**Impact of inorganic nitrogenous fertilizers and farmyard manure combinations on yield and soil properties of medium land rice (*Oryza sativa* L.): A review**

**ABSTRACT**

As a cereal grain, rice is the staple diet of more than half of the world's population, especially in Asia and Africa. The grass species oryza sativa, also known as Asian rice, and, less frequently, oryza glaberrima, sometimes known as African rice, are the seeds of rice. African rice was domesticated in Africa approximately 3,000 years ago, while Asian rice was domesticated in China between 13,500 and 8,200 years ago. A staple in many cultures around the world, rice ranked fourth in terms of production in 2021 (787 million tons), behind wheat, maize, and sugarcane. The amount of rice traded worldwide is only about 8%. The three countries that consume the most rice are China, India, and Indonesia. Various rice cultivars have been developed to increase crop yield and quality. Green Revolution rice, made possible by biotechnology, can yield large amounts of grain when given nitrogen fertilizer and carefully tended. Additional products include flood-tolerant or deep-water rice, drought-tolerant and salt-tolerant rice, and rice that may express human proteins for therapeutic purposes. In biology, rice is utilized as a model organism.

**Keywords:** Rice, Deep-water, Fertilizer, Countries

**1. INTRODUCTION**

One of the most significant cereal crops in the world is rice (*Oryza sativa L*.). Over 70% of the world's population eats it as a staple diet. Around 155.62 million hectares of land are used to grow rice worldwide, with yields of 461 million tons and 4.09 t ha-1 respectively. Drought and water scarcity are two major factors restricting rice production globally as a result of ongoing climate change. Iron (Fe) and aluminum (Al) toxicity, phosphate (P) shortage, reduced biological activity, poor base saturation, and other acidity-induced issues with soil plant nutrition and fertility are the key factors limiting Odisha soil productivity. One of the primary factors influencing rice production is nitrogen (N), and low crop nitrogen recovery in these troublesome soils necessitates a sustainable nitrogen management strategy to boost yield and improve use efficiency. Therefore, a combination of both inorganic and organic fertilizers is the ideal way to regulate soil fertility, with the inorganic fertilizer providing nutrients and the organic fertilizer primarily increasing soil organic matter, improving soil structure, and increasing the soil's buffering ability, (Jobe, 2003). 4.18 million hectares of rice are grown in Odisha, with an average yield of 1815 kg ha-1 and an annual production of 7.58 million tons. Odisha accounts for 8.51% of the nation's total gross area under rice cultivation. However, compared to the national productivity, its productivity is 33.55% lower, (GOI, 2014). The state economy is directly linked with improvements in production and productivity of rice in the state (Das, 2010). Although this is typically relatively modest, a significant amount of nitrogen in rice soils occurs in the organic pool. Conclusive research suggests that increasing the soil's organic carbon content, initial soil nitrogen concentration, and applied fertilizer efficiency are more crucial for the development of irrigated rice. Although rice consumes a lot of nitrogen, its fertilizer N efficiency in tropical climates is extremely low, seldom exceeding 50% and typically falling between 15% and 35%. (De Datta *et al*.,1983). Without applying organic amendments, the years-long use of inorganic fertilizers in rice fields changed the structure of the soil and reduced its fertility, Sannathimmappa *et al.,* (2015).

2. **Effect of organic and inorganic sources of nutrients on growth parameters and yield of rice**

Dutta and Sangtam (2014) revealed that plant height, numbers of tillers and productive tillers increased significantly in all the treatments whereas, grain yield increased significantly in all the treatments. Kumar *et al.,* (2017) revealed that using poultry manure in combination with urea, zinc, and other nutrients increased the amount of organic carbon, accessible N, P, K, and S in the soil beneath rice plants considerably more than using chemical fertilizer alone. The residual soil fertility significantly improved in the plots that had been treated with chemical fertilizers and poultry manure. It is also possible to draw the conclusion that using poultry manure performs better than applying manure alone. The combination of chemical fertilizers and organic manure increased the uptake of N, P, and K compared to the control.

Integrated nutrient management practice including FYM and recommended dose of NPK showed as best treatment with respect to growth and yield parameters like plant height, panicle length number of tillers and effective tillers, and grain test weight as compare to other treatments. The grain (46 q ha-1) and straw (51.3 q ha-1) yield of rice was registered higher in treatment (100% NPK+5 t FYM+ ZnSO4@25kg ha-1 + Lime 3 q ha-1), followed by treatment (100% NPK+5 t FYM+ ZnSO4@25kg ha-1)with 44.8 and 50.2 q ha-1yield and lowest in control treatment(24.5 and 37.5q ha-1) ([Sahu](http://krishikosh.egranth.ac.in/browse?type=author&value=Sahu%2C+Poornima) P, 2017). (Manimaran and Prakash, 2018) found that, in comparison to other treatments, the 100% recommended dose of NPK kg ha-1 (120:38:38) with soil application of 25 kg ha-1 of Beema green granules at 20 DAT, foliar spray of pancha-gavya 3% at 30 DAT, and foliar spray of 750 ml ha-1 of Nitrobenzene at 45 DAT increased the growth parameters of rice, including plant height, number of tillers per hill, LAI, and DMP. When compared to other treatments, the optimum treatment for growth and yield characteristics such as plant height, panicle length, number of tillers and effective tillers, and test weight was an integrated nutrition management strategy that included FYM and the recommended dosage of NPK.The grain (46 q/ha) and straw (51.3 q ha-1) yield of rice was registered higher in treatment (100% NPK(100:60:40 kg ha-1)+5 t FYM+ ZnSO4@25kg ha-1 + Lime 3 q ha-1 ) followed by treatment (100% NPK+5 t FYM+ ZnSO4@25kg ha-1 ) with yield 44.8 and 50.2 q ha-1respectively and lowest in control treatment (24.5 and 37.5 q ha-1). Additionally, the findings imply that the rice production, soil fertility, and soil physical and chemical environment were all improved by the addition of organic manure (FYM) to inorganic fertilizer, Sahu *et al*., (2018).

**3. Effect of organic and inorganic sources of nutrients on N, P, K uptake in grain and straw of rice**

Ranjitha *et al.,*(2013) The application of 50% of the recommended dose of nitrogen (through urea) and the remaining 50% of RDN through vermi-compost led to significantly higher grain (5520.8 kg ha-1) and straw yield (6264.9 kg ha-1) in addition to nutrient uptake (157.9, 30.7, and 166 N, P, and K kg ha-1, respectively). This was observed when the various nutrient management options were examined. Bahadur *et al.,*(2012) revealed that, in comparison to RDF alone and its organic mixtures, rice's uptake of N, P, and K was higher when a higher nitrogen dose was applied together with zinc and RDF in conjunction with farm yard manure and bio fertilizers. The application of 1/3 N each of chemical fertilizer, FYM, and *Azolla* produced the maximum rice yield; however, 50% N of chemical fertilizer and 50% N of dhaincha were shown to increase K uptake. (Mohanty *et al.,*2013).When combined, the use of both organic and inorganic nutrition sources significantly improved rice yield, yield characteristics, and nutrient uptake. When compared to other treatments, yields, yield characteristics, and nutrient uptake were significantly greater for 125% RDF + 5 tha-1 vermi-compost, followed by 100% RDF + 5 tha-1 vermi-compost. The number of panicles (20.50%), panicle length (23.12%), panicle weight (13.02%), 1000 grain weight (12.90%), grain yield (31.15%), straw yield (37.12%), protein content (18.77%), N uptake in grain (36.81%) and straw (42.81%), P uptake in grain (32.62%) and straw (31.56%), and K uptake in grain (35.46%) and straw (25.39%) were all higher than the control group when 125% RDF + 5 tha-1 vermi-compost was added. The control group had a poorer yield, yield characteristics, gross return, and nutrient uptake. (Kumar *et al.,* 2014).( Puli *et al*., 2017)The results of experimentation revealed that significantly higher nitrogen phosphorus and potassium uptake (131.32, 26.95 and 113.07 kg ha-1 respectively) was observed with application of RDF + Vermi-compost + PSB + 25% Nitrogen through Glyricidia and also higher available nitrogen (269.40 kg ha-1 ) available phosphorus (86.95 kg ha-1 ) was observed with the application of RDF + Vermi-compost + PSB + 25% Nitrogen through Glyricidia. However, it was followed by the application of RDF + FYM + PSB + 25% Nitrogen through Glyricidia (262.62 kg ha-1 ) (Kumar *et al.,* 2018)

**4. Effect of organic and inorganic sources of nutrients on physico-chemical properties of soil**

(Kannan *et al,.* 2013) Bulk density and pore space were found to be at their highest in INM practice, which included vermi-compost and the recommended dosage of NPK. The FYM treatments had the highest reported particle density. The highest amount of organic carbon was found in the INM treatment, which included vermin-compost and the suggested dosage of NPK.(Zayed *et al.,* 2013) claimed that in terms of their capacity to raise soil organic matter content and soil nutrient availability, the applications of 7 t ha-1 farmyard manure + 110 kg Nha-1 and 5 t ha-1 rice straw compost + 110 kg Nha-1 were equivalent and both were superior to the use of chemical nitrogen fertilizer alone. (Rao *et al.,* 2013) reported that pH of soil was not influenced statistically by various treatments. The continuous use of manures and fertilizer slightly lowered the pH. Increased dose of fertilizer decreased the pH. (Yaduvanshi *et al.* 2013) The SOC increased in plots receiving N120 P26 K42 plus green manure (GM) andN120, P26, K42 plus farmyard manure (FYM) by 28 and 23%over the initial value but decreased by 31 and 24% in unfertilized and N120, P26, K42 treated plots, respectively. (Lungmuana *et al.,* 2013) reported chemical fertilizers and vermi-compost furnished the highest amount of available phosphorus in the rhizosphere and produced the highest rice grain yield. These parameters were found to be significantly and positively correlated. Application of S (40 kgha-1), Zn (5 kg ha--1) and B (1.5 kg ha--1) along with NPK (120:60:60) in rice with other treatments RDF + S, Zn, B (40:05:1.5 kg ha--1), customized fertilizer with composition of N:P:K:Zn:B;11:32:13:0.9:0.24% @ 312.5 kg ha--1, 75% RDF + 25% N through sewage sludge, 75% RDF + 25% N through vermi-compost, 75% RDF + 25% N through Sesbania indicated that application of Sesbania perhaps increased N, P, B and Zn in soil while inorganic S, B and Zn fertilizers had residual effect in post-harvest soil (Gour *et al*., 2015).Application of FYM (1/3) + vermi-compost (1/3) + green leaf manure (1/3) equivalent to 100 kg recommended N ha-1 with recommended FYM (5 t ha-1) + microbial consortium with soil application of bio digester @ 2500 l ha-1 at 30, 60 and 90 DAS recorded higher organic carbon (5.97 g kg-1), available soil nitrogen (310.46 kg ha-1), phosphorus (30.90 kg ha-1), potassium (328.16 kg ha-l) and sulphur (15.16 ppm) in soil after harvest of rice under aerobic cultivation(Basha and Basavarajappa 2015). The results revealed that highest organic carbon, cation exchange capacity, available and total nitrogen, phosphorus, and potassium were recorded where organic, inorganic and biofertilizers were applied conjunctively (Singh and Dubey 2018). The application of NPK along with organic residues increased the pH, EC, organic carbon. The content of available S and Ca improved significantly over the control. The content of S and Ca ranged from 16.87 to 30.41ppm and 141.87 to 268.53 ppm, respectively at the surface layer and 15.07 to 22.51 ppm and 108.21 to 308.61 ppm, respectively at the sub-surface layer. The partial replacement of N through FYM, wheat straw and mung straw caused significant improvement in soil physico-chemical properties. In all the treatments of sub-subsurface layer nutrient status decreased as compared to surface layer except in case of pH, bulk density and Calcium. The treatment where 25 percent N was applied through FYM and 75 percent through NPK fertilizer and the other treatment where 50 percent N was applied through mung straw and 50 percent through NPK were found best among all the treatments (Bhatt *et al.,* 2019)

**5. Effect of organic and inorganic nutrient sources on** **available nutrient content of soil**

(Singh *et al.,* 2006) found that applying vermi-compost had the largest amount of accessible phosphorus, followed by FYM, green manuring, and residue incorporation. Due to the production of CO2 and organic acids during decomposition, which assisted in solubilizing the native soil P, the soil's accessible p content rose. Urkurkar *et al.,* 2010 claimed that using farmyard manure, composted rice straw, and green manure along with 50% of the prescribed fertilizer dosage greatly raised the soil's accessible P content compared to the starting value and control. Shilpashree *et al.,*2012 studied the effect of different nitrogen sources on yield and revealed that lower available nitrogen status was recorded in the treatments which received nitrogen only through fertilizers and without any organic matter application (196.00-200.50 kg ha-1) including absolute control compared to all other treatments (238.00-243.60 kgha-1). Kumar *et al.,* 2018 observed that higher available nitrogen (269.40 kg ha-1) available phosphorus (86.95 kg ha-1) was observed with the application of RDF + Vermi-compost + PSB + 25% Nitrogen through Glyricidia. However, it was followed by the application of RDF + FYM + PSB + 25% Nitrogen through Glyricidia (262.62 kg ha-1).

6. **Effect of organic and inorganic sources of nutrients on** **microbial activities and population in soil**

Basha *et al.,* 2016 reported higher soil microbial population viz., N fixers, PSB, spp. and soil enzyme activity of dehydrogenase and phosphatase at flowering and harvest with the application of FYM (1/3) + vermi-compost (1/3) + green leaf manure (1/3) equivalent to RDN of 100 kg ha with recommended FYM (5 t ha-1 ) and microbial consortium ( + PSB) with soil application of bio-digester in aerobic rice. Liu *et al.,* 2017 described that organic amendments (NPK + pig manure) produced more favorable effects on soil productivity and exhibited the highest levels of nutrient availability, microbial biomass carbon (MBC), activities of most enzymes and the microbial community. This resulted in the highest soil quality index (SQI) and rice yield, indicating better soil fertility and quality. Significant differences in enzyme activities and the microbial community were observed among the treatments also. Goutami *et al.,* 2018 reported highest enzyme activity was observed with application of 100 % NPK + ZnSO4 +FYM (both Kharif and Rabi) which was significantly superior over remaining treatments. The application of zinc did not show any significant effect on enzyme activity. Raghavendra *et al.* 2018 reported highest phosphatase activity (14.91 μg PNP g-1 soil hr-1) of soil with application of nutrients as per targeted yield approach as compared to absolute control (9.47 μg PNP g-1 soil hr-1). Application of nutrients as per site specific nutrient management (SSNM) approach for targeted yield of 55 q ha-1 for dry Direct Seeded Rice (DSR) registered significantly higher soil microbial population viz., bacterial (25.73×106 cfu g-1 of soil), fungal (8.62 × 103 cfu g-1 of soil) and actinomycetes (10.14 × 104 cfu g-1 of soil) over farmers practice and other soil test methods. Upadhyay *et al.,* 2019 stated that combined application of organic source of nutrient and inorganic fertilizers increases nutrient synchrony and reduces losses leading to sustainable productivity. They observed that application of *panchagavya*(blend of five cow products i.e. dung, ghee, curd, urine and milk) at seedling root dip + one spray at 30 days after transplanting-DAT @ 6% + application through irrigation water at 60 DAT produced higher soil bacterial and fungal population, and dehydrogenase activity . Rajput *et al.,* 2019 showed that significantly higher magnitude of soil organic carbon, microbial biomass carbon, microbial quotient, available nitrogen, and enzymatic activities (dehydrogenase, alkaline phosphatase and urease) was obtained in T6 (mix of wheat+rice compost) and T7 (green manure) than biochar T2(rice compost) and T5(wheat compost) and crop residue amendments. The experimental results imply that composting of crop residues could be the most reliable practice to improve soil nutritional quality as well as crop growth for sustainable rice–wheat cropping system in the hilly area.

**7. CONCLUSION**

Several types of rice found in India have therapeutic qualities and meet the criteria for a health food according to both contemporary and traditional ideas. Due to pressure from high-yielding cultivars and other cash crops, these varieties are rapidly going extinct, hence conservation is desperately needed. It is imperative that these types be vigorously marketed and promoted by raising public knowledge of their significance, particularly among the younger population. Establishing a niche in the global market requires clinical evidence of their medicinal benefits (just how China sells red rice yeast worldwide). Promoting and preserving this national treasure as a nutritious food is essential to halting the rise of diseases linked to a poor lifestyle.

**REFFERENCE**

Bahadur L, Tiwari DD, Mishra J and Gupta BR (2012). Effect of integrated nutrient management on yield, microbial population and changes in soil properties under rice-wheat cropping system in sodic soil. *Journal of the Indian Society of Soil Science*, **60**(4): 326-329

Basha SJ and Basavarajappa (2015). Effect of organic and inorganic sources of nutrients on soil chemical properties under aerobic rice cultivation, Karnataka *J. Agric. Sci*., **28**(4): 489-493

Basha SJ, Basavarajappa J, Shirnalli G and Babalad HB (2016). Soil microbial dynamics and enzyme activities as influenced by organic and inorganic nutrient management in vertisols under aerobic rice cultivation, *Journal of Environmental Biology,* Vol.**38**Page No. 131-138

Bhatt M, Singh AP, Singh V, Kala DC and Kumar V (2019). Long-term effect of organic and inorganic Fertilizers on soil physico-chemical properties of a silty clay loam soil under rice- wheat cropping system in Tarai region of Uttarakhand, *Journal of Pharmacognosy and Phytochemistry*,**8(1):** 2113-2118**.**

Dash D, Patro H, Tiwari RC and Shahid M (2010). Effect of organic and inorganic sources of nitrogen on Fe, Mn, Cu and Zn uptake and content of rice grain at harvest and straw at different stages of rice (*Oryza sativa L.*) crop growth, *Advances in Applied Science Research,***1** (3): 36-49

De Datta SK, Fillery IRP and Craswell ET (1983) Results from recent studies on nitrogen fertilizer efficiency in wetland rice. Outlook on Agriculture 12:125–134

Dutta M and Sangtam R (2014). Integrated nutrient management on performance of rice in terraced land. *International Journal of Bio-resource and Stress Management,* **5**(1):107-112

Gour SP, Sngh SK, Lal R, Singh RP, Bohra JS, Srivastava JP, Singh SP,KumarM,Kumar O and Latare AM (2015) Effect of organic and inorganic sources of plant nutrients on growth and yield of rice (*Oryza sativa* L.) and soilfertility, *ndian Journal of Agronomy***60** (2): 328-331

Goutami N, Rao CH, Sireesha A, Rao CP and Gopal AV (2018) Effect of Long-Term Use of Inorganic Fertilizers, Organic Manures and their Combination on Soil Properties and Enzyme Activity in Rice-Rice Cropping System, *Int.J.Curr.Microbiol.App.Sci*, **7**(9): 469-486

Government of India (2014) Agricultural Statistics at a Glance, Ministry of Agriculture and Cooperation. Directorate of Economics and Statistics. Oxford University Press, New Delhi, 72-74

Jobe (2003) Integrated Nutrient Management for Increased Rice Production in the Inland Valleys of The Gambia. In: SanyangAjayi SA and A. A. Sy (eds). Proc. 2nd*Biennial Regional Rice Research Review*. WARDA Proceedings Series No. 2 Vol **1**: 35-41

Kumar A, Meena RN, Yadav L and Gilotia YK (2014) Effect of organic and inorganic sources of nutrient on yield, yield attributes and nutrient uptake of rice cv. prh-10, The Bioscan**9(2)**: 595-597

Kumar K, Sridhara CJ and Nandini KM (2018) Effect of integrated use of organic and inorganic fertilizers on soil fertility and uptake of nutrients in aerobic rice(*Oryza sativaL*.),*International Journal of Chemical Studies*,**6**(4):417-421

Kannan RL, Dhivya M, Abinaya D, Krishna RL and kumar SK (2013) Effect of integrated nutrient management on soilfertility and productivity in maize. Bull. *Env. Pharmacol. Life Sci***, 2**(8): 61-67

Kumar S, Saha B, Saha S, Das A, Poddar P and Prabhakar M (2017) Integrated Nutrient Management for Enhanced Yield, Nutrients Uptake and their Use Efficiency in Rice under Intensive Rice-Wheat Cropping System, *Int.J.Curr.Microbiol.App.Sci,***6**(10):1958-1972

Lungmuana, Ghosh M. and Patra PK (2013) Effect of integrated nutrient management on available phosphorus influencing grain and straw yield of rice, (*cv. IR-36*) in an Alfisol,*Journalof Crop and Weed,* **9**(1)*:*89-93

Mohanty M, Nanda SS and Barik AK (2013) Effect of integrated nutrient management on growth, yield, nutrient uptake and economics of wet season rice (*Oryza sativa L.*) in Odisha,*Indian Journal of Agricultural Sciences*, **83**(6): 599–604

Puli MR, Prasad PRK, Jayalakshmi M and Rao BH (2017) Effect of Organic and Inorganic Sources of Nutrients on NPK Uptake by Rice Crop at Various Growth Periods, *Research Journal of Agricultural Sciences,* **8**(1): 64-69

Raghavendra, K. Narayana Rao ,Swamy M and S.P. Wani (2018) Influence of Nutrient Management Approaches on Soil Enzyme Activity, Soil Microbial Population and Grain Yield of Dry Direct Seeded Rice, *Int.J.Curr.Microbiol.App.Sci*

Rajput R,  Pokhriya P,  Panwar P**,** Arunachalam A, Arunachalam K (2019) Soil nutrients, microbialbiomass, and crop response to organic amendments in rice cropping system in the Shiwaliksof Indian Himalayas. *International Journal of Recycling of Organic Waste in Agriculture,* **8:**73–85,2018 **7**(6): 2558-2567

Ranjitha PS, Kumar RM and Jayasree G (2013) Evaluation ofrice (*Oryza sativa L.*) varieties and hybrids in relation to different nutrient management practices for yield, nutrient uptake and economics in SRI. Annals of Biological Research**, 4**(10): 25-28

Rao M, Katkar RN, Rao BS and Jayalakshmi M (2013) Effect of long term fertilization on pH, Ec and Exchangeable Ca and Mg in vertisols under sorghum - wheat cropping sequence. *International Journal of Applied Biology and PharmaceuticalTechnology*, **4**(4): 431 - 433.

Sahu P (2017) Long term effect of inorganic and organic sources of nutrients on soil fertility and productivity of direct seeded rice under rainfed midland situation in rice- field pea cropping system, M.Sc.(Ag), Agriculture, Soil Sc, Agricultural Chemistry Thesis, Indira Gandhi Krishi Vishwavidyalaya, Raipur.

Sahu YK, Prahalad K, Dhruw TK and Joshi SK (2018) Effects of Integrated Nutrient Management on Rice (*Oryza sativa L.*) Yield and Yield Attributes, Nutrient Uptake - A Review,*TrendsinBiosciences* **11**(1)*, ,* 01-06*,*

S. Manimaran, V Prakash (2018) Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar 608 002, Tamil Nadu, India, Innovations in Agriculture 2018, 1(1): 16-18

Sannathimmappa H G, Gurumurthy BR, Jayadeva HM, Rajanna D and Shivanna MB (2015). Effect of Paddy Straw BasedIntegrated Nutrient Management Practicesfor Sustainable Production of Rice. IOSR Journal of Agriculture and VeterinaryScience,8:74-77

Shilpashree VM, Chidanandappa HM, Jayaprakash R and Punitha BC (2012) Effect of integrated nutrient management practices on distribution of nitrogen fractions by maize crop in soil. *Indian Journal of Fundamental and Applied Life Sciences*,**2**(1): 38-44

Singh G, Singh OP, Singh RG, Mehta RK, Kumar V and Singh RP (2006). Effect of integrated nutrient management on yield and nutrient uptake of rice-wheat cropping system in lowlands of eastern Uttar Pradesh. *Indian Journal of Agronomy*, **51**(2): 85-88

Singh V and Dubey YP (2018) Impact of organic and inorganic sources of nutrients on chemical properties of soil, yield attributes and yield in Sesamum-pea cropping sequence,*Journalof Pharmacognosy and Phytochemistry*,**7**(6): 1925-1931

Urkurkar JS, Tiwari A, Chitale S and Bajpai RK (2010) Influence of long-term use of inorganic and organic manures on soil fertility and sustainable productivity of rice (*Oryza sativa L*.) and wheat

Yaduvanshi NPS, Sharma DR and Swarup A (2013) Impact of integrated nutrient management on soil properties and yield ofrice and wheat in a long-term experiment on a reclaimed sodic soil. *Journal of the Indian Society of Soil Science***, 61**(3): 188-194

Zayed BA, Elkhoby WM, Salem AK, Ceesay M and Uphoff NT (2013) Effect of integrated nitrogen fertilizer on riceproductivity and soil fertility under saline soil conditions. *Journal of Plant Biology Research***, 2**(1): 14-24