in such a way so that border effect could be avoided. Initial soil samples were collected following the procedure and analysed as per the standard method. The kernels and stovers were kept separately in paper envelopes, labelled properly and dried in hot air oven at 60ºC. Each sample was ground separately with the help of a Willy Mill to pass through 20 mesh sieve and was used for analysis of different nutrient elements. As per the method outlined by Piper (1950), 1 g of ground grain sample was pre-digested with 20 ml of concentrated HNO_3 followed by digestion with 10 ml of diacid (HNO_3 : $HClO_3$) on hot plate at 100°C for analysis of elements like P, K, S and B. However, the element N was estimated by taking H_2SO_4 in place of HNO_3. After suitable dilution of the aliquot, the samples were analysed by standard methods specific for particular nutrient element (Piper, 1950). From the nutrient content, uptake of nutrients were calculated by multiplying its value with the biomass or yield of the crop. Crop yield and nutrient analysis data were recorded and compiled. The statistical analysis was done as per the procedure given by Gomez and Gomez, 1984. The nutrient uptake was calculated by adopting the formula given below (Pradhan *et al.*, 2019).

Nutrient Uptake (kg ha^{-1}) = Dry matter (q ha^{-1}) x Nutrient concentration (%)

III Results and discussion:

Combined effect of B and S nutrition on growth and yield attributes in Groundnut

The treatment T_7 (STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering) recorded higher plant stand (260), number of branches per plant

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(7.00) , number of pods per plant (22.51) and 100 kernel weight (38.93g) followed by T_4 (STBFR + Sulphur @ 20kg /ha from Gypsum Source + spraying of Borax @ 0.3% twice before and after flowering) having plant stand (251), number of branches per plant(6.00 nos.), number of pods per plant (20.42 nos.) and 100 kernel weight (37.60g) respectively. The positive effect of B application on groundnut yield components is in harmony with that obtained by Noor *et al*., (1997) and Khalifa (2005) who stated that pods yield and some yield components, i.e. number of pods /plant, 100 seed weight were significantly increased with foliar application of B as compared with STBFR (Table 1). B has an essential role in plants where it plays a role in plant metabolism and in the synthesis of nucleic acid. This result also confirms with the findings of Abd EL-Kader *et al*, 2013.

Combined effect of B and S nutrition on Yield and Economics in Groundnut

From the result it was revealed that T_7 (STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering) recorded significantly higher pod yield (17.14 q ha^{-1}) with a yield advantage of 24.2 % over STBFR. T_4 (STBFR + Sulphur @ 20kg /ha from Gypsum Source + spraying of Borax @ 0.3% twice before and after flowering) also recorded yield of 15.80 q ha^{-1}respectively. Similarly T_7 and T_4were superior over the treatments with higher % shelling of (66.00) and (65.10) respectively. Du Ying Qiong *et al.,* (2002) reported that application of B significantly enhanced chlorophyll content and photosynthetic intensity of the leaves, increased dry matter accumulation of the plants, advanced their flowering and promoted the transport of the photosynthesis from the vegetative organs to the reproductive organs, thus resulting in significant improvement of the groundnut yield.

The highest B: C (2.10) was obtained from T_7 (STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering) followed by T_4 (STBFR + Sulphur @ 20kg /ha from Gypsum Source + spraying of Borax @ 0.3% twice before and after flowering) having B: C value of 2.00. However, the lowest B: C was indicated under the treatment only with STBFR (1.75).

Table – 1 :Yield and yield attributing characters of Groundnut Var. Devi as affected by different doses of Sulphur and Boron application

Tr. No.	Plant stand	Days to flowering	Branches /Plant (no.)	Pods / Plant (no.)	100 kernel Wt. (gm)	Pod yield (q /ha	Shelling (%)	% Increase in Yield	B:C
T_1	216	24.33	6.00	14.88	34.20	13.80	62.10	-	1.75
T_2	231	24.80	5.00	16.28	35.50	14.20	62.80	2.9	1.86
T_3	207	24.33	7.00	18.67	36.80	14.90	63.40	8.0	1.94
T_4	241	24.33	5.00	20.12	37.10	15.80	64.80	14.5	2.00
T_5	246	24.67	6.00	19.61	36.40	14.50	63.90	5.1	1.86
T_6	251	24.17	5.00	20.42	37.60	15.70	65.10	13.8	1.98
T_7	260	24.67	7.00	22.51	38.93	17.14	66.00	24.2	2.10
S.E.m (±)	4.136	-	0.939	0.278	0.415	0.240	0.28	-	-
CD at 5 %	12.54	NS	2.847	0.843	1.260	0.727	0.87	-	-

Effect of B and S on Nutrient content and uptake by groundnut

Data from Table (2-6) indicated that application of sulphur fertilizer and foliar spraying of B increased significantly the nutrient content of N, P, K, S and B in groundnut pod and haulm as compared to the T_1 (STBFR). Combination of sulphur and micronutrient B had marked influence on nutrient uptake. Application of sulphur and boron recorded the higher uptake and was significantly superior and at par with treatments receiving only sulphur. This trend might be due to increased growth and growth components, total dry matter production and yield and yield components. Combined application of sulphur and B attributed higher content of K which helped in better absorption and translocation which was confirmed with Babhulkar *et al.,* (2000). The highest sulphur content was found when sulphur was applied and the lowest from no sulphur application. These results are in agreement with Ganeshamurthy (1996) who reported that sulphur application significantly increased the sulphur uptake. Von Uexkull, (1986) who found that Sulphur availability may influence photosynthetic rate since ferredoxin and acetyl-CoA contain S and play a significant role in the reduction of CO_2 and production of organic compounds. Also, sulphur is necessary for enzymatic reactions, chlorophyll formation, synthesis of certain amino acids and vitamins, hence, it helps to have a good vegetative growth leading to have a high yield (Marschner, 1998). The foliar application of micronutrient B on groundnut provided high values of N, P and K uptake in groundnut seed and halum with significant improvement over T_1 (STBFR).These increases in elemental constituents of seed may be due to the effect of B on stimulating biological activities, i.e. enzyme activity, chlorophyll synthesis, rate of translocation of photosynthetic products and increased nutrient uptake through roots after foliar fertilization. Such improvement could be explained by the role of this nutrient in increasing adsorbing surface of the root and transportation of the nutrients from the soil to plant organs via the roots. Similar results were obtained by Shaban *et al*., (2010). Application of sulphur, and B together significantly increased the nutrient uptake and produced the highest content of nitrogen, phosphorus, potassium and sulphur in seeds. The treatment T_7 (STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering) recorded higher uptake of N, P, K, S and B in pod with 79.47, 9.20, 19.83, 6.23 kg ha^{-1} and 31.43 g ha^{-1} respectively followed by T_4 (STBFR + Sulphur @ 20kg /ha from Gypsum Source + spraying of Borax @ 0.3% twice before and after flowering) having N, P, K, S and B with 73.30, 8.17, 19.27, 5.8 kg ha^{-1} and 30.00 g $ha^{-1.}$

Highest concentration of boron content were recorded in treatment receiving combined application of sulphur and boron which was significantly superior to T_1 (STBFR). This may be attributed to the enhancement of assimilation and translocation from the leaves to seeds. These results are further supported by the findings of Abd El-Hady, (2007)),who mentioned that foliar application of micronutrients led to an increase in concentrations of macro and micronutrients in groundnut seeds and this is mainly due to the vital physiological roles in plant cells which promote the uptake of plant nutrients. The Concentration of nutrient N, P, K, S and B in the harvested pod was also found highest in T_7 i.e. 4.34 %, 0.70% , 0.88 %, 0.39% and 17.77 $mgkg^{-1}$ followed by T_4 having concentration of

4.26% ,0.66 % , 0.83 %, 0.35% and 17.23 $mgkg^{-1}$ respectively

Table 2: Effect of S and B on N content and uptake by groundnut

Treatments	Content (%)		Uptake Kg/ha	
	Pod	Haulm	Pod	Haulm
T_1	3.35	1.15	58.50	21.07
T_2	3.54	1.22	61.70	23.63
T_3	3.70	1.26	62.23	26.57
T_4	4.26	1.48	73.30	35.30
T_5	3.96	1.32	66.60	29.33
T_6	4.10	1.41	69.27	32.17
T_7	4.34	1.57	79.47	37.87
S.E.m(.±)	0.08	0.02	0.63	0.70
C.D at 5 %	0.24	0.07	1.93	2.16

Table 3: Effect of S and B on P content and uptake by groundnut

Treatments	Content (%)		Uptake Kg/ha	
	Pod	Haulm	Pod	Haulm
T_1	0.48	0.24	4.00	1.90
T_2	0.52	0.26	5.07	2.30
T_3	0.55	0.29	5.83	2.92
T_4	0.66	0.40	8.17	4.43
T_5	0.60	0.32	7.00	3.35
T_6	0.64	0.35	7.77	3.83
T_7	0.70	0.43	9.20	5.17
S.E.(m.±)	0.01	0.01	0.18	0.08
C.D at 5 %	0.03	0.04	0.55	0.24

Table 4: Effect of S and B on K content and uptake by groundnut

Treatments	Content (%)		Uptake Kg/ha	
	Pod	Haulm	Pod	Haulm
T_1	0.57	0.38	16.10	11.00
T_2	0.66	0.42	17.00	11.50
T_3	0.71	0.48	17.43	12.43
T_4	0.83	0.62	19.27	14.57
T_5	0.75	0.52	18.07	13.33
T_6	0.78	0.60	18.80	14.20
T_7	0.88	0.68	19.83	15.27
S.E.(m.±)	0.02	0.01	0.17	0.17
C.D at 5 %	0.06	0.04	0.53	0.54

Table 5: Effect of S and B on S content and uptake by groundnut

Treatments	Content (%)		Uptake Kg/ha	
	Pod	Haulm	Pod	Haulm
T_1	0.20	0.15	3.53	1.9
T_2	0.22	0.18	4.00	2.3
T_3	0.25	0.20	4.33	2.92
T_4	0.35	0.27	5.8	4.43
T_5	0.28	0.21	4.57	3.35
T_6	0.31	0.25	5.00	3.83
T_7	0.39	0.29	6.23	4.90
S.E.(m.±)	0.02	0.01	0.12	0.07
C.D at 5 %	0.05	0.03	0.38	0.20

Table 6: Effect of S and B on B content and uptake by groundnut

Treatments	Content (mg/kg)		Uptake g/ha	
	Pod	Haulm	Pod	Haulm
T_1	14.47	10.50	24.27	19.63
T_2	15.23	11.00	26.00	20.73
T_3	15.97	11.23	27.10	21.67
T_4	17.23	12.77	30.00	25.23
T_5	16.37	11.77	28.17	22.50
T_6	16.87	12.00	29.40	23.50
T_7	17.77	13.10	31.43	26.83
S.E.(m.±)	0.15	0.14	0.40	0.33
C.D at 5 %	0.45	0.44	1.25	1.01

Conclusion: From the experimental finding it was revealed that STBFR + Sulphur @ 20kg /ha from Bentonite Sulphur Source + Spraying of Borax @ 0.3% twice before and after flowering recorded the higher pod yield of 17.14 q ha^{-1} and B: C of 2.10 with yield advantage of 24.2 % over STBFR. The same treatment recorded higher uptake of N, P, K, S and B both in pod and Haulm with (79.47 &37.87), (9.20 &5.17), (19.83 &15.27), (6.23 &4.90) kg $ha^{-1}$and (31.43 &

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26.83) g ha^{-1}respectively.The same treatment also recorded higher concentration of N, P, K, S and B both in pod and Haulm with (4.34 &1.57), (0.70 & 0.43), (0.88 &0.68), (0.39 & 0.29) % and (17.17 & 13.10) mg kg^{-1}respectively.

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For the Fish meat aquaculture is a promising option, fish consumption will permit a significant amplify by 2050 [1]. For different conditions it will be implementing. Different type of amenities are developed in ocean even though some facilities available in inland. To eliminate the turbidity, filters can be used in water entrance then the negative effectives of turbidity are reduced for improving fish performance [3]. Usually not modified the parameters of water temperature and water conductivity but it are possible to modify. The parameters of water are conductivity and temperature can alter the feeding necessities of fish held in reserve in the tanks [2].

The main aim of this work is to monitor water quality in aquaculture tanks by using low-cost wireless sensor. to determine different parameters of water the systems is collected of different sensors. the parameters are temperature, turbidity, or conductivity, among others. for organize the different parameters in fish tank by using nodes. the server receives the statistics from access point (ap) that are linked by nodes. in the internet and on the local area network data is available.

II. RELATED WORK

For water quality monitoring few authors given dissimilar systems. Water superiority monitoring and fish performance monitor be vital toward acquire better effectiveness of aquiculture. Wireless Sensor Networks (WSN) has grown to be a justification for the water feature monitor. Francisco J. Espinosa-Faller et al. explained in [4] a WSN-based water monitoring arrangement. In this method Zig-Bee is used to drive the information collect by the sensors from the recirculation group. Temperature, pressure, and dissolved oxygen be measured all the manner through the date. While a problem was detected, an SMS was forward to alert the person liable for the ability. Another

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WSN-based water monitoring system was presented by Mingfei Zhang et al. in [5]. Finally, messages were forward via SMS or graphical mechanism flash to the users. The water eminence check collection accessible by Daudi S. Simbeye et al. in [6] measured water pH, level, temperature, and dissolved oxygen and engaged ZigBee to advance an in sequence. In addition, more than a little experiments concerning message presentation, battery performance and sensor readings to be performed more than a time of six months. Xiuna Zhu et al. explained [7] a water importance monitoring system for fish farms. It employed artificial neural networks (ANN) to expect water quality to stop losses. The information was next forwarded to a server to be rather access. Gianni Cario et al. presented [8] fish ponds water quality monitoring system. Likewise, energy spending was compact employ original snooze plus acquires positive mechanisms.

The systems for water eminence monitoring evaluate the same parameters not allowing for other significant factors to monitor such as the turbidity of the water. In addition, many of the papers do not specify which sensors they have utilized, or they employ expensive sensors, resulting in a high-cost system that is complicated to execute in fish farms with few resources. In this job, we present a low-cost water brilliance monitoring system.

III. MATERIALS AND METHODS

In this section, the structural design of the projected system is offered and the engaged significant sensors and its conditioning circuits are described.

Architecture: The formation is based on sensors for monitoring unlike parameters such as water quality, tank parameters and moisture inside the node boxes. The three nodes are monitoring in each tank at dissimilar parts of the tank. The working nodes send the information wirelessly to the access points. The substantial topology is shown in Figure 1. dissimilar box nodes are positioned in some points of the services. The nodes are wirelessly connected to the access point using Wi-Fi technology.

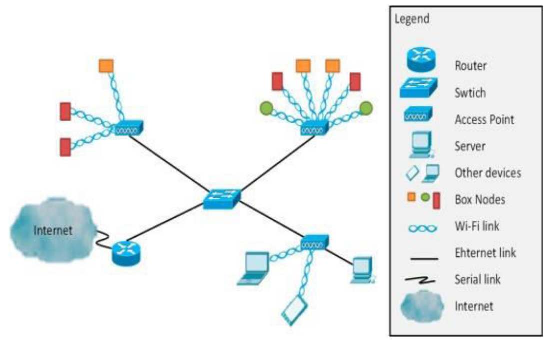

Fig 1. Network topology proposed.

The Access Points are coupled to the switch with an Ethernet link. Several Access Point s are positioned at dissimilar points of the amenities; a few of them are located in the rooms with the production tanks. Staff receive the signal if any alarm message are generated from the Access Point. Finally, the switch is linked to a router to have internet access with a serial connection.

The structural design of the whole systems is shown in Figure 2, together with the folder and the neat algorithms functional in the cloud. The figure 2 shows the location of the sensor and box nodes in the fish ponds. All the sensors are located in box nodes. In addition, the box nodes contain humidity sensors also. In usual situation, the nodes sense the signals and send the information to the documentation.

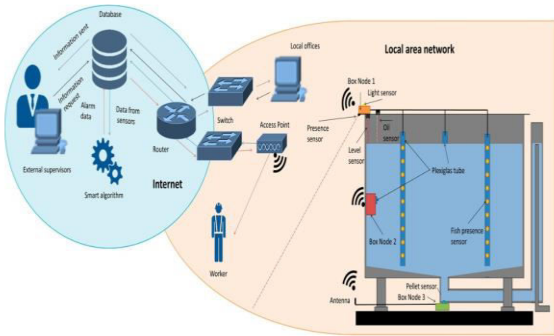

Fig 2. Architecture of the proposed system.

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Water Parameters: Here demonstrate the engaged sensor for temperature monitoring. Here the thermistor type negative temperature coefficient was employed. The advantage of the Negative Temperature Coefficient is the linear relationship sandwiched between resistance and temperature. The employed NTC is the NTCLE413E2103F520L.

To find out the turbidity by using two main methods these are acoustic and optical methods. Here we are using the optical method. It is composed of an IR light emitting diode (LED) and an IR photo detector. The IR photo detector offers a fast response, Turbidity increases when the resistance of the photo detector decreases. The relationship between these two is linear. However, the expected values of turbidity in fish farms are low. Only in adverse conditions the turbidity values can increase. The turbidity sensor can be seen in Figure 4.

Node: To collect the data from all sensors, we have selected a compatible Arduino Mega 2560 module. This microprocessor board has 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports), 16 MHz crystal oscillator, USB connection, power jack, In-Circuit Serial Programming (ICSP) connector and reset button. Here we are using Wi-Fi module ESP8266 ESP-01 [9] and a micro SD card reader which will be connected to our microprocessor module as shown in Figure 3.

IV. Results and Discussion

Here we are expose all the sensor result for quality of water in the fishponds are shown. For operation in the system, it is necessary to obtain the data as the output voltage (V_{out}) that arrives at the node. From the NTC, based on the data offered by the manufacturer it is possible to extract the expected resistances at different temperatures. To increases the difference of V_{out} min and max values of NTC resistance a voltage divisor must be used. An R_2 of 12 KΩ must be used and the NTC is used as R_1. We can calculate the V_{out} of the NTC at different temperatures. The data and the mathematical model that follows this data are presented in Figure 4. The relation between V_{out} and NTC temperature can be seen in the below equation (1). The correlation coefficient of equation (1) is 0.9995. The formula that relates the temperature and the volt-temp value is extracted from Equation (1).

$$Temperature\ (^{\circ}C) = 0.0309 \times V_{out}\ (V) + 1.1947 \quad (1)$$

Using the V_{in} of 3.3 V the infrared photo detector as R_1 and R_2 of 6 MΩ increase the difference between the max and min V_{out}. The data after applying the voltage divisor and the mathematical model that adjust to this data are presented in the Figure 5.

$$Turbidity = 1764.5 + 1032.4 \times V_{out}^2 - 2746.5 \times V_{out} \quad (2)$$

The node resolution was consider, the min variation of turbidity that can be detected by the turbidity sensor goes from 1.8 NTU in low turbidity circumstances to 4 NTU in high turbidity circumstances. The formula that relates the turbidity and the volt-turb value is obtained from concerning the data shown in Figure 5.

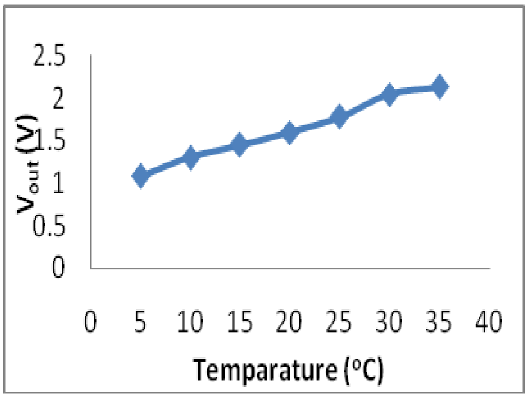

Fig 4. Temperature sensor data.

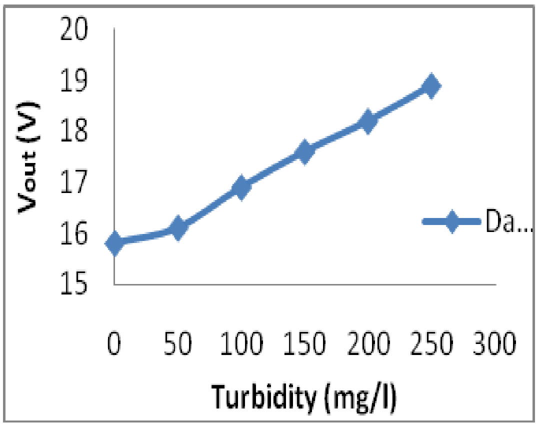

Fig 5. Turbidity sensor data.

V. Conclusions

The arrangement can control the changes in water parameters throughout the feeding procedure. Temperature, conductivity and turbidity are the monitored water parameters. All the sensors are designed and calibrated for their appropriateness for the aquaculture monitoring has been showing. Neat algorithms were deliberate to moderate the use of energy in the information transmission from the node to the database.

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